



FISHERY MANAGEMENT PLANS

Status of Ongoing Plans

Amendment 2 to the Estuarine Striped Bass FMP

Amendment 3 to the Southern Flounder FMP

Amendment 2 to the Interjurisdictional FMP

Amendment 2 to the Shrimp FMP



ROY COOPER
Governor

ELIZABETH S. BISER
Secretary

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Director

November 1, 2021

MEMORANDUM

TO: N.C. Marine Fisheries Commission

FROM: Corrin Flora, Fishery Management Plan Coordinator
Fisheries Management Section

SUBJECT: Fishery Management Plan Update and Schedule Review

Issue

Update the N.C. Marine Fisheries Commission (MFC) on the status of North Carolina fishery management plans (FMPs).

Action Needed

For informational purposes only, **no action is needed at this time.**

Overview

This memo provides an overview on the status of six North Carolina FMPs for the November 2021 MFC business meeting.

Southern Flounder FMP

At the March 2021 Special Meeting, the MFC passed a motion adjusting allocations to the southern flounder fishery to meet a 50/50 parity in 2024 and requested several management additions to draft Amendment 3. Based on this motion, division staff have revised Amendment 3. Because of the changes that resulted from the amendment to the allocation decision the Division held an additional Southern Flounder FMP Advisory Committee workshop in August 2021. This additional workshop was needed for stakeholder input on the sustainable harvest allocation within fisheries and additional management that was not discussed at the previous workshops. The draft plan was edited based on input received. At the November 2021 business meeting, lead staff will present draft Amendment 3 for the MFC to vote to send for public and MFC AC review.

Shrimp FMP

At the May 2021 business meeting, the MFC voted to send draft Amendment 2 for public and MFC AC review. In June 2021, the division held a 30-day public comment period and meetings with all standing and regional ACs. Recommendations from the division, public, and ACs were added to the draft plan. Lead staff will present an overview of recommendations during the November business meeting of the MFC and the MFC will select preferred management options

for the Shrimp FMP Amendment 2 at that time. Once MFC preferred management options are selected, the plan will be sent to the DEQ Secretary and legislative committees for 30-day reviews.

Estuarine Striped Bass FMP

Development of Amendment 2 began with a scoping period held November 2-15, 2020. At the February 2021 business meeting, the MFC approved the Goal and Objectives and advised the division on additional management strategies to be considered in Amendment 2. Division and Wildlife Resources Commission (WRC) staff developed the full draft of Amendment 2. A Workshop was held with the Estuarine Striped Bass FMP AC, Division, and WRC staff in September and October 2021. The draft plan is now under revision based on Workshop input. Management continues under Amendment 1, including the supplement and revision, until the adoption of Amendment 2.

Spotted Seatrout FMP

A benchmark stock assessment for spotted seatrout is underway coinciding with the scheduled Spotted Seatrout FMP review. The prior stock assessment from 2014 indicated the stock is not overfished and is not experiencing overfishing. The benchmark stock assessment will be completed in early 2022.

Striped Mullet FMP

A benchmark stock assessment for striped mullet is underway coinciding with the scheduled Striped Mullet FMP review. The previous stock assessment update, through terminal year 2017, indicated the stock is not experiencing overfishing. Due to a poor relationship between spawning stock biomass and juvenile abundance, overfished status was unable to be determined. The benchmark stock assessment will undergo peer review November 8-10, 2021.

Interjurisdictional FMP

The scheduled review of the N.C. FMP for Interjurisdictional Fisheries is underway. The management strategy of this unique state FMP is to adopt management measures appropriate for North Carolina contained in finfish FMPs approved by the federal Councils or the Atlantic States Marine Fisheries Commission (ASMFC), which North Carolina is subject to, by reference as minimum standards. This avoids duplication of effort in the development of North Carolina species plans under the Fisheries Reform Act for species or species groups subject to federal Councils or ASMFC FMPs. The last update to the FMP for Interjurisdictional Fisheries was completed in 2015. A new item being incorporated in Amendment 2 will address the best mechanism to shift from our current two state FMP management system to a single state FMP management system. Lead staff will present the Amendment 2 Goal and Objectives for MFC approval at the November 2021 business meeting.

Estuarine Striped Bass Fishery Management Plan Amendment 2 Decision Document



October 2021



N.C. Division of Marine Fisheries

3441 Arendell Street

Morehead City, North Carolina 28557

This Decision Document is a companion document to Amendment 2 to the Estuarine Striped Bass Fishery Management Plan. It provides a brief overview and context for the issues. The document also provides references to the full Amendment document where more detailed information is located. The Estuarine Striped Bass Fishery Management Plan Amendment 2 document is the plan under consideration and is the focus of all NCMFC action.

Summary

The Estuarine Striped Bass Fishery Management Plan Amendment 2 continues to be developed. An advisory committee workshop was held over four days in September and October, 2021 to review the full draft plan with stakeholders. Staff are now editing the plan based on input received during the workshop. In November 2021, the North Carolina Marine Fisheries Commission (NCMFC) will receive a verbal update on the progress of the draft plan. There is no required action at this time. However, commissioners are encouraged to review all management options and inform the division if there are additions to consider at this time.

Amendment Timing

November 2020	Division holds public scoping period
February 2021	NCMFC approves goal and objectives of FMP
October 2020 – September 2021	Division drafts FMP
September - October 2021	Division holds workshops to further develop draft FMP with Plan Advisory Committee
October 2021 – January 2022	Division updates draft plan
February 2022	NCMFC votes to send draft FMP for public and AC review
March 2022	NCMFC Advisory Committees meet to review draft FMP and receive public comment
May 2022	NCMFC selects preferred management options
June - July 2022	DEQ Secretary and Legislative review of draft FMP
August 2022	NCMFC votes on final adoption of FMP
TBD	NCDMF and NCMFC implement management strategies

Goal and Objectives

The goal of Amendment 2 is to manage the estuarine striped bass fisheries to achieve self-sustaining populations that provide sustainable harvest based on science-based decision-making processes. If biological and/or environmental factors prevent a self-sustaining population, then alternate management strategies will be implemented that provide protection for and access to the resource. The following objectives will be used to achieve this goal.

- Implement management strategies within North Carolina and encourage interjurisdictional management strategies that maintain and/or restore spawning stock with adequate age structure and abundance to maintain recruitment potential and to prevent overfishing.
- Restore, enhance, and protect critical habitat and environmental quality in a manner consistent with the Coastal Habitat Protection Plan, to maintain or increase growth, survival, and reproduction of the striped bass stocks.
- Use biological, social, economic, fishery, habitat, and environmental data to effectively monitor and manage the fisheries and their ecosystem impacts.
- Promote stewardship of the resource through public outreach and interjurisdictional cooperation regarding the status and management of the North Carolina striped bass stocks, including practices that minimize bycatch and discard mortality.

Background

There are three estuarine striped bass management areas and four stocks in North Carolina. The Albemarle Sound Management Area (ASMA) and Roanoke River Management Area make up the Albemarle-Roanoke Stock (A-R). The Central Southern Management Area (CSMA) includes the Tar-Pamlico, Neuse, and Cape Fear stocks.

Stock Assessment

Albemarle-Roanoke Stock

- Overfishing is occurring
- Overfished

CSMA Stocks

- Sustainability of Tar-Pamlico and Neuse stocks unlikely at any level of fishing mortality
- Natural recruitment primary limiting factor
- Without stocking, abundance will decline
- Even with no-possession Cape Fear abundance reduced

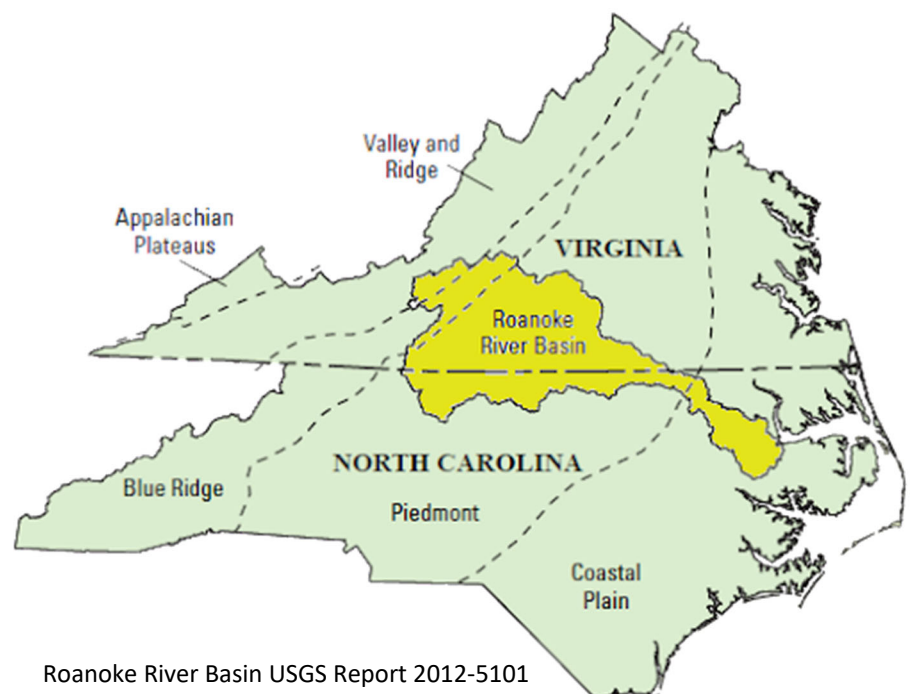
The North Carolina Fisheries Reform Act and Amendment 6 to the Atlantic States Marine Fisheries Commission (ASMFC) Interstate FMP for Atlantic Striped Bass require management measures to be implemented to end overfishing in 2-years and end the overfished status in 10-years. The November 2020 Revision to Amendment 1 began implementing management to end overfishing in one year.

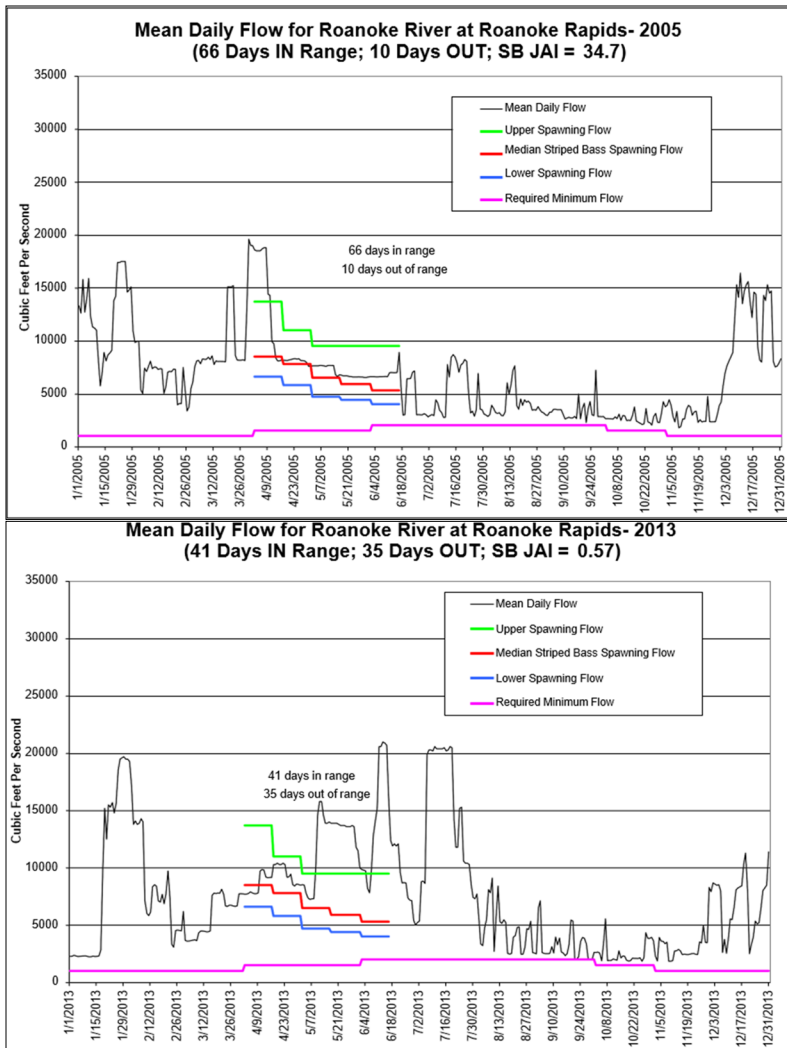
No-possession measures were implemented in the Cape Fear River in 2008 and the Tar-Pamlico and Neuse rivers in 2019. The overall goal to increase the age structure and abundance of fish in these systems. The ASMA is managed by Total Allowable Landings (TAL) set in the November 2020 revision. The commercial and recreational fisheries are set at a 50/50 allocation among the ASMA.

River Flow

Striped bass are broadcast spawners, producing eggs that must remain suspended in the water column to develop and hatch. Proper river flow is a very critical environmental factor influencing year class strength. In the ASMA, extended periods of high water from May to June negatively impact eggs and fry. Recruitment failures since 2001 are thought to be due to spring flooding.

There are three dams on the Roanoke River above Weldon. The Federal Energy Regulatory Commission does limit activities, such as hydropeaking, to limit dam impacts. However, rainfall in the river basin impacts the ability to regulate river flow while limiting flooding. The Roanoke River is impacted by rain north of Winston-Salem, NC and into southern Virginia.





A cooperative agreement with the US Army Corp. of Engineers (ACOE) strives to maintain Roanoke River flow rates within specified ranges to allow for striped bass spawning success. Flow rates are negotiated which strive to benefit striped bass spawning.

Spawning success is measured by the annual juvenile abundance index (JAI). In 2005, the flow was ideal for spawning and the JAI was high. In 2013, the flow rate was too high for half of the spawning period. The resulting JAI was low.

Poor recruitment is a major factor causing population declines. Inter-agency work continues to address these environmental concerns.

Stocking

In the late 19th century, striped bass began to be grown at the Weldon Hatchery. Since then striped bass have been stocked in the Albemarle Sound, Tar-Pamlico, Neuse, and Cape Fear rivers. An interagency cooperative agreement between the US Fish and Wildlife Service, NC

Division of Marine Fisheries, and NC Wildlife Resources Commission was established in 1986 to oversee the North Carolina Coastal Striped Bass Stocking Program. An annual workplan is set each year to establish stocking goals by river system. A brief history and assessment of the state stocking program will serve as an information paper in Amendment 2 to inform sustainable harvest issue papers.

Stocking is necessary to maintain the Tar-Pamlico, Neuse, and Cape Fear stocks. Assessments continue to evaluate if a naturally spawning stock is achievable in these systems. If not, alternative management may be considered such as put-grow-take fisheries.

Historically, Roanoke River broodstock were used when stocking the rivers of North Carolina. This has resulted in genetically similar fish stocks across the state. Broodstock are now retrieved from the different river systems; however, the fish are genetically from the same stock.



Management Strategies in this Amendment

Albemarle-Roanoke Sustainable Harvest Issue Paper

The peer reviewed stock assessment indicates the A-R stock is overfished and overfishing is occurring. The state Fisheries Reform Act and the ASMFC FMP require management measures to be implemented. The November 2020 Revision to Amendment 1 began implementing management to end overfishing in one year. This issue paper considers management beyond the revision to achieve sustainable harvest.

Options:

1. Implement harvest moratorium
2. Status Quo: Use a TAL
 - a. Commercial fishery managed as bycatch fishery
 - b. Accountability measures address TAL overages
 - i. Status Quo accountability measures:
 - Short-term: harvest exceeds TAL by 10%, overage deducted from the next year and other restrictions in responsible fishery.
 - Long-term: five-year average exceeds the five-year average TAL by 2%, the responsible fishery TAL for the five years.
 - ii. Accountability measures:
 - Short-term: harvest exceeds TAL by 5%, overage deducted from the next year and other restrictions in responsible fishery.
 - Long-term: five-year average exceeds the five-year average TAL by 2%, the responsible fishery TAL for the five years.
 - iii. Deduct overages from the responsible fishery the following year without a percent buffer around the TAL.
3. Size limits to expand age structure
 - a. Status Quo: 18-inch ASMA and 18 – 22-inch harvest slot with 1 greater than 27-inch in RRMA
 - b. Increase minimum size
 - c. Implement slot limit
4. Gear modifications and area closures to reduce discard mortality
 - a. Status Quo: harvest of striped bass with gill nets and recreational harvest includes catch-and-release fishing on the spawning grounds
 - b. Do not allow harvest of striped bass with gill nets
 - c. Do not allow harvest or targeted catch-and-release fishing for striped bass on the spawning grounds or areas of high concentration
 - d. Expand the single barbless hook to the entire RRMA during striped bass season
 - e. Require non-offset, circle hooks when fishing live or natural bait in RRMA during striped bass season
5. Adaptive Management
 - Updated stock assessment at least once between benchmarks to review BRPs and TAL.
 - If F exceeds the F_{Target} , reduce the TAL.
 - Ability to change daily possession limits, open and close seasons, and require gear modifications to keep below the TAL.

Tar-Pamlico and Neuse rivers Sustainable Harvest

This issue paper considers management measures in the Tar-Pamlico and Neuse rivers to promote sustainable harvest. A no-possession measure was implemented in 2019 to protect important age classes in order to increase the age structure and abundance of Tar-Pamlico and Neuse river striped bass. Options 2 and 3 are based on continuing the no-possession measure for CSMA striped bass.

Options:

1. Striped Bass Harvest
 - a. Continue no-harvest measure
 - b. Discontinue no-harvest measure
2. Gill net restrictions/Limits
 - a. Maintain gill net closure at ferry lines
 - i. 50-yd distance from shore (DFS) and tie-down requirements year round
 - ii. 50-yd DFS and tie-down requirements April 15-December 31
 - b. Remove gill net closure at ferry lines
 - i. 50-yd DFS and tie-down requirements year round
 - ii. 50-yd DFS and tie-down requirements April 15-December 31
 - iii. 200-yd DFS January 1-April 14. 50-yd DFS and tie-down requirement April 15-December 31
3. Adaptive management
 - a. Annual review of fishery-independent and fishery-dependent data
 - i. If age structure expanded and natural recruitment is occurring, update matrix model to evaluate harvest strategies. Examine possibility of a stock assessment.
 - ii. If recruitment is not occurring, examine causes.

Cape Fear River Sustainable Harvest

This issue paper considers management measures in the Cape Fear River to promote sustainable harvest. A no-possession measure was implemented in 2008 to increase the age structure and abundance of Cape Fear River striped bass.

Options:

1. Maintain No Possession Provision
2. Allow Seasonal Harvest in the Cape Fear
3. Allow Seasonal Harvest in the Mainstem Cape Fear River Joint and Inland Fishing Waters above the 140 Bridge
4. Allow Seasonal Harvest in Inland Fishing Waters on the Mainstem of the Cape Fear River
5. Adaptive Management
 - a. Continue YOY surveys and PBT analysis (Appendix 4 page 13)
 - b. Management measures which may be adjusted include means and methods, harvest area, season, size, and creel limit.
 - c. Must be evaluated by staff with the MFC Finfish AC consultation.

Hook and Line as a Commercial Gear

Amendment 1 management did not approve hook-and-line at that time. However, a rule change was made to allow as an adaptive management tool if a framework was created. This issue paper develops the framework the NCMFC required for further consideration of hook-and-line as a commercial gear.

Options:

1. Do not allow hook and line as a commercial gear for estuarine striped bass
2. Allow hook and line as a commercial gear for estuarine striped bass with framework



Southern Flounder Fishery Management Plan Amendment 3 Decision Document



October 2021



**N.C. Division of Marine Fisheries
3441 Arendell Street
Morehead City, North Carolina 28557**

This Decision Document is a companion document to Amendment 3 to the Southern Flounder Fishery Management Plan. It provides a brief overview and context for the issue. The document also provides references to the full Amendment document where more detailed information is located. The Southern Flounder Fishery Management Plan Amendment 3 document is the plan under consideration and is the focus of all MFC action.

Summary

In November 2021 the North Carolina Marine Fisheries Commission (MFC) will be reviewing draft Amendment 3 of the Southern Flounder Fishery Management Plan (FMP) to send for public and advisory committee review.

Following the 2019 Coast-wide Stock Assessment that determined southern flounder to be overfished and overfishing to be occurring the Division of Marine Fisheries recommended and the MFC approved Amendment 2 to the Southern Flounder FMP. Amendment 2 was intended as a stop-gap to reduce harvest pressure on the portion of the stock in North Carolina and to allow for continued development of more long-term management measures in Amendment 3. Since that action by North Carolina, Florida and South Carolina have also implemented management measures to address the status of the stock. Amendment 3 has been developed to address comprehensive, long-term management strategies to continue rebuilding the southern flounder stock. The Division of Marine Fisheries (DMF) has drafted seven issue papers (see Appendix 4, p. 61) which address sustainable harvest, increased recreational access, inlet corridors, adaptive management, sector allocations, slot limits, and phasing out large-mesh gill nets. The division has provided a list of management options for each issue paper along with initial recommendations where appropriate.

Amendment Timing

December 2019	Division holds public scoping period
February 2020	MFC approves goal and objectives of FMP
February – October 2020	Division drafts FMP
October 2020 & August 2021	Division holds workshops to further develop draft FMP with Plan Advisory Committee
November 2020 – October 2021	Division updates draft plan
November 2021	MFC votes to send draft FMP for public and AC review
January 2022	MFC Advisory Committees meet to review draft FMP and receive public comment
February 2022	MFC selects preferred management options
March – April 2022	DEQ Secretary and Legislative review of draft FMP
May 2022	MFC votes on final adoption of FMP
May 2022	DMF and MFC implement management strategies

Goal and Objectives

The goal of Amendment 3 is to manage the southern flounder fishery to achieve a self-sustaining population that provides sustainable harvest using science-based decision-making processes. The following objectives will be used to achieve this goal.

- Implement management strategies within North Carolina and encourage interjurisdictional management strategies that maintain/restore the southern flounder spawning stock with expansion of age structure of the stock and adequate abundance to prevent overfishing.
- Restore, enhance, and protect habitat and environmental quality necessary to maintain or increase growth, survival, and reproduction of the southern flounder population.
- Use biological, environmental, habitat, fishery, social, and economic data needed to effectively monitor and manage the southern flounder fishery and its ecosystem impacts.
- Promote stewardship of the resource through increased public outreach and interjurisdictional cooperation throughout the species range regarding the status and management of the southern flounder fishery, including practices that minimize bycatch and discard mortality.
- Promote the restoration, enhancement, and protection of habitat and environmental quality in a manner consistent with the Coastal Habitat Protection Plan.

Background

The southern flounder found in North Carolina waters were recently determined to be part of a larger regional stock shared with South Carolina, Georgia and the east coast of Florida. This means the stock is impacted by harvest and management in all states within the region. As a result, and unlike previous assessments, the most recent stock assessment was conducted collaboratively with academics, scientists and managers from North Carolina, South Carolina, Georgia, and Florida. The resulting stock assessment showed the regional southern flounder stock to be overfished and overfishing still occurring. It also indicated recovery is dependent on action by all states in the region. North Carolina took decisive action to end overfishing and begin recovering the regional stock by adopting substantial harvest reductions in 2019 and continuing to actively develop improved management measures.

The southern flounder fishery is currently managed under Amendment 2 to the Southern Flounder FMP. In August 2019, the MFC approved Amendment 2 which implemented reductions in total removals (harvest + dead discards) of southern flounder of 62% in 2019 and 72% in 2020 and on. These reductions were more conservative than the 52% reductions that were required and were recommended and selected to increase the likelihood of meeting the management targets. These reductions were applied across all fishery sectors and were implemented using seasonal management. Approval of Amendment 2 specified the development of Amendment 3 begin immediately to develop more comprehensive, long-term management measures to address the stock status. While the seasonal management implemented under Amendment 2 has been successful in reducing removals at a level expected to end overfishing, may not be sufficient to rebuild the stock within 10 years because of potential overages due to shifts in fishing behavior. The draft of Amendment 3 contains a suite of management options, including adaptive management, that will increase the likelihood for long-term rebuilding of the stock.

In November 2020, during development of Amendment 3, the MFC requested the DMF prepare an issue paper to consider various sector allocations of the total allowable removals remaining after the 72% reductions across the fishery. While the MFC initially approved a 70/30 commercial/recreational allocation, they revisited the allocation decision and voted to amend the allocation to a stepped approach to reach a 50/50 allocation by 2024. Due to the complicated nature of the allocation decision, Amendment 3 timing was shifted, giving the DMF time to evaluate how the different sector allocations would effect the management measures contained in the Sustainable Harvest, Increased Recreational Access, and Adaptive Management issue papers and to revise the full FMP as needed. Staff incorporated these changes and developed a suite of sustainable harvest management options for the MFC to consider. In addition, per the request of various commissioners, DMF staff also addressed additional management options, such as slot limits and inlet corridors, in the existing issue papers as well as developed an issue paper considering the phasing out of large mesh gill nets from the southern flounder fishery. The resulting seven issue papers are now ready for MFC review and a vote on sending draft Amendment 3 out for public and advisory committee review.

Amendment 2 Management

During the May 2021 MFC business meeting, staff provided an update to the commission on the 2019 and 2020 southern flounder harvest during the commercial and recreational seasons established under Amendment 2. As a result of the observed overages in the fishery, particularly in the recreational sector, the

	Total Removals (pounds)			Realized Percent Reduction*
	Allowable	Actual	Overage	
Commercial				
2019	531,629	804,117	272,488	43%
2020	391,726	482,832	91,106	66%
Recreational				
2019	207,382	461,588	254,206	15%
2020	152,808	456,636	303,828	16%
Overall				
2019	739,011	1,265,705	526,694	35%
2020	544,534	939,468	394,934	52%

*Based on 2017 landings, the final year of the coast-wide stock assessment.

Amendment 3 to the Southern Flounder FMP Proposed Management Measures

Draft Amendment 3 to the Southern Flounder FMP provides an overview of the southern flounder fishery, including a discussion of the current stock status, which informs all of the management options in Amendment 2 and Amendment 3. An updated coast-wide stock assessment cannot be undertaken until management actions are in place for a sufficient length of time to effect a measurable change on the entire stock. Typically this length of time is 5 years from management implementation. Because southern flounder is a coast-wide stock, the timing will also depend on management implemented by the other states. South Carolina and Florida implemented management changes in 2021 (Appendix 2, pg. 58).

All seven issue papers are located in Appendix 4 of the FMP and were developed with the aim of rebuilding the southern flounder population and achieving a sustainable fishery. Management measures are based on the 72% reduction in harvest established in Amendment 2. Quota and seasonal management targets are based the sector allocations set by MFC (Appendix 4.5, pg. 136-144) which are discussed briefly below. The 10-year rebuilding timeline began with Amendment 2 (2019) and will not restart with the adoption of Amendment 3. In addition, several management measures from Amendment 2 will be clarified and carried forward in Amendment 3 (See Appendix 4.1, pg. 69).

Initial DMF recommendations are denoted in **orange text**. Please note that several options for the recreational fishery are dependent on others for management to be successful.

Sector Allocation

Quota management of the southern flounder fishery is one of the management options under consideration in Amendment 3 (See Sustainable Harvest). Establishing a quota, sets the harvest for the fishery at a sustainable level. Quota allocations describe the portion of the quota that is available to each sector of the fishery. In this case, the quota is divided between the commercial and recreational sectors.

For Amendment 2 and during the development of Amendment 3 the DMF identified the historical sector harvests for the commercial and recreational fisheries, then reduced both by 72%. At the MFC November 2020 quarterly business meeting the MFC approved a motion requesting the DMF consider several alternative sector harvest allocation options for Amendment 3. The motion specified consideration of the following commercial/recreational percentage splits: 70/30, 65/35, 60/30 with a 10 percent allotment for gigging, 60/40, and 50/50. Division staff drafted an issue paper in response and staff presented analysis of the options at the February 2021 business meeting (see Appendix 4.5; p136—144). The DMF did not endorse, recommend, or advocate any one of these options including the status quo option. Allocation does not impact the total allowable catch levels needed to rebuild the stock. If the catch reductions are met in the southern flounder fishery, then the stock is predicted to rebuild.

MFC Selected Management

At the March 2021 special meeting, the MFC approved the following stepped allocations: 70/30 in 2021 and 2022; 60% commercial and 40% recreational in 2023; and 50/50 parity in 2024. The Total Allowable Catch available to both the commercial and recreational sectors combined is 548,034 pounds (532,352 pounds of Total Allowable Landings + 15, 682 pounds of Dead Discards).

Total Allowable Landings for Each Sector Based on the MFC-Selected Sector Allocations.

Year	Allocation	Total Allowable Landings	
		Commercial	Recreational*
2021	70/30	372,646	159,706
2022	70/30	372,646	159,706
2023	60/40	319,411	212,941
2024	50/50	266,176	266,176

Sustainable Harvest

This issue paper proposes management options to that are based on available data and are predicted to achieve a sustainable southern flounder fishery (Appendix 4.1, pg. 61 - 112). Several key points are important to take into consideration (pg. 68).

Key points include:

- Total Allowable Catch (TAC) is are the landings plus dead discards that can be removed from the harvest based on the reductions.
- Total Allowable Landings (TAL) is calculated by removing the dead discards, and describes the landings available to each sector annually.
- These management measures meet rebuilding and are based on the corresponding TAL and TAC.
- Dead discards are calculated after the landings are tallied for the year. Only after these are calculated can TAC be evaluated for overages.
- Rebuilding projections included the minimum size limits, gear requirements, and selected soak time and daytime restrictions. Changes to these will have an impact on the rebuilding schedule.
- Additional management measures beyond seasonal closures will improve the southern flounder stock and provide flexibility for fishermen.

Management Options

Option 1: Commercial Quota—Mobile Gears and Pound Nets (pg. 74-84)

- Option 1.1 Mobile Gears Quota (Figure 4.1.5, see below left)

The mobile gears targeting southern flounder are primarily gig and gill nets.

A: Divide mobile commercial gears into two areas, using ITP line for units B-D

B: Single mobile gear allocation

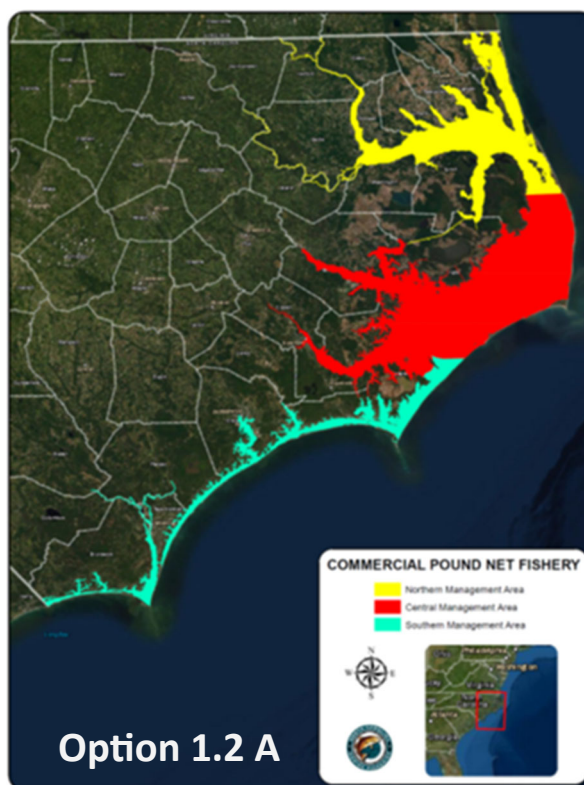
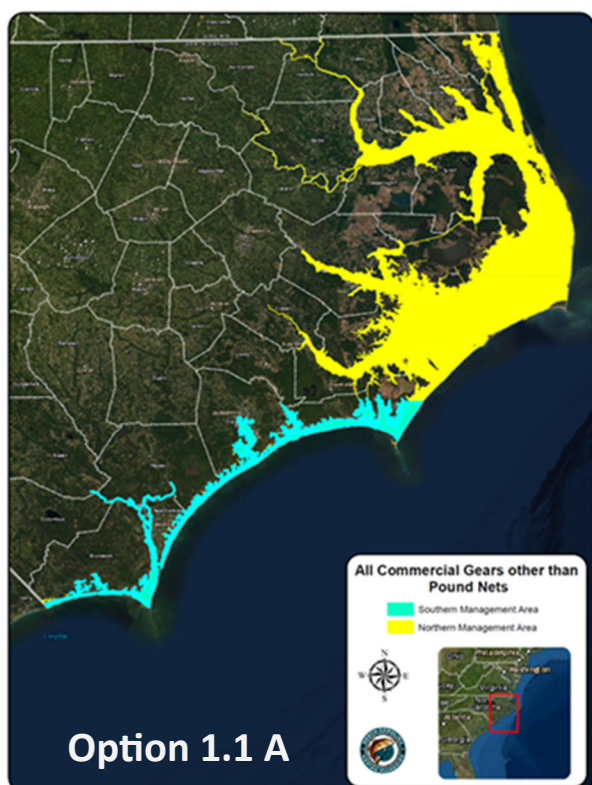
C: Divide mobile gears into three areas consistent with Amendment 2

- Option 1.2 Pound Net Quota (Figure 4.1.6, see below right)

A: Divide pound net into three areas consistent with Amendment 2

B: Single pound net allocation

C: Divide pound net into two areas at approximately Pea Island



Sustainable Harvest

Option 1 cont...

DMF Rationale for Initial Recommendations

Two categories provides flexibility to use multiple gears in a trip without having to separate catches unless a pound net is involved. Combining mobile gears into a single category prevents users from switching between categories or altering behavior to increase harvest.

- Allows flexibility to accommodate opening dates by gear within and between areas
- Allows commercial gig fishery in summer when prices are high and the weather is better
- Remaining quota would be available to fall gill net fishery
- Splitting mobile gears into two areas at ITP boundary reduces regulatory burden if ITP management unit closure is needed
 - Boundary line is already established.
 - Can re-evaluate if the large-mesh gill net fishery is phased out.
- Pound net areas are based on natural breaks in effort and landings, consistent with current management.

Option 2: Commercial Sub-Allocation (pg. 72 – 83)

Due to the MFC selection of a sector allocation, it is prudent to evaluate the sub-allocations for the commercial fishery.

- Option 2.1: Sub-allocations based on 2017 landings (Tables 4.1.3 and 4.1.6)
- **Option 2.2: Maintain current sub-allocations for pound net fishery (Tables 4.1.4 and 4.1.7)**
- Option 2.3: Redistribute gill-net allocation equally between mobile and pound net gears in 2023 (Tables 4.1.5 and 4.1.8)

DMF Rationale for Initial Recommendations

- Pound net fishery may not be viable below current TAL
- Pound net maintenance costs are high
- Pound net fishery considered relatively clean
 - Reduces available harvest for gill nets
- Difficult to manage quota if historical allocations used at 50:50 parity
 - If fish move due to weather, southern area quota at 50:50 parity can be landed in one day

Option 3: Recreational Season (pg. 85 – 88; Tables 4.1.9 – 4.1.11)

A single recreational season is necessary to achieve the needed reductions. Limitations in recreational monitoring allows less flexibility in management measures. Final recreational harvest and dead discard estimates are not available until the season ends.

Southern flounder recreational TAL in pounds by gear at recreational allocations

Year	Allocation %	Recreational Gear		Total
		Hook-and-Line	Gig	
2021/2022	30	142,206	17,500	159,706
2023	40	189,608	23,333	212,941
2024	50	237,010	29,166	266,176

DMF Rationale for Initial Recommendations

- A single season allows for greater potential to achieve reductions
 - Separate seasons increase the probability of harvest overages
- Season will be within the August 16 – September 30 window
 - Season length will be based on previous year’s landings and any potential paybacks
 - 2020 six-week season indicative of behavior shift occurring; season cannot be expanded beyond this window even if 2017 data indicates possibility of longer seasons

Option 4: Commercial Trip Limits (pg. 89; Tables 4.1.12-13)

Trip limits may help maintain quota allocations in the gig and pound net fisheries, but are not ideal for the gill-net fishery. Trip limits cannot be determined at this time, as they depend on the fishery and available harvest.

- **Option 4A: Implement trip limit for pound net and gigs upon reopening after reaching division closure threshold**
- Option 4B: Implement commercial gear trip limit
- Option 4C: Status Quo, no trip limits

DMF Rationale for Initial Recommendations

- Trip limits would be in numbers of fish for the gig fishery and pounds for the pound net fishery
- Trip limits not ideal for large-mesh gill-net fishery due to the potential for increased dead discards
 - Gill nets would not re-open after closure threshold met
- Maximizes available allocations
- Not static, available quota will determine trip limit
- Would not reopen if there is not sufficient quota remaining

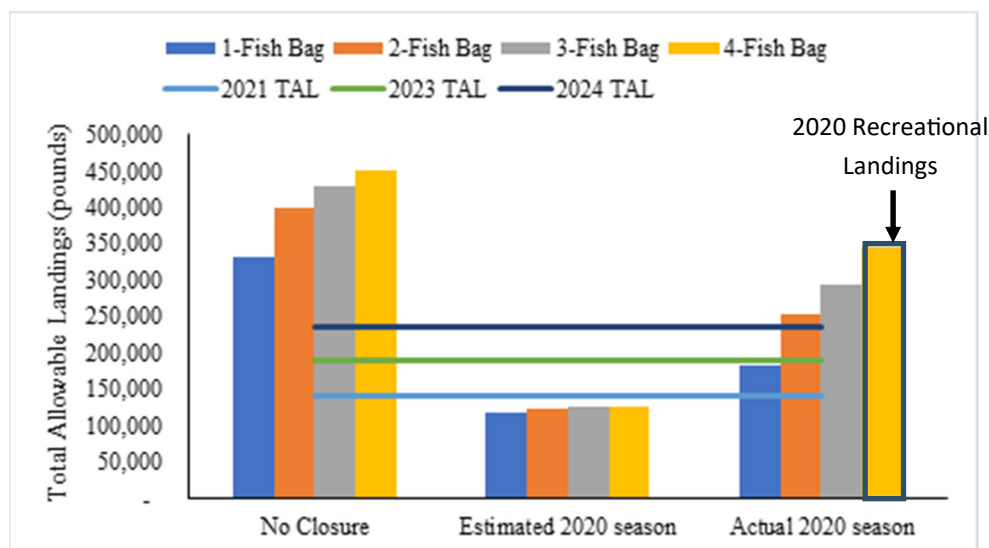
Option 5: Recreational Bag Limit (pg. 90; Table 4.1.14)

Reducing the recreational bag limit will increase the likelihood of meeting reductions as the stock rebuilds. Currently, anglers harvest 93% of the TAL during trips where only one fish is harvested. If bag limit is not decreased to one fish, then vessel limits should be considered (Appendix 4.1.A, beginning pg. 112).

- **Option 5A: 1 fish/person/day**
- Option 5B: 3 fish/person/day
- Option 5C: 2 fish/person/day
- Option 5D: 4 fish/person/day

DMF Rationale for Initial Recommendations

- Prior to 2019, most anglers landed 1-fish per trip
- Reducing the bag limit could buffer overages as angler success increases with rebuilding stock.
- The 2020 MRIP data indicates catch rates and trip numbers have increased.



The figure above shows the estimated pounds landed if there was no closure of the fishery, the landings that were estimated for a Aug 16-Sept 30 season, and what the actual 2020 season (Aug.16 -Sept. 30) landings were. The actual 2020 landings are the yellow bar, the bag limit is currently 4-fish. Also shown are estimates of the 2020 landings if the bag limit was set at 1-, 2- or 3-fish. This demonstrates that even at a 1-fish bag limit the 2020 recreational landings would have exceeded the current TAL.

Option 6: RCGL (pg. 94)

Recreational use of commercial fishing gears is allowed in North Carolina and is subject to the same reductions as the other fisheries. Recreational commercial gear license (RCGL) holders primarily use large-mesh gill nets for southern flounder but may harvest southern flounder from shrimp trawls and crab pots. Both the recreational and commercial seasons must be open to use a RCGL, and the user is only allowed to harvest the recreational limit.

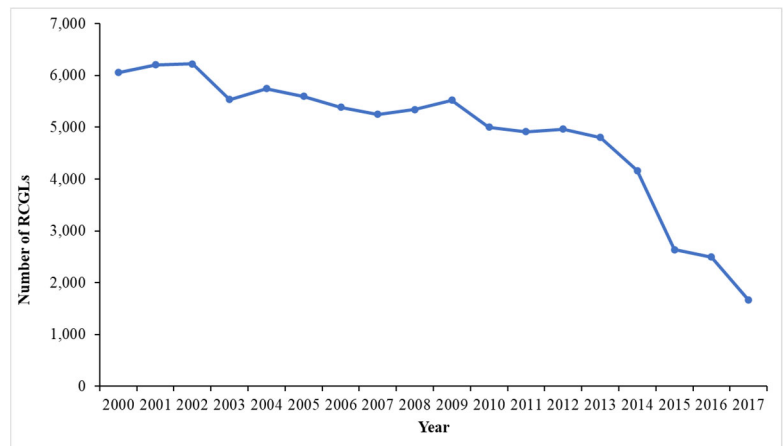
- Option 6A: Allow RCGL to harvest flounder when commercial and recreational fisheries both open
- **Option 6B: Prohibit use of RCGL to harvest flounder**

DMF Rationale for Initial Recommendations

- Does not require a statute or rule change
- Possible the recreational and commercial seasons will not overlap
 - In 2020, only Northern area overlapped
 - In 2021, no areas overlapped
- Landings unknown since 2008, but thought to be low
 - Number of RCGLs consistently dropping (Figure 18)
- Not allowing harvest has potential to increase discards from these gears

Number of Recreational Commercial Gear Licenses (RCGL) issued 2000–2017.

(Source: DMF License and Statistics Annual Report)



Increased Recreational Access

This issue paper analyzes a spring ocellated (Gulf and summer flounder) season in the ocean for the recreational hook-and-line fishery when the southern flounder season is closed (Appendix 4.2, pg. 113-120). The key to allowing an ocellated season is educational outreach. The division launched the Catch-U-Later mobile app, with one of the research objectives being to determine if anglers can differentiate between flounder species. Marine Patrol officers and fishery management staff would work with the public on identification. Additionally, there is a Flounder Identification Guide available. Because southern flounder will be caught during offshore fishing, those removals will count towards the total allowable catch. Thus the season selected is a season that is the least impactful to southern flounder.

Management Options

- Option 1: Status quo, manage as one group
- **Option 2: 1-fish ocellated bag March 1-April 15 in ocean; 1-fish any species bag during southern flounder season (Table 4.2.1)**

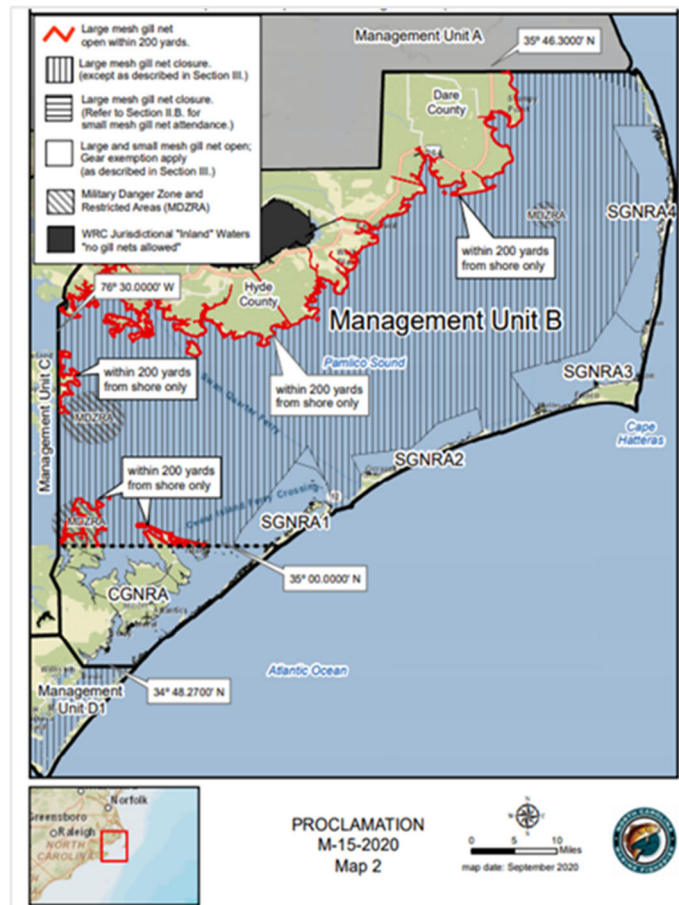
DMF Rationale for Initial Recommendations

- May cause shortened southern flounder season if southern flounder harvested during ocean season
- Needs to be evaluated for Summer Flounder conservation equivalency by MAFMC/ASMFC
- Allows limited access outside of southern flounder season
- Misidentification impact minimized due to season timing
- Timing during lower effort (does not take into consideration behavior shifts)
- Ocellated season cannot be later in the year, data must be analyzed before southern flounder season
- Adjustments to fall season will be made based on spring harvest



Estimated ocean ocellated flounder landings and southern flounder landings under various options for the hook-and-line fishery.

Ocean Only				Ocean and Estuarine				
Ocellated Flounder Season	Bag Limit Ocellated Season	Estimated Ocellated Flounder Landings	Southern Flounder Landings Early Season	Southern Flounder Season	Bag Limit Southern Flounder Season	Southern Flounder Landings Late Season	Total Southern Flounder Landing	TAL
None	0	0	0	Aug 16 –Sep 30	1	118,128	118,128	142,206
Mar 1–Apr 15	1	1,025	1,267	Aug 16 –Sep 30	1	118,128	119,395	142,206
Apr 1–June 30	1	23,116	50,159	Aug 16 –Sep 30	1	118,128	168,287	142,206
Apr 1–Sep 30	1	56,009	143,330	Aug 16 –Sep 30	1	74,860	218,190	142,206



Inlet Corridors

This issue paper considers the development of inlet corridors to provide protection to mature female southern flounder during their migration out coastal inlets into oceanic waters (Appendix 4.3, pg. 121-130).

Management Options

- **Option 1: Status quo, do not establish inlet corridors during spawning migration**
- Option 2: Establish inlet corridors during spawning migration
 - 2A: Implement for all gear
 - 2B: implement for specific gear

DMF Rationale for Initial Recommendations

- In most cases seasons close before peak spawning migration (Figure 4.3.1, pg. 123)
- Research is ongoing to determine southern flounder inlet use
 - Available data has not identified inlets as a bottleneck where increased harvest occurs
- Movement through inlets is over a short time period
- High energy habitats limit use of gill nets and pound nets
- Inlets are used by giggers and hook-and-line fishermen
- May be best approached through the CHPP as inlet corridors would impact many species

Adaptive Management

Adaptive management (Appendix 4.4, pg. 131-135) is a structured approach to decision making based on the most current data to implement accountability measures. These are Implemented by proclamation. The southern flounder adaptive management include:

- Determine opening dates for commercial seasons
- Close the commercial fishery based on quota monitoring data to maintain harvest levels at or below TAL
- Develop and implement commercial trip limits
- Select recreational season dates for the hook-and-line and gig fisheries.
- Implement and alter bag limits for the recreational fishery.
- Implement and alter vessel limits for the recreational fishery.
- Change the recreational southern flounder season based on harvest of southern flounder that occurs during the ocellated season.
- Cancel the early recreational ocellated season, if necessary, to prevent exceeding the TAL
- Apply accountability measures for both the commercial and recreational fisheries.

Management Options

- **Option 1: Adopt adaptive management framework**
- Option 2: Do not adopt

DMF Rationale for Initial Recommendations

- Provides flexibility for maintaining the TAL
- Lack of flexibility jeopardizes stock rebuilding
- Management based on biological reference points
- Allows for additional protections to the stock and ensures future sustainability

Slot Limits

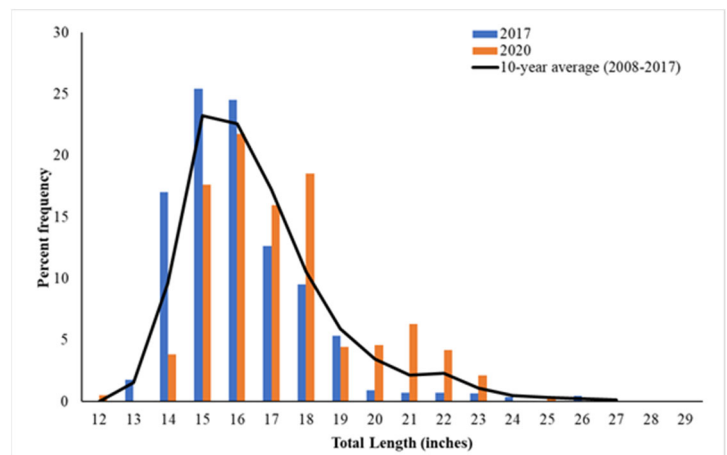
This issue paper analyzes slot limits for the recreational hook-and-line fishery as requested by a MFC commissioner (Appendix 4.6, pg. 145-160). Due to the current size limit, no data is available on fish under 15-inches. Two of the research objectives of the Catch-U-Later app aim to address this data limitation. In 2020, a shift occurred in size of flounder landed. This shift will continue to occur as the stock rebuilds, the age structure expands and seasons continue to limit fishing. A slot limit will increase dead discards of the larger fish. The implementation of a slot limit will not increase the season or bag limit. Conservation equivalency approval by the ASMFC/MAFMC Board will be needed before a slot limit can be implemented.

Management Options

- **Option 1: Status Quo, no slot limit**
- Option 2: Implement slot limit for recreational hook and line
 - 2A. 15 - 16 Inch TL Slot Limit.
 - 2B. 15 - 17 Inch TL Slot Limit.
 - 2C. 15 - 18 Inch TL Slot Limit.
 - 2D. 15 - 19 Inch TL Slot Limit.

DMF Rationale for Initial Recommendations

- Need more information on length and weight of discarded flounder to accurately assess benefit
- Length and age structure are currently truncated, so anticipate a limited benefit to a slot limit
- Consideration of a slot limit would be more appropriate once the age and length structure of the stock expands and more data is available on discarded fish.



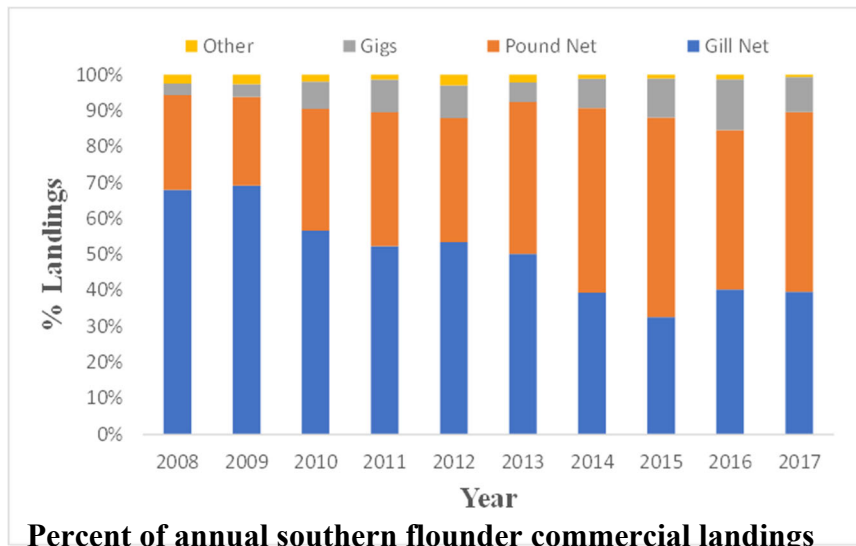
Percent frequency of recreational southern flounder harvest by total length, 2017 and 2020. The 10-year average (2008-2017) indicated by black line.

Phase Out Anchored Large-mesh Gill Nets

At the request of commissioners, this issue paper evaluates phasing out anchored large-mesh gill nets (Appendix 4.7, pg. 161-169). Not allowing harvest from a single gear does not impact the southern flounder stock in a quota-based fishery. Harvest by all gears can be allowed if the total harvest level does not exceed the TAL and dead discards and harvest combined do not exceed the TAC. The possible elimination of specific gears (i.e., anchored large-mesh gill nets) for harvesting southern flounder for either the commercial or recreational fishery is statutorily granted to the MFC by G.S. 143B-289.52. It is unknown how effort would shift within or outside of the southern flounder fishery if large-mesh gill nets are phased out. At this time, the division does not have a recommendation and will consider public and AC input on the issue.

Management Options

- Option 1: Phase out anchored large-mesh gill nets from the southern flounder fishery at the end of the current sea turtle ITP
- Option 2: Status quo, allow large-mesh gill nets to harvest southern flounder during the commercial season



Percent of annual southern flounder commercial landings by gear type, 2008-2017.

Ex-vessel values for gigs, gill nets, pound nets, and other gear from the North Carolina southern flounder fishery, 2008-2017.

Year	Gear				Total
	Gigs	Gill Net	Other	Pound Net	
2008	\$173,360.40	\$3,798,463.23	\$132,612.99	\$1,545,858.19	\$5,650,294.81
2009	\$159,031.29	\$3,160,714.37	\$116,727.33	\$1,173,458.93	\$4,609,931.91
2010	\$267,481.76	\$2,067,067.19	\$66,800.66	\$1,294,539.05	\$3,695,888.65
2011	\$256,846.25	\$1,397,565.13	\$34,239.01	\$1,064,477.33	\$2,753,127.72
2012	\$388,313.40	\$2,343,199.01	\$126,800.50	\$1,593,169.23	\$4,451,482.14
2013	\$320,379.72	\$2,742,686.75	\$114,816.10	\$2,495,307.19	\$5,673,189.76
2014	\$414,205.88	\$1,884,626.34	\$53,262.79	\$2,487,576.97	\$4,839,671.98
2015	\$417,188.88	\$1,235,835.53	\$38,535.39	\$2,132,006.71	\$3,823,566.52
2016	\$506,533.39	\$1,442,921.16	\$42,422.91	\$1,618,655.33	\$3,610,532.80
2017	\$547,308.32	\$2,220,594.81	\$32,975.26	\$2,854,872.71	\$5,655,751.10
Total	\$3,450,649.29	\$22,293,673.52	\$759,192.93	\$18,259,921.64	\$44,763,437.39

State Regulations (Appendix 2)

East coast and Gulf of Mexico southern flounder regulations as of July 2021. **Bold states** included in stock assessment.

State	Size	Daily Bag	Commercial Limits	Seasons
North Carolina	15"	4 fish /person/day	None	Recreational: Aug 16–Sep 30: Commercial: Northern Sep 15–Oct 6, Central Oct 1–19, Southern Oct 1–Nov 2
¹ South Carolina	16"	5 fish/person/day 10 fish/boat/ day	None	Open all year
Georgia	12"	15 fish/person/day	None	Open all year
² Florida	14"	5 fish/person/day	Dec 1–Oct 14: 150 fish; Oct 15–Nov 30: 50 fish;	Oct 15–Nov 30 recreational closed season
Alabama	14"	5 fish/person/day	40 per person or per vessel	Closed Nov 1–30
Mississippi	12"	10 fish/person/day	12"	Open all year
Louisiana	non e	10 fish/person/day	None	Open all year
Texas	14"	5 fish/person/day Nov 1–Dec 14: 2/person/day	None	gig fishery is closed Nov 1–30

¹South Carolina regulations are effective July 1, 2021.

²Florida regulations are effective March 1, 2021.

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Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

North Carolina
Southern Flounder (*Paralichthys lethostigma*)
Fishery Management Plan

Amendment 3

By

North Carolina Division of Marine Fisheries



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ACKNOWLEDGMENTS

Amendment 3 to the North Carolina (NC) Southern Flounder Fishery Management Plan (FMP) was developed by the NC Department of Environmental Quality (NCDEQ), North Carolina Division of Marine Fisheries (NCDMF) under the direction of the NC Marine Fisheries Commission (NCMFC) with the advice of the Southern Flounder Advisory Committee (AC). Deserving special recognition are the members of the Southern Flounder AC and the NCDMF Plan Development Team (PDT) who contributed their time and knowledge to this effort.

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Disclaimer: Data in this Fishery Management Plan may have changed since publication based on updates to source documents.

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TABLE OF CONTENTS

ACKNOWLEDGMENTS	ii
TABLE OF CONTENTS	iv
LIST OF TABLES	ix
LIST OF FIGURES	xiii
GLOSSARY OF TERMS	xvii
LIST OF ACRONYMS	xvii
EXECUTIVE SUMMARY	xix
INTRODUCTION	1
MANAGEMENT AUTHORITY	1
GOAL AND OBJECTIVES.....	2
DESCRIPTION OF THE STOCK	2
BIOLOGICAL PROFILE.....	2
Physical Description.....	2
Distribution.....	3
Habitat	4
Reproduction	5
Age and Growth	6
Predator-Prey Relationships.....	6
STOCK STATUS	6
Stock Unit Definition	6
Assessment Methodology	6
Current Stock Status.....	7
Projections.....	9
ECOSYSTEM AND FISHERY IMPACTS	11
HABITAT DEGRADATION AND LOSS	12
WATER QUALITY DEGRADATION	13
GEAR IMPACTS ON HABITAT.....	13
BYCATCH AND DISCARDS OF NON-TARGET SPECIES	14
Other Finfish Species	14
Protected Species.....	15
CLIMATE CHANGE AND RESILIENCY	15

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

HABITAT AND WATER QUALITY PROTECTION	16
DESCRIPTION OF THE FISHERIES	17
COMMERCIAL FISHERY	17
Commercial Fishery Data Collection.....	19
Annual Landings and Value.....	19
Landings by Gear	20
Characterization of Trips.....	21
Landings by Season and Waterbody	23
Commercial Discards and Bycatch of Southern Flounder	23
Summary of Economic Impact of Commercial Fishing.....	27
RECREATIONAL FISHERY	29
Recreational Fishery Data Collection	29
Hook-and-Line Fishery	30
Gig Fishery.....	33
RCGL Fishery	33
Recreational Discards and Bycatch of Southern Flounder.....	34
Demographic Characteristics	35
Summary of Economic Impact of Recreational Fishing	37
SUMMARY OF FISHERIES CONCLUSION.....	38
PROPOSED MANAGEMENT STRATEGIES UNDER SOUTHERN FLOUNDER	
AMENDMENT 3	40
RESEARCH RECOMMENDATIONS	41
Biological/Stock Assessment/Fishery	41
Ecosystem.....	42
Socio/Economic.....	43
Research Recommendations Summary	43
LITERATURE CITED	44
APPENDICES.....	53
APPENDIX 1. MANAGEMENT ISSUES CONSIDERED BUT NOT DEVELOPED	53
Elimination of Gears Including Gigs (both sectors), Gill Nets, and RCGL.....	53
Limited Entry in the Pound Net Fishery	54
Stocking.....	55
Use of Circle Hooks in the Southern Flounder Fishery	55
Reducing Shrimp Trawl Bycatch.....	56
LITERATURE CITED.....	56

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

APPENDIX 2. REGULATIONS OF OTHER STATES	58
APPENDIX 3. NORTH CAROLINA FISHERY MANAGEMENT	59
APPENDIX 4. ISSUE PAPERS	61
APPENDIX 4.1. ACHIEVING SUSTAINABLE HARVEST IN THE NORTH CAROLINA SOUTHERN FLOUNDER FISHERY	61
I. ISSUE.....	61
II. ORIGINATION	61
III. BACKGROUND.....	61
IV. AUTHORITY.....	67
V. DISCUSSION	67
VI. PROPOSED MANAGEMENT OPTIONS	98
VII. RECOMMENDATIONS.....	102
VIII. LITERATURE CITED.....	103
APPENDIX 4.2. INCREASED RECREATIONAL ACCESS BY MANAGING SOUTHERN FLOUNDER SEPARATELY FROM OTHER FLOUNDER SPECIES	113
I. ISSUE.....	113
II. ORIGINATION	113
III. BACKGROUND.....	113
IV. AUTHORITY.....	115
V. DISCUSSION	115
VI. PROPOSED MANAGEMENT OPTIONS	119
VII. RECOMMENDATION.....	119
VIII. LITERATURE CITED	120
APPENDIX 4.3. INLET CORRIDORS AS A MANAGEMENT TOOL TO INCREASE SOUTHERN FLOUNDER ESCAPEMENT	121
I. ISSUE.....	121
II. ORIGINATION	121
III. BACKGROUND.....	121
IV. AUTHORITY.....	121
V. DISCUSSION	122
VI. PROPOSED MANAGEMENT OPTIONS	129
VII. RECOMMENDATION.....	129
VIII. LITERATURE CITED.....	129
APPENDIX 4.4. ADAPTIVE MANAGEMENT STRATEGY FOR THE NORTH CAROLINA SOUTHERN FLOUNDER FISHERY	131

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

I. ISSUE.....	131
II. ORIGINATION	131
III. BACKGROUND	131
IV. AUTHORITY	132
V. DISCUSSION	132
VI. PROPOSED MANAGEMENT OPTIONS	135
VII. RECOMMENDATION.....	135
VIII. LITERATURE CITED.....	135
APPENDIX 4.5. RECREATIONAL AND COMMERCIAL SECTOR ALLOCATION IN THE NORTH CAROLINA SOUTHERN FLOUNDER FISHERY	136
I. ISSUE.....	136
II. ORIGINATION	136
III. BACKGROUND	136
IV. AUTHORITY	137
V. DISCUSSION	137
VI. PROPOSED MANAGEMENT OPTIONS	143
VII. NCMFC SELECTED MANAGEMENT STRATEGY	144
VIII. LITERATURE CITED.....	144
APPENDIX 4.6. IMPLEMENTING A SLOT LIMIT IN THE SOUTHERN FLOUNDER FISHERY.....	145
I. ISSUE.....	145
II. ORIGINATION	145
III. BACKGROUND	145
IV. AUTHORITY	148
V. DISCUSSION	149
VI. PROPOSED MANAGEMENT OPTIONS	157
VII. RECOMMENDATIONS.....	158
VIII. LITERATURE CITED.....	158
APPENDIX 4.7. PHASING OUT ANCHORED LARGE-MESH GILL NETS IN THE NORTH CAROLINA SOUTHERN FLOUNDER FISHERY.....	161
I. ISSUE.....	161
II. ORIGINATION	161
III. BACKGROUND	161
IV. AUTHORITY	163
V. DISCUSSION	163

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

.....	165
VI. PROPOSED MANAGEMENT OPTIONS	168
VII. NCMFC SELECTED MANAGEMENT STRATEGY	168
VIII. LITERATURE CITED.....	169
APPENDIX 5. SUGGESTED STATUTORY CHANGES	169

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

LIST OF TABLES

Table 1.	Water quality parameter ranges and habitats associated with different life stages of southern flounder.	13
Table 2.	North Carolina commercial southern flounder landings in pounds and value, 2008–2017. (Source: North Carolina Trip Ticket Program).....	20
Table 3.	Number of commercial pound net permits by year of expiration and estuarine gill net permits by license year (July 1 to June 30). (Source: Fisheries Information Network).	21
Table 4.	Annual commercial southern flounder landings in pounds by gear type, 2008–2017. Numbers in parentheses are the percent of the total landings for each gear in a given year. (Source: North Carolina Trip Ticket Program).....	22
Table 5.	Annual trips, average landings per trip (APT), and number of participants (#PAR) by gear type in the commercial southern flounder fishery, 2008–2017. (Source: North Carolina Trip Ticket Program).....	22
Table 6.	Commercial southern flounder landings (millions of pounds) and average dockside price per pound by area, 2008–2017. Numbers in parentheses are the percent of the total landings for each area for a given year. (Source: North Carolina Trip Ticket Program)	24
Table 7.	Pounds of southern flounder landed as bycatch in commercial non-major (“Other”) gears, 2008–2017.	26
Table 8.	Economic impacts associated with commercial southern flounder fishery in North Carolina, 2008–2017. Data below represent the actual effort data from southern flounder harvest, along with the estimated economic impacts to North Carolina using IMPLAN statistical software. Data from the 2016 NOAA Fisheries Economics of the U.S. report, along with internal division survey data, are also used to generate estimates. Note: impact estimates across categories are not additive.	28
Table 9.	Contribution of North Carolina counties and other states to recreational flounder fisheries according to three sources of data: Access Point Angler Intercept Survey (APAIS), Recreational Commercial Gear License Survey (RCGL), and Gig Mail Survey.	36
Table 10.	Economic impacts associated with recreational southern flounder fishing in North Carolina from 2008–2017. Impacts are generated using IMPLAN statistical software and division recreational survey data. Trips are defined as a fishing trip for which any flounder is the primary or secondary target, or if southern flounder was caught during that trip. All job impacts represent both part- and full-time jobs. Note: impact estimates across categories are not additive.....	38
Table 2.1.	East coast and Gulf of Mexico southern flounder regulations by state as of July 2021.	58
Table 4.1.1.	Southern flounder total allowable catch (TAC) and total allowable landings (TAL) in pounds needed to meet the necessary reductions for the overfishing threshold and SSB threshold and target of the commercial and recreational fisheries, following the NCMFC selection of a 70/30 allocation.....	66

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

Table 4.1.2.	Allocations for commercial and recreational fisheries and associated sub-allocations for each sector for the North Carolina Southern Flounder Fishery that maintains overall reductions of 72%.....	71
Table 4.1.3.	Allocations for the North Carolina Southern Flounder commercial and recreational fisheries and associated sub-allocations for each sector for the North Carolina Southern Flounder Fishery that maintains overall reductions of 72% and historical sub-allocations.	73
Table 4.1.4.	Allocations for the North Carolina Southern Flounder commercial and recreational fisheries and associated sub-allocations for each sector that maintains overall reductions of 72% but maintains the current level of sub-allocation for the pound net fishery.....	73
Table 4.1.5.	Allocations for the North Carolina Southern Flounder commercial and recreational fisheries and associated sub-allocations for each sector that maintains overall reductions of 72% but redistributes the gill net allocation equally between mobile and pound net gears.	74
Table 4.1.6.	Allocation for the North Carolina Southern Flounder commercial fishery and associated sub-allocations for each sector that maintains overall reductions of 72% and historical sub-allocations.	77
Table 4.1.7.	Allocation for the North Carolina Southern Flounder commercial fishery and associated sub-allocations for each sector that maintains overall reductions of 72% but maintains the current level of sub-allocation for the pound net fishery. 78	
Table 4.1.8.	Allocation for the North Carolina Southern Flounder commercial fishery and associated sub-allocations for each sector that maintains overall reductions of 72% but redistributes the gill net allocation equally between mobile and pound net gears beginning in 2023 (shown in the 60% and 50% allocations).	79
Table 4.1.9.	Southern flounder recreational fishery total allowable landings allocations in pounds by gear and total recreational allocation percentage.	86
Table 4.1.10.	Seasons identified to reach the TAL (142,206 pounds in 2021 and 2022, 189,608 pounds in 2023, and 237,010 pounds in 2024) of the NC recreational hook-and-line fishery quota in pounds at the current four fish bag limit based on average landings from 2008–2017. Seasons may vary as the TAL increases until 50% parity is reached and will be determined through Adaptive Management. (2020 landings for the recreational hook and line fishery for the Aug 16 – Sep. 30 season with a four-fish bag limit was 362,119 pounds).	86
Table 4.1.11.	Seasons identified to reach the initial TAL (17,500 lb in 2021 and 2022, 23,333 lb in 2023, and 29,166 lb in 2024) of the N.C. recreational gig fishery landings (observed harvest) at the current four-fish bag limit based on average landings from 2010–2017. Seasons may vary as the TAL increases until 50% parity is reached and will be determined through Adaptive Management. (2020 landings for the recreational gig fishery for the Aug 16 – Sep. 30 season with a four-fish bag limit was 26,475 pounds).	87
Table 4.1.12.	Commercial southern flounder pound net trip limit scenarios (in pounds), including the number and cumulative of % trips, and % harvest within each trip	

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

	limit bounds, September through November, 2008–2017. Note: Rounding of values may cause cumulative percentages to differ slightly.....	91
Table 4.1.13.	Commercial southern flounder gig fishery trip limit scenarios (in number of fish), including the number and cumulative % of trips, and % of harvest within each trip scenario, 2008–2017. Note: Rounding of values may cause cumulative percentages to differ slightly.....	92
Table 4.1.14.	Percent contribution of bag limit trips to total harvest of southern flounder for select seasons.	93
Table 4.1.15.	Summary of quantifiable management measures for Amendment 3.....	96
Table 4.1.16.	Summary of non-quantifiable management measures for Amendment 3.	97
Table 4.1.A1.	Season and total harvest for an 18-inch TL minimum size limit based on 2017 data.....	107
Table 4.1.A2.	Southern flounder harvest projections from seasons using day-type specific combinations.	110
Table 4.1.A3.	Average, minimum, and maximum number of anglers present on a vessel in the Private/Rental Boat mode for the recreational southern flounder fishery from 2008–2017.....	112
Table 4.2.1.	Estimated ocean ocellated flounder landings and anticipated southern flounder landings under various options for the hook-and-line fishery.	117
Table 4.5.1.	Allocation options for the North Carolina southern flounder fishery that maintain overall landings reduction of 72%.	137
Table 4.5.2.	Sub-allocations for the commercial and recreational sectors for the NCMFC options based on the 2017 harvest.	138
Table 4.5.3.	Recreational hook-and-line landings of southern flounder Aug. 16–Sept. 30 at the four-fish bag limit for current season and years compared to the status quo allocation (73/27 does not include discards). Highlighted cells indicate overages in TAL the previous year resulting in closures the following year.....	139
Table 4.5.4.	Example of predicted harvest of southern flounder for a recreational hook-and-line season and compared to a 73/27 allocation and then applied to subsequent years to show future harvest during an Aug. 16–Sept. 30 season. Highlighted cells indicate bag limits that exceed the TAL for the indicated year: the darker the shade the higher the overage.....	141
Table 4.5.5.	Example of predicted harvest of southern flounder for a recreational hook-and-line season and compared a 60/40 allocation and then applied to subsequent years to show future harvest during an Aug. 16–Sept. 30 season. Highlighted cells indicate bag limits that exceed the TAL for the indicated year.	142
Table 4.5.6.	Ex-vessel value of the commercial southern flounder fishery by year and gear.	143
Table 4.6.1.	Pounds of southern flounder harvest (no discards) at a four-fish and one-fish bag limit, 2013. This year represents a year of high harvest and what could happen as the stock rebuilds. For reference, the NCMFC allocations are 142,206 lb (30% recreational allocation), 189,608 lb (40%), and 237,010 lb (50%).....	150

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

Table 4.6.2. Pounds of southern flounder harvested by the recreational hook-and-line fishery during the 2020 season, by slot limit option. The no slot example shows the harvest under the current 15-inch TL minimum size limit. The TAL in 2020 was 126,315 pounds. 151

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

LIST OF FIGURES

Figure 1.	Metamorphosis stages of the summer flounder <i>Paralichthys dentatus</i> . (A) Hatched yolk-sac larva. (B) Pre-transformation larva before eye migration commences. (C) Early metamorphosis and the beginning of eye migration. (D) Mid-metamorphosis. (E) Metamorphic climax, right eye has migrated over the dorsal midline. (F) Young juvenile. Left column in B–D shows the migration of the eye across the skull; migrating right eye is shaded in gray. Rightmost column shows whole-body morphological changes at each stage. Image originally printed in Martinez and Bolker 2003.	3
Figure 2.	Artist interpretation of the southern flounder life cycle. Image originally printed in Hollensead 2018.	5
Figure 3.	Predicted female spawning stock biomass (SSB) from the base run of the ASAP model, 1989–2017. Dotted lines represent ± 2 standard deviations (SD) of the predicted values. (Source: Flowers et al. 2019)	8
Figure 4.	Predicted number of recruits (thousands of fish) from the base run of the ASAP model, 1989–2017. Dotted lines represent ± 2 standard deviations (SD) of the predicted values. (Source: Flowers et al. 2019)	8
Figure 5.	Predicted fishing mortality (F) rates (numbers-weighted, ages 2–4) from the base run of the ASAP model, 1989–2017. Dotted lines represent ± 2 standard deviations (SD) of the predicted values. (Source: Flowers et al. 2019)	9
Figure 6.	Projections of spawning stock biomass (SSB) related to fishing at a level to end overfishing in the required two-year period. Note: SSB does not rebuild within required ten-year time period. (Source: Flowers et al. 2019).....	10
Figure 7.	Predicted future spawning stock biomass (metric tons) assuming the fishing mortality value necessary to end the overfished status by 2028 (indicated by vertical red line). (Source: Flowers et al. 2019).....	10
Figure 8.	Predicted future spawning stock biomass (metric tons) assuming the fishing mortality value necessary to reach the SSB_{Target} by 2028 (indicated by vertical red line). (Source: Flowers et al. 2019)	11
Figure 9.	Effects of threats and alterations on water quality and coastal habitats and their ultimate impact on the growth and survival of southern flounder.	12
Figure 10.	Average contribution to U.S. South Atlantic coast southern flounder commercial landings by state, 1978–2017. (Source: NOAA Fisheries Annual Commercial Landing Statistics and North Carolina Trip Ticket Program)	18
Figure 11.	North Carolina annual southern flounder commercial landings and ex-vessel value, 1950–2017. (Source: North Carolina Trip Ticket Program)	19
Figure 12.	Estimated number of dead discards associated with the North Carolina commercial estuarine gill net fishery, 1989-2017.....	25
Figure 13.	Pounds of southern flounder harvested as bycatch from commercial crab and peeler pots, crab and shrimp trawls, channel nets, fyke nets, and haul seines, 2008–2017. (Source: North Carolina Trip Ticket Program)	27

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

Figure 14.	Distribution of flounder species harvested recreationally in North Carolina, 1989–2017. (Source: Marine Recreational Information Program)	31
Figure 15.	Hook-and-line recreational harvest of southern flounder (in pounds) estimated by MRIP for North Carolina through the east coast of Florida, 1981–2017. (Source: Marine Recreational Information Program)	32
Figure 16.	Recreational hook-and-line trips targeting five top species in North Carolina 1981–2017. (Source: Marine Recreational Information Program)	32
Figure 17.	Seasonality of southern flounder recreational harvest in North Carolina, 1981–2017. (Source: Marine Recreational Information Program)	33
Figure 18.	The number of Recreational Commercial Gear Licenses (RCGL) issued 2000–2017. (Source: NCDMF License and Statistics Annual Report).....	34
Figure 19.	Ratio of the number of southern flounder released compared to harvested in the recreational hook-and-line fishery as estimated through MRIP for North Carolina through the east coast of Florida, 1981–2017. (Source: Marine Recreational Information Program).....	35
Figure 20.	Number of southern flounder harvested in the recreational fishery by MRIP mode, 1989–2017. (Source: Marine Recreational Information Program)	36
Figure 21.	Commercial and recreational harvest (measured in pounds) and effort (measured in trips) from the N.C. Southern Flounder Fishery, 1994–2017. Recreational landings and trips do not include recreational commercial gear or the gig fishery due to data limitations. (Source: North Carolina Trip Ticket Program and Marine Recreational Information Program).....	39
Figure 4.1.1.	Predicted future spawning stock biomass (metric tons) assuming the fishing mortality value ($F=0.26$; 62% reduction in total removals) necessary to reach between the SSB_{Target} and $SSB_{Threshold}$ by 2028 (indicated by vertical red line). (Source: Flowers et al. 2019)	63
Figure 4.1.2.	Contribution of the total removals (observed harvest and dead discards in percent pounds) for the commercial and recreational (hook-and-line and gig) fisheries in North Carolina, 2017. (Source: North Carolina Trip Ticket Program, Marine Recreational Information Program, NCDMF Gig Mail Survey)	64
Figure 4.1.3.	Estimated escapement of southern flounder (pounds) and contribution of the total removals for the commercial and recreational (hook-and-line and gig) fisheries in North Carolina, 2017, at a 52% reduction and a 70% commercial and 30% recreational allocation. (Source: North Carolina Trip Ticket Program, Marine Recreational Information Program, NCDMF Gig Mail Survey)	65
Figure 4.1.4.	Estimated escapement of southern flounder (pounds) and contribution of the total removals for the commercial and recreational (hook-and-line and gig) fisheries in North Carolina, 2017, at a 72% reduction and a 70% commercial and 30% recreational allocation. (Source: North Carolina Trip Ticket Program, Marine Recreational Information Program, NCDMF Gig Mail Survey)	65
Figure 4.1.5.	Boundary descriptions for two (left) and three (right) areas to consider for mobile gears. The three area boundaries are identical as seen for pound nets.	75

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

Figure 4.1.6. Boundary descriptions for two (left) and three (right) areas to consider for the pound net fishery. The three area boundaries are the same as mobile gears.....	76
Figure 4.1.7. Average commercial southern flounder landings (pounds) by month in North Carolina, 2008-2017. (Source: North Carolina Trip Ticket Program).....	81
Figure 4.1.8. Average weekly harvest (in percent, 2008–2017) through the year from mobile gears statewide (A) and for two (B) and three (C) areas management scenarios as identified in Figure 4.1.5.	82
Figure 4.1.9. Average weekly harvest (in percent, 2008–2017) from the commercial pound net fishery statewide (A) and for two (B) and three (C) areas management scenarios as identified in Figure 4.1.6.	83
Figure 4.1.10. North Carolina southern flounder recreational fishing season relating to the increasing TAL (142,206 pounds in 2021 and 2022, 189,608 pounds in 2023, and 237,010 in 2024) and changes to the daily bag limit.	92
Figure 4.1.11. North Carolina southern flounder recreational fishing season relating to the increasing TAL (142,206 pounds in 2021 and 2022, 189,608 pounds in 2023, and 237,010 in 2024). The 2020 season was Aug. 16 through Sept. 30.....	93
Figure 4.1.12. North Carolina southern flounder recreational fishing season relating to the increasing TAL (142,206 pounds in 2021 and 2022, 189,608 pounds in 2023, and 237,010 in 2024) anticipating angler success increasing to two fish per trip in the future.	94
Figure 4.1.A1. Total hook-and-line harvest for seasonal options based on data for 18-inch minimum size limit from 2008–2017. Years 2010, 2011, and 2013 represent years of above average harvest. TAL of 142,206 pounds is represented by the blue solid line.	107
Figure 4.1.A2. Southern flounder harvest projections from seasons using day-type specific combinations. (Note: WD = Weekdays and WE = Weekends).	109
Figure 4.1.A3. Annual variability in harvest of southern flounder (pounds) during identified day type combinations, 2013–2017. (Note: WD = Weekdays and WE = Weekends)...	111
Figure 4.2.1. Pounds of harvest by flounder species from the ocean and estuarine waters, 1981–2019.....	114
Figure 4.2.2. Southern flounder landings (in pounds) for seasons in reference to total allowable landings (TAL). All scenarios are based on a one-fish bag limit.	118
Figure 4.3.1. Estimates of instantaneous Emigration (E) for the New River estuary produced by a telemetry model. Annual E assumed to be equal across years. (Source: Scheffel et al. 2020)	123
Figure 4.3.2. The number of days from the initiation of migratory behavior until southern flounder emigrated out of the New River estuary. The cumulative frequency distribution (solid black line) indicated that 50% of emigrants left the system within five days after initiation of migration behavior (bottom dashed red line), while 75% of emigrants exited within about 10 days of first showing emigration behavior (top dashed red line). (Source: Scharf et al. 2015)	124

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

Figure 4.3.3.	Tagging locations and number of southern flounder tagged (in circles by waterbody) in North Carolina estuarine waters from 2014 through 2019.	125
Figure 4.3.4.	Recapture locations of southern flounder tagged in North Carolina estuarine waters from 2014 to 2019.	126
Figure 4.6.1.	Sex ratios of southern flounder relative to total length.	146
Figure 4.6.2.	Percent frequency (by pound per inch) of commercial southern flounder harvest by total length, 2017 and 2020. The 10-year average (2008-2017) is also included for reference. (Source: North Carolina Trip Ticket Program and NCDMF fish house sampling biological data).	147
Figure 4.6.3.	Percent frequency (by pound per inch) of recreational southern flounder harvest by length, 2017 and 2020. The 10-year average (2008-2017) is also included for reference. (Source: Marine Recreational Information Program)	148
Figure 4.6.4.	Total hook-and-line harvest during Aug. 16–Sept.30 at a four-fish and one-fish bag limit and a 15–16-inch slot based on data from 2008 to 2017 and 2020. The years 2010, 2011, and 2013 represent years of above average harvest; 2020 represents the first full year under seasonal management through Amendment 2. NCMFC allocations are presented for reference.	152
Figure 4.6.5.	Total hook-and-line harvest during Aug. 16–Sept.30 at a four-fish and one-fish bag limit and a 15–17-inch TL slot based on data from 2008 to 2017 and 2020. The years 2010, 2011, and 2013 represent years of above average harvest; 2020 represents the first full year under seasonal management through Amendment 2. NCMFC allocations are presented for reference.	153
Figure 4.6.6.	Total hook-and-line harvest during Aug. 16–Sept.30 at a four-fish and one-fish bag limit and a 15–18-inch TL slot based on data from 2008 to 2017 and 2020. The years 2010, 2011, and 2013 represent years of above average harvest; 2020 represents the first full year under seasonal management through Amendment 2. NCMFC allocations are presented for reference.	153
Figure 4.6.7.	Total hook-and-line harvest during Aug. 16–Sept.30 at a four-fish and one-fish bag limit and a 15–19-inch TL slot based on data from 2008 to 2017 and 2020. The years 2010, 2011, and 2013 represent years of above average harvest; 2020 represents the first full year under seasonal management through Amendment 2. NCMFC allocations are presented for reference.	154
Figure 4.7.1.	Percent of annual southern flounder commercial landings by gear type, 2008-2017.	162
Figure 4.7.2.	Number of flounder <i>species</i> harvested by RCGL gear type, 2002-2008.	163
Figure 4.7.3.	Total gill net trips compared to gill net trips targeting or landing southern flounder.	165
Figure 4.7.4.	Top species harvested from anchored large-mesh gill nets where southern flounder are the most abundant species, 2013-2017.	166

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

GLOSSARY OF TERMS

Several links to resources with a glossary of fishery terms are available below.

NCDMF: [Defining Fisheries: A User's Glossary](#)
ASMFC: [Acronyms and Glossary of Commonly Used Terms](#)
NOAA: [Fisheries Glossary](#)
FAO: [Term Portal](#)

LIST OF ACRONYMS

ACCSP—Atlantic Coast Cooperative Statistics Program
APAIS—Access Point Angler Intercept Survey
APT—Average Landings Per Trip
ASAP—Age Structured Assessment Program
ASMFC—Atlantic State Marine Fisheries Commission
CAP—Coastal Angling Program
CHPP—Coastal Habitat Protection Plan
CRFL—Coastal Recreational Fishing License
EEZ—Exclusive Economic Zone
ESA—Endangered Species Act
F—Fishing Mortality
FAO—Food and Agriculture Organization of the United Nations
FES—Fishing Effort Survey
FEUS—Fishery Economics of the U.S.
FMP—Fishery Management Plan
G.S. —General Statute
IMPLAN—Impact Analysis for Planning
ISM—Inch Stretched Mesh
ITP—Incidental Take Permits
MAFMC—Mid-Atlantic Fishery Management Council
MRIP—Marine Recreational Information Program
NCAC—North Carolina Administrative Code
NCDEQ—North Carolina Department of Environmental Quality
NCDMF—North Carolina Division of Marine Fisheries
NCDWR—North Carolina Division of Water Resources
NCMFC—North Carolina Marine Fisheries Commission
NCTTP—North Carolina Trip Ticket Program
NMFS—National Marine Fisheries Service
NOAA—National Oceanic and Atmospheric Administration
PSE—Proportional Standard Error
RSCFL—Retired Standard Commercial Fishing License
RCGL—Recreational Commercial Gear License
SAV—Submerged Aquatic Vegetation

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

SCFL—Standard Commercial Fishing License

SSB—Spawning Stock Biomass

TAC—Total Allowable Catch

TAL—Total Allowable Landings

TL—Total Length

#PAR—Number of Participants

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

EXECUTIVE SUMMARY

North Carolina's southern flounder resource has been harvested since at least the 1800s, with the first recorded landings in 1889. Southern flounder supports one of the largest and most valuable commercial fisheries in North Carolina and accounts for approximately 99% of the Atlantic coast commercial southern flounder landings. Recreationally, southern flounder in North Carolina have been the most targeted species for 20 of the last 30 years. The North Carolina recreational southern flounder fishery ranks second on the east coast for harvest and has more releases than any other state.

The 2019 coast-wide stock assessment determined the southern flounder stock is overfished and overfishing is occurring. North Carolina law requires management action to be taken to end overfishing within two years and to recover the stock from an overfished condition within 10 years with a 50% probability of success from the date of adoption of the plan. This 10-year rebuild requires a minimum reduction of 52% in total removals for both the commercial and recreational fisheries based on 2017 landings and dead discards. Amendment 3 further refines and builds on action taken in Amendment 2.

The goal of Amendment 3 is to manage the southern flounder fishery to achieve a self-sustaining population that provides sustainable harvest using science-based decision-making processes. The following objectives will be used to achieve this goal: 1.) implement management strategies within North Carolina and encourage interjurisdictional management strategies that maintain/restore the southern flounder spawning stock with expansion of age structure of the stock and adequate abundance to prevent overfishing; 2.) restore, enhance, and protect habitat and environmental quality necessary to maintain or increase growth, survival, and reproduction of the southern flounder population; 3.) use biological, environmental, habitat, fishery, social, and economic data needed to effectively monitor and manage the southern flounder fishery and its ecosystem impacts; 4.) promote stewardship of the resource through increased public outreach and interjurisdictional cooperation throughout the species range regarding the status and management of the southern flounder fishery, including practices that minimize bycatch and discard mortality; and 5.) promote the restoration, enhancement, and protection of habitat and environmental quality in a manner consistent with the Coastal Habitat Protection Plan (CHPP).

To meet statutory requirements to achieve a self-sustaining population, sustainable harvest is addressed in the FMP. Other issues addressed in the plan include investigating increased recreational access by managing southern flounder separately from other flounder species, evaluating inlet corridors, developing a framework for adaptive management, identifying sector allocations in the southern flounder fishery, implementing a slot limit in the southern flounder fishery, and phasing out anchored large-mesh gill nets from the North Carolina southern flounder fishery. Specific recommendations for each issue are as follows:

- 1) Sustainable Harvest
- 2) Increased Recreational Access by Managing Southern Flounder Separately from other Flounder Species
- 3) Inlet Corridors
- 4) Adaptive Management
- 5) Sector Allocations in the Southern Flounder Fishery

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

- 6) Implementing a Slot Limit in the Southern Flounder Fishery
- 7) Phasing Out Large-Mesh Gill Nets in the North Carolina Southern Flounder Fishery

Note: the executive summary will be completed after the NCMFC selects its preferred management options.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

INTRODUCTION

This is Amendment 3 to the N.C. Southern Flounder FMP. The last review of the plan (Amendment 2) was approved by the NCMFC in August 2019 and implemented a reduction in fishing mortality in the commercial and recreational fisheries to a level that ends overfishing within two years and allows the spawning stock biomass (SSB) to increase between the threshold and the target within 10 years. This was accomplished via targeted reductions of 62% in total removals in 2019 and 72% beginning in 2020. While the minimum statutory requirement to meet the rebuilding threshold was a 52% reduction, management actions approved through Amendment 2 exceeded the minimum in order to increase the probability of successfully rebuilding this important recreational and commercial resource. Amendment 2 followed a peer review workshop evaluating the 2018 coast-wide stock assessment for southern flounder. At the end of the peer review workshop, the Southern Flounder Review Panel accepted the pooled-sex run of the Age Structured Assessment Program (ASAP) model presented at the review workshop as a valid basis of management for at least the next five years, with the expectation that the model will be updated with data through 2017 to provide the best, most up to date estimate of stock status for management. Results of the 2019 update indicate the stock is overfished and overfishing is occurring (Flowers et al. 2019). Analyses were conducted to estimate projections of reductions to fishing mortality that is necessary to end overfishing and to determine which reductions would be necessary to rebuild the spawning stock biomass and end the overfished status.

Amendment 2 was expedited to begin rebuilding the stock immediately. Due to the shortened time frame for development, Amendment 2 incorporated a seasonal approach to meet reductions while deferring more complex and comprehensive management strategies to be developed in Amendment 3. In Amendment 3, the management strategy is updated to include a quota-based fishery for both the commercial and recreational sectors. The quota will be implemented through an adaptive management framework and remain in place until an update of Amendment 3 is completed.

To see further details on past FMP amendments, supplements, or revisions, go to the latest annual FMP update (<https://deq.nc.gov/about/divisions/marine-fisheries/public-information-and-education/managing-fisheries/fmp>).

MANAGEMENT AUTHORITY

All management authority for the North Carolina southern flounder fishery is vested in the State of North Carolina. The NCMFC adopts rules and policies and implements management measures for the southern flounder fishery. While sole management authority of southern flounder rests with the state, in North Carolina recreational flounder management is by an aggregate of three species [southern, summer (*P. dentatus*), and Gulf (*P. albigutta*) flounders]. Therefore, the state's management of southern flounder is also impacted in the ocean by the joint Atlantic States Marine Fisheries Commission (ASMFC)/Mid-Atlantic Fishery Management Council (MAFMC) Summer Flounder, Black Sea Bass, and Scup FMP. This impacts southern flounder management in ocean waters off North Carolina with ASMFC impacting the state waters and

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

MAFMC impacting the federal Economic Exclusion Zone (EEZ) waters. Approval of changes by ASMFC may not be required if the changes are expected to be more restrictive than the management measures already approved by ASMFC. Changes to the summer flounder fishery in EEZ waters off North Carolina may be impacted by the MAFMC and National Marine Fisheries Service (NMFS) until conservation equivalencies are approved by NMFS.

See <http://portal.ncdenr.org/web/mf/nc-fisheries-management> for further information on fishery management in North Carolina.

GOAL AND OBJECTIVES

Goal: Manage the southern flounder fishery to achieve a self-sustaining population that provides sustainable harvest using science-based decision-making processes. The following objectives will be used to achieve this goal:

Objectives:

1. Implement management strategies within North Carolina and encourage interjurisdictional management strategies that maintain/restore the southern flounder spawning stock with expansion of age structure of the stock and adequate abundance to prevent overfishing.
2. Restore, enhance, and protect habitat and environmental quality necessary to maintain or increase growth, survival, and reproduction of the southern flounder population.
3. Use biological, environmental, habitat, fishery, social, and economic data needed to effectively monitor and manage the southern flounder fishery and its ecosystem impacts.
4. Promote stewardship of the resource through increased public outreach and interjurisdictional cooperation throughout the species range regarding the status and management of the southern flounder fishery, including practices that minimize bycatch and discard mortality.
5. Promote the restoration, enhancement, and protection of habitat and environmental quality in a manner consistent with the Coastal Habitat Protection Plan.

DESCRIPTION OF THE STOCK

BIOLOGICAL PROFILE

Physical Description

Southern flounder exhibit a unique body type compared to most other fish species, belonging to a subgroup known as flatfishes. While most fish species are bilaterally symmetrical and have body parts equally distributed on each side of their body, flatfish species, including southern flounder, possess both eyes on one side of the body and are considered to lack symmetry. Newly hatched southern flounder larvae have bilateral symmetry but after currents carry them into the estuaries

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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they, like other left-eyed flounder (e.g., summer flounder), undergo metamorphosis (Figure 1; Francis and Turingan 2008; Schreiber 2013).

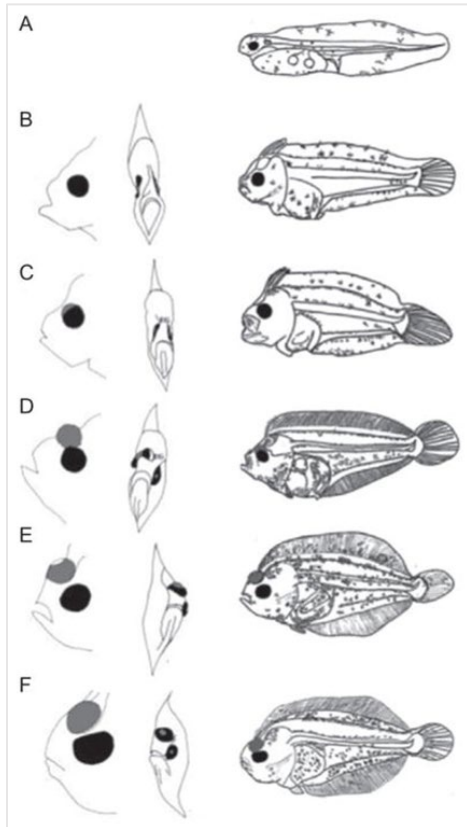


Figure 1. Metamorphosis stages of the summer flounder *Paralichthys dentatus*. (A) Hatched yolk-sac larva. (B) Pre-transformation larva before eye migration commences. (C) Early metamorphosis and the beginning of eye migration. (D) Mid-metamorphosis. (E) Metamorphic climax, right eye has migrated over the dorsal midline. (F) Young juvenile. Left column in B–D shows the migration of the eye across the skull; migrating right eye is shaded in gray. Rightmost column shows whole-body morphological changes at each stage. Image originally printed in Martinez and Bolker 2003.

Due to this metamorphosis, southern flounder are known to be “left handed” because the right eye shifts and the eye-side of the flounder is the left side (Daniels 2000). Southern flounder also exhibit a unique pattern of pigmentation where the “top” side of the fish is dark, contrasting with the white coloration typical of the “bottom” side. Southern flounder tend to be bottom dwellers and can use the dark pigmentation on the “top” side to blend into the surrounding habitat to hide from predators and ambush prey (Arrivillaga and Baltz 1999).

Distribution

Southern flounder are widely distributed along the United States (Blandon et al. 2001). In the Atlantic Ocean, southern flounder reside in coastal habitats from North Carolina to Cape Canaveral, Florida. A small number of southern flounder have been observed north of North

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

Carolina. In the Gulf of Mexico, southern flounder can be found from northern Mexico to Tampa, Florida. Genetic studies have indicated there is little to no movement of southern flounder between the Gulf of Mexico and Atlantic Ocean as the peninsula of Florida acts as an ecological barrier (Blandon et al. 2001; Anderson and Karel 2012; Midway et al. 2014).

Tagging studies show that individual southern flounder are capable of undergoing movements from North Carolina to the east coast of Florida (Craig et al. 2015; Loeffler et al. 2019). Additionally, genetic studies indicate that individuals from North Carolina to Florida are capable of spawning together and that the Atlantic Ocean population is well mixed (Wang et al. 2015). While each Atlantic state manages southern flounder in their own waters, based on this life history information, a multi-state cooperative group stock assessment was used to determine the status of the unit stock (see the *Stock Status* section below).

Habitat

More information is known about habitat use for southern flounder in estuarine habitats than the ocean. As southern flounder mature around age-2, they migrate out of the estuaries and spawn in the ocean but this migration to ocean spawning grounds is not well understood (Figure 2). No surveys or large-scale fisheries exist for these fish in the ocean and therefore, it is difficult to directly observe where adult southern flounder go after they leave the estuary and what drives their habitat selection once offshore. The location and/or the number of offshore spawning ground(s) is currently unknown (Midway and Scharf 2012), though research is currently underway to determine these locations and migratory pathways. Most of the direct examination of southern flounder habitat use has occurred within estuarine environments where juveniles are easily accessible for scientific study (Burke et al. 1991; Fitzhugh et al. 1996; Froeschke et al. 2013).

Larval southern flounder are transported into sounds and estuaries during late winter and early spring by wind-driven currents (Figure 2; Taylor et al. 2010) and survival is greatly influenced by a number of variables. Once within the estuary, southern flounder typically settle in low salinity areas (Burke et al. 1991; Miller et al. 1991; Lowe et al. 2011). Despite the tolerance of young juvenile southern flounder to various salinities, low dissolved oxygen values have been shown to inhibit growth of newly settled southern flounder (Taylor and Miller 2001; Del Toro-Silva et al. 2008). As southern flounder age they can tolerate prolonged periods of low dissolved oxygen, and are thought to remain in low oxygen areas as a trade-off to expending energy by moving into other areas where environmental conditions may not necessarily improve (Ellis 2007).

In addition to water quality influences, bottom structure and water depth are important drivers of juvenile southern flounder habitat selection. The presence of sea grass and/or marsh edge has been shown to have a positive effect on southern flounder abundance (Nañez-James et al. 2009; Furey and Rooker 2013) and these structures have been known to serve as refuge for estuarine juvenile fishes (Rooker et al. 1998; Stunz et al. 2002). Several studies have indicated that water depths of less than three feet are significantly related to southern flounder abundance (Walsh et al. 1999; Furey et al. 2013; Froeschke et al. 2013). Potentially, the use of shallow near-shore areas by southern flounder during their juvenile period increases survivorship by protecting

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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individuals from predators (Manderson et al. 2004). However, southern flounder overwintering in the estuary may select deeper waters or move to higher salinity areas near ocean inlets where environmental conditions are more stable during winter months (Hollensead 2018). For additional information on how habitat and water quality affect southern flounder see the *Ecosystem and Fishery Impacts* section.

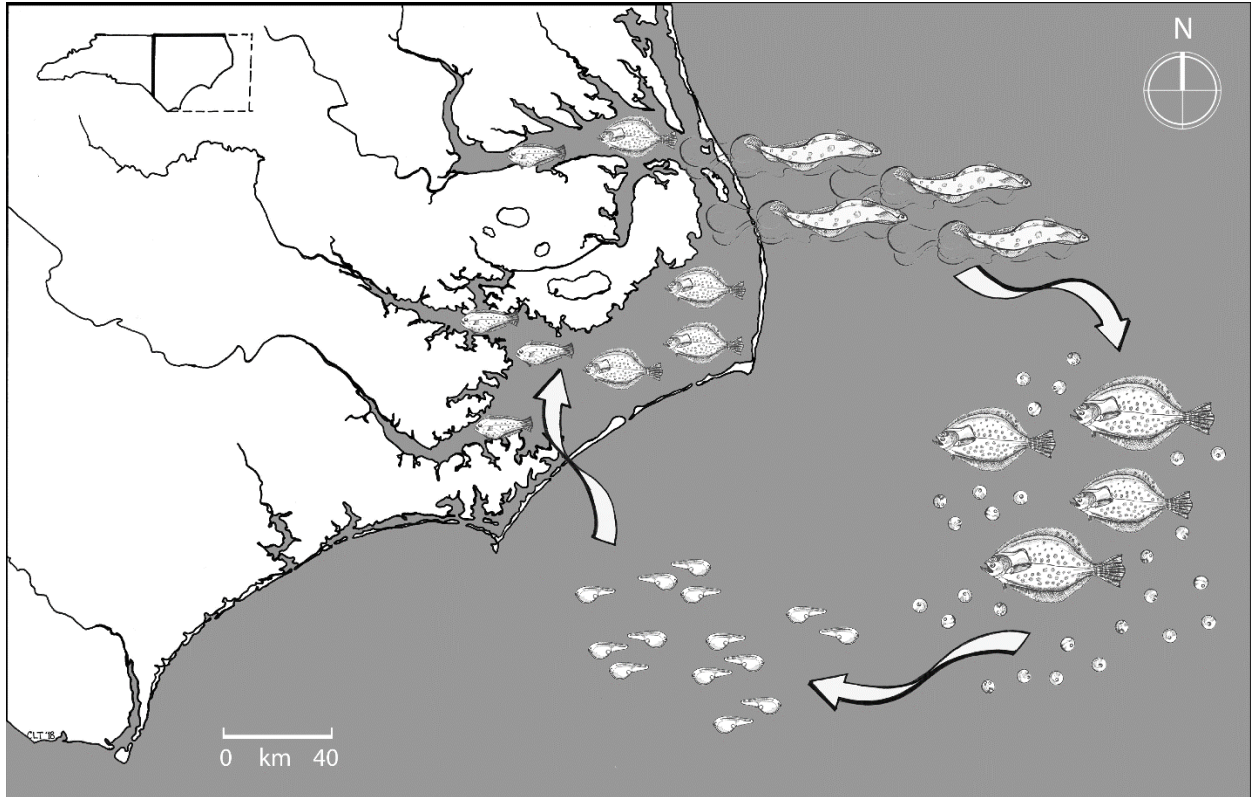


Figure 2. Artist interpretation of the southern flounder life cycle. Image originally printed in Hollensead 2018.

Reproduction

Southern flounder migrate out of North Carolina estuaries from mid-October to mid-November to spawn (Hollensead 2018). No direct observation of spawning has been observed in the wild, but laboratory experiments have been conducted to quantify southern flounder fecundity (number of eggs) and fertilization success (Watanabe et al. 2001).

In North Carolina, 50% of females are considered mature by 16 inches total length (TL) and ages 1 or 2 (Midway and Scharf 2012). This length at maturity is larger than what has been reported in Florida (8.4 inches TL; Topp and Hoff 1972) and the Gulf of Mexico (12 inches TL; Corey et al. 2017), indicating a potential shift in length-at-maturity the further south the species occurs (Lee et al. 2018).

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Age and Growth

Growth rate and length-at-age in North Carolina are highly variable for southern flounder (Fitzhugh et al. 1996). Juvenile female southern flounder exhibit a higher growth rate than male southern flounder (Midway et al. 2015) and females generally attain a larger maximum size compared to males (Fischer and Thompson 2004). In North Carolina, the maximum observed age is older for females at nine years compared to six years for males and maximum observed length was 33 inches TL for females and 20 inches TL for males (Lee et al. 2018). Additional information on age and growth of southern flounder can be found in the annual Southern Flounder FMP Update located here: <https://deq.nc.gov/about/divisions/marine-fisheries/public-information-and-education/managing-fisheries/fmp>.

Predator-Prey Relationships

Southern flounder are bottom dwelling, ambush predators that use their unique coloring to camouflage themselves in order to opportunistically feed on a wide range of prey species (Burke 1995; Arrivillaga and Baltz 1999). Young juvenile southern flounder generally eat small invertebrate species (Ellis 2007) before shifting to a diet made up of mostly other fish species (Fitzhugh et al. 1996). In general, the most common prey fish species encountered in adult southern flounder diets are bay anchovy (*Anchoa mitchilli*), spot (*Leiostomus xanthurus*), and spotfin mojarra (*Eucinostomus argenteus*; Wenner et al. 1990). Some predators of southern flounder include sandbar sharks (*Carcharhinus plumbeus*; Ellis and Musick 2007) and bird species (Kellison et al. 2000; Hossain et al. 2002).

STOCK STATUS

Stock Unit Definition

The biological unit stock assumed for the stock assessment (Flowers et al. 2019) is based on multiple tagging studies (Ross et al. 1982; Monaghan 1996; Schwartz 1997; Craig and Rice 2008), genetic studies (Anderson and Karel 2012; Wang et al. 2015), and an otolith morphology study (Midway et al. 2014), all of which provide evidence of a single stock occurring in waters of North Carolina, South Carolina, Georgia, and the east coast of Florida.

Assessment Methodology

Landings and dead discards were incorporated into a quantitative model that estimates both historical and current population sizes and harvest rates. Landings and dead discards were available from the commercial and recreational fisheries. Eight fishery-independent surveys were also inputs into the model, including recruitment indices from North Carolina, South Carolina, and Florida and adult indices from North Carolina, South Carolina, Georgia, and Florida, and a near-shore ocean survey from Cape Hatteras, North Carolina to Cape Canaveral, Florida.

When considering population size and long-term viability, stock assessments most often use a measure of female spawning stock biomass to determine the population's health. Female

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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spawning stock biomass includes female fish that are mature and capable of producing offspring. Fishing mortality, abbreviated as F , is a measure of how fast fish are being removed from the population by the different fisheries. Removals include those fish that are kept and those that are discarded dead or die after release.

The stock assessment's current (2017) estimates of female SSB and fishing mortality rates were compared to levels that are considered sustainable. These sustainable levels are based on established reference points that include a target and threshold. The threshold is the minimum level required for sustainability and when that level is achieved, the stock is considered healthy. The target is a level that provides a buffer to minimize risk and increases the probability of successfully rebuilding the stock. If current female SSB is less than the threshold for biomass, the stock is said to be overfished. If the current harvest rate is greater than the associated threshold, the current rate of removals is too high and overfishing is said to be occurring. Overfishing is the state of removing fish at an unsustainable rate that will ultimately reduce the female spawning stock biomass and result in an overfished stock.

Current Stock Status

Results show that SSB has decreased since 2006 (Figure 3) and recruitment, while variable among years, has a generally declining trend (Figure 4). Fishing mortality did not exhibit much inter-annual variability and suggests a decrease in the last year of the time series (Figure 5).

The model estimated a value of 0.35 for $F_{35\%}$ (fishing mortality target) and a value of 0.53 for $F_{25\%}$ (fishing mortality threshold; Figure 5). The estimate of $SSB_{35\%}$ (target) was 5,452 metric tons and the estimate of $SSB_{25\%}$ (threshold) was 3,900 metric tons (Figure 3).

The level of female SSB that represents the minimum level of sustainability for southern flounder was estimated at 8.6 million pounds. The stock assessment estimate of female SSB for southern flounder in 2017 was 2.3 million pounds. Because the current (2017) estimate of female SSB is below the threshold reference point, the stock is considered overfished (Figure 3). The probability that the 2017 estimate of SSB is below the threshold value is 100%.

The assessment model estimated that F can be no greater than 0.53 for a sustainable southern flounder population. The current (2017) estimate of F from the stock assessment was 0.91, which is above the threshold F reference point (Figure 5). Because the current (2017) F is above the threshold, overfishing is occurring. The probability the 2017 F is above the threshold value is 96%.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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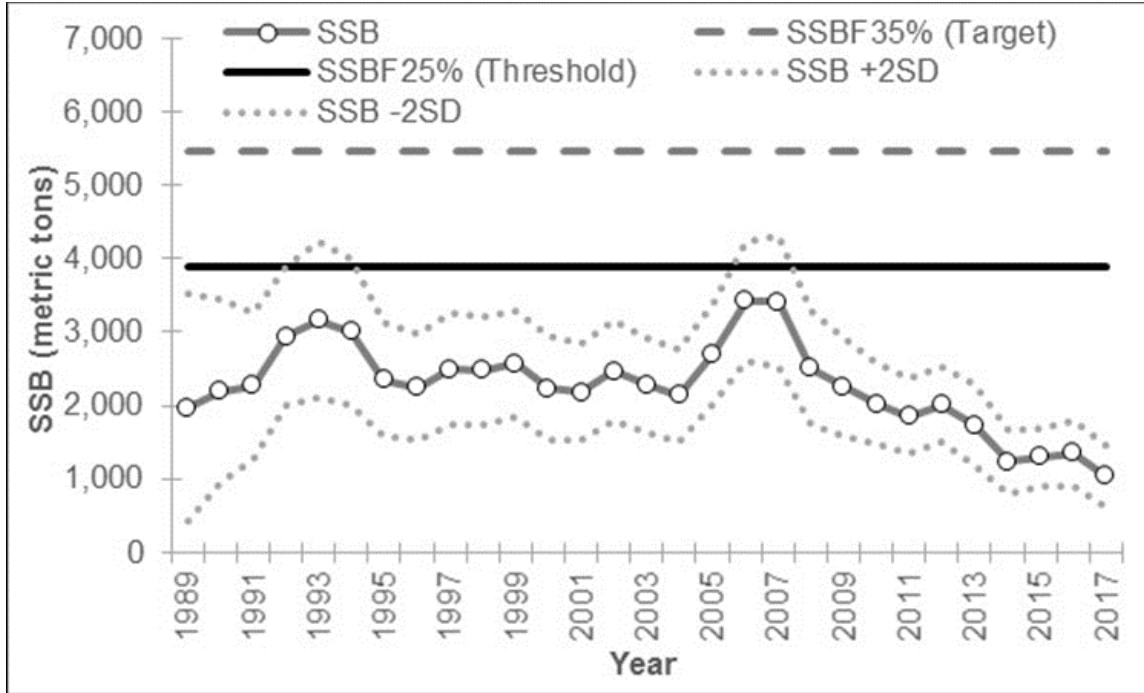


Figure 3. Predicted female spawning stock biomass (SSB) from the base run of the ASAP model, 1989–2017. Dotted lines represent ± 2 standard deviations (SD) of the predicted values. (Source: Flowers et al. 2019)

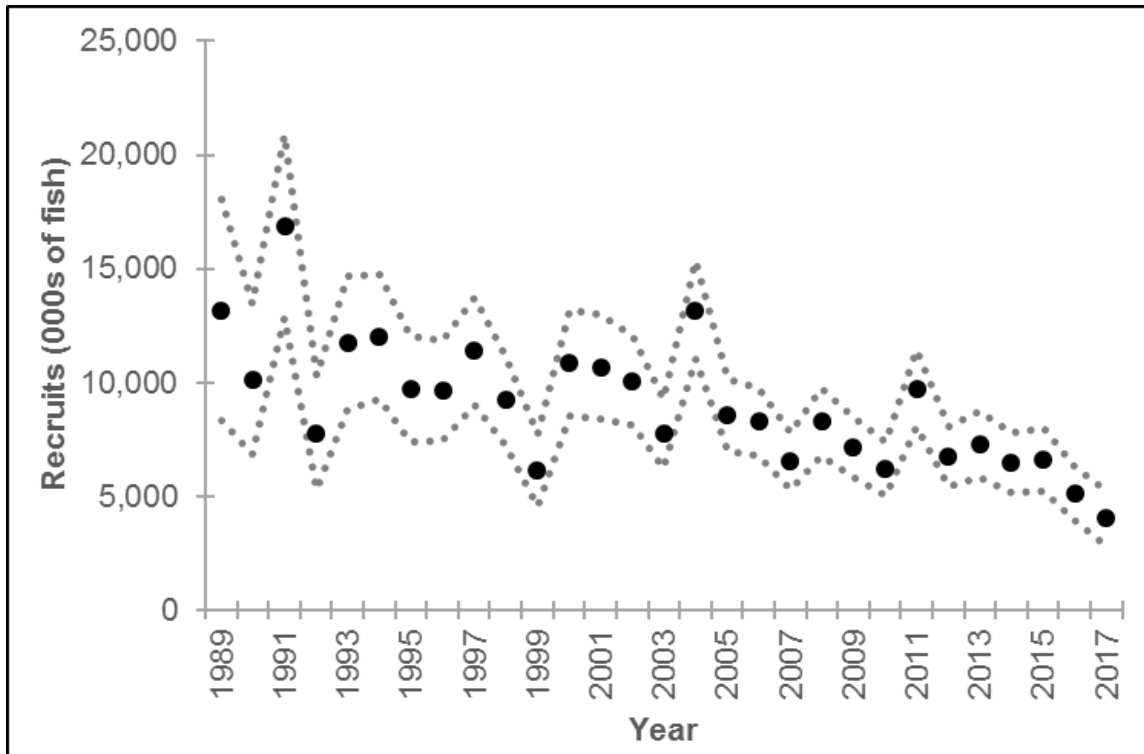


Figure 4. Predicted number of recruits (thousands of fish) from the base run of the ASAP model, 1989–2017. Dotted lines represent ± 2 standard deviations (SD) of the predicted values. (Source: Flowers et al. 2019)

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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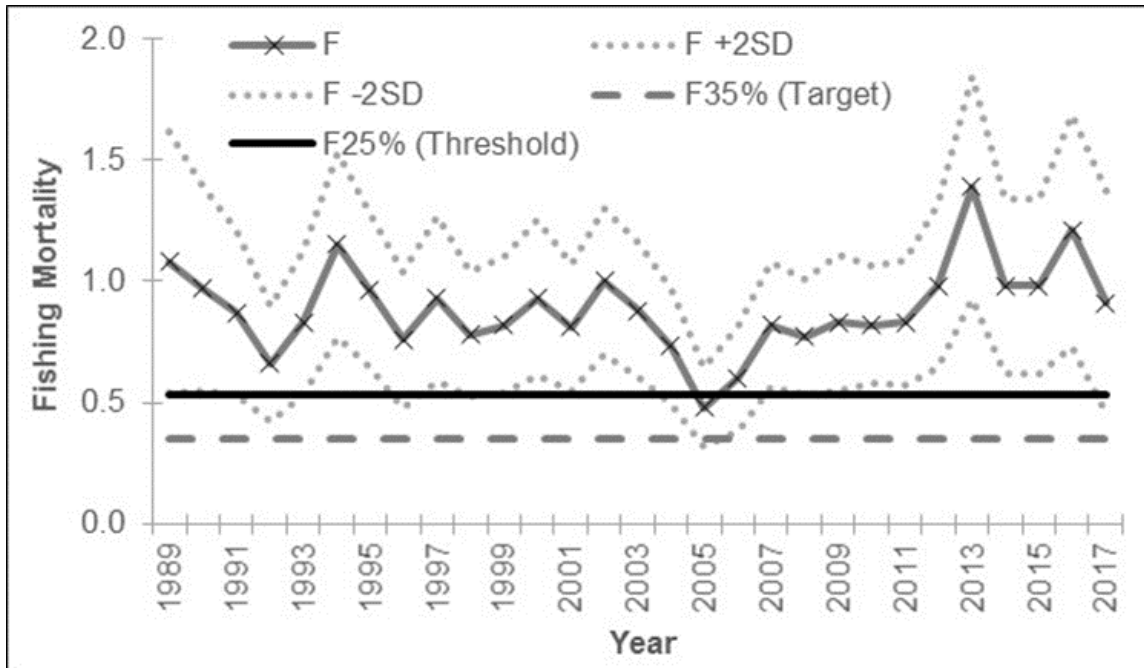


Figure 5. Predicted fishing mortality (F) rates (numbers-weighted, ages 2–4) from the base run of the ASAP model, 1989–2017. Dotted lines represent ± 2 standard deviations (SD) of the predicted values. (Source: Flowers et al. 2019)

Projections

Calculations were made to determine the reductions in total catch necessary to end overfishing and to reach the fishing mortality threshold and target. Additionally, a series of projections were performed to examine future stock conditions under various management scenarios. The calculations of percent reductions indicate that a minimum of a 31% reduction in total catch (landings plus discards from all fleets) would be required to end overfishing. However, while this reduction is sufficient to end overfishing in two years, it is not sufficient to rebuild SSB to meet the 10-year schedule to end the overfished status (Figure 6).

Projections were also carried out to determine the fishing mortality and the associated reduction in total catch necessary to end the overfished status and to reach the SSB target within 10 years (by 2028, assuming management imposed regulations beginning in 2019). The projections indicate that an F equal to 0.34 and a 52% reduction in total catch is needed to reach the SSB threshold by 2028 and end the overfished status (Figure 7). To reach the SSB target by 2028, F needs to be lowered to 0.18 and total catch needs to be reduced by 72% (Figure 8).

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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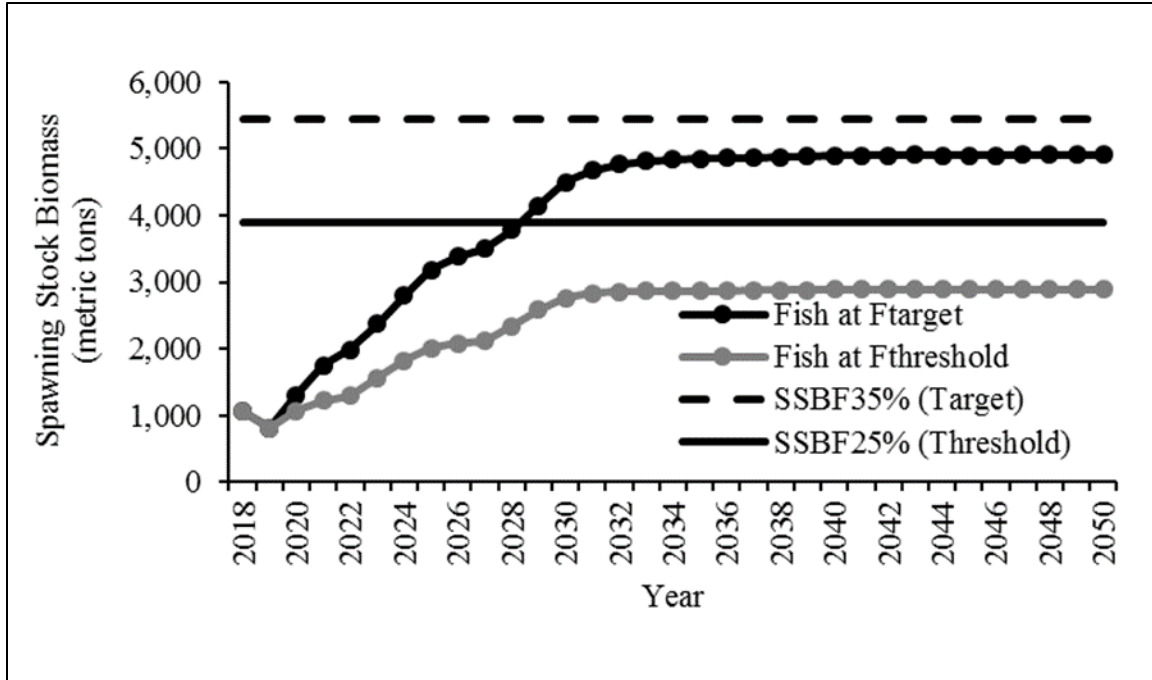


Figure 6. Projections of spawning stock biomass (SSB) related to fishing at a level to end overfishing in the required two-year period. Note: SSB does not rebuild within required ten-year time period. (Source: Flowers et al. 2019)

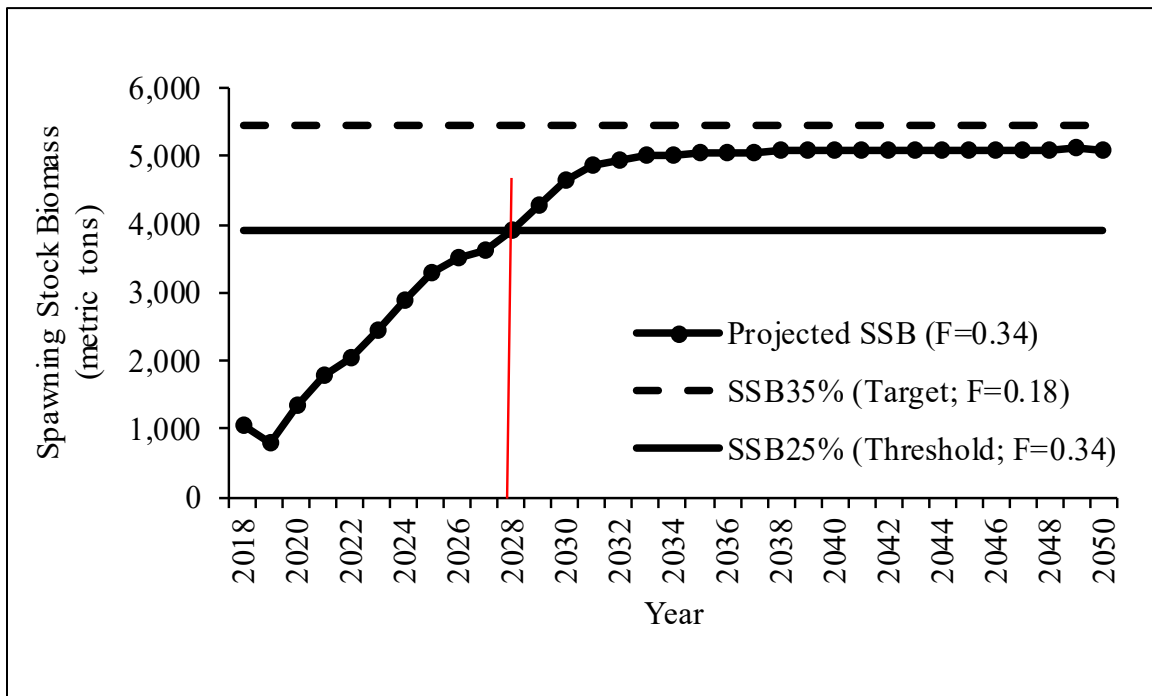


Figure 7. Predicted future spawning stock biomass (metric tons) assuming the fishing mortality value necessary to end the overfished status by 2028 (indicated by vertical red line). (Source: Flowers et al. 2019)

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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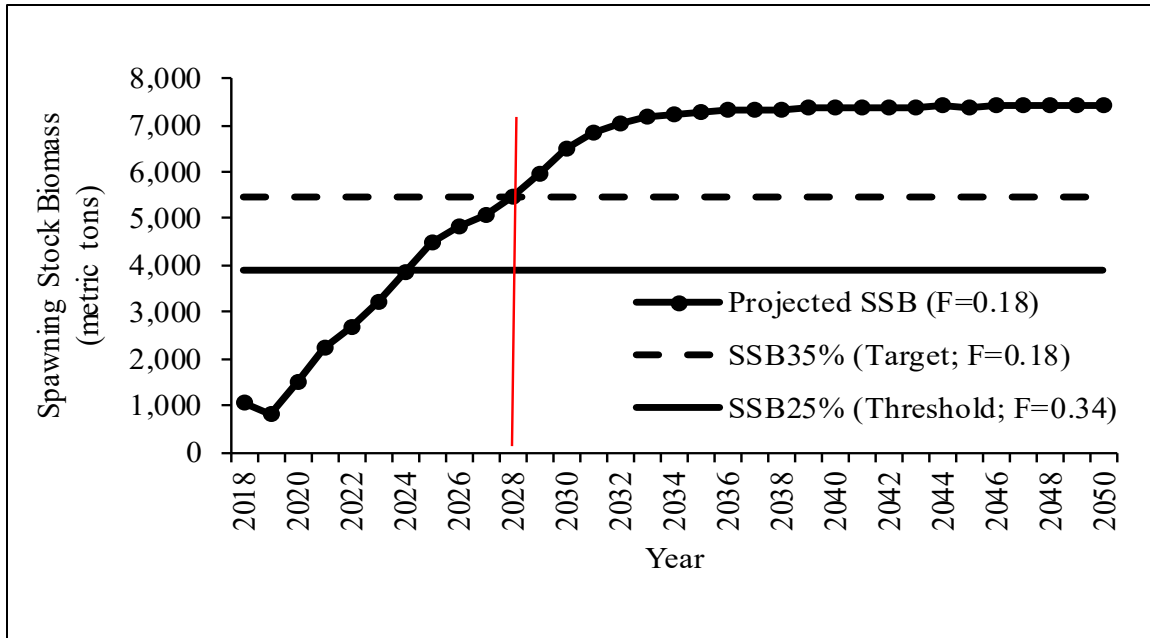


Figure 8. Predicted future spawning stock biomass (metric tons) assuming the fishing mortality value necessary to reach the SSB_{Target} by 2028 (indicated by vertical red line). (Source: Flowers et al. 2019)

ECOSYSTEM AND FISHERY IMPACTS

Habitat use patterns of southern flounder vary over time and space by life stage. The growth and survival of southern flounder within the habitats they use are maximized when water quality parameters, such as temperature, salinity, and dissolved oxygen, are within optimal ranges. For further information on habitat use by life stage and optimal water quality parameters, see the *Description of the Stock* section. Additional information on the habitats discussed below, threats to these habitats, and water quality degradation, as well as how these topics relate to fisheries can be found in the CHPP and various Division of Water Resources (NCDWR) publications (NCDWQ 2000a, 2008a; NCDEQ 2016a) (Figure 9).

While southern flounder can be found in both the estuaries and the ocean, more is known about the species as it occurs in the estuary. This section will mostly focus on the importance of the estuarine habitats, inlets, and ocean bottoms used by southern flounder and the broad effects of the southern flounder fishery on the habitat and ecosystem in these areas.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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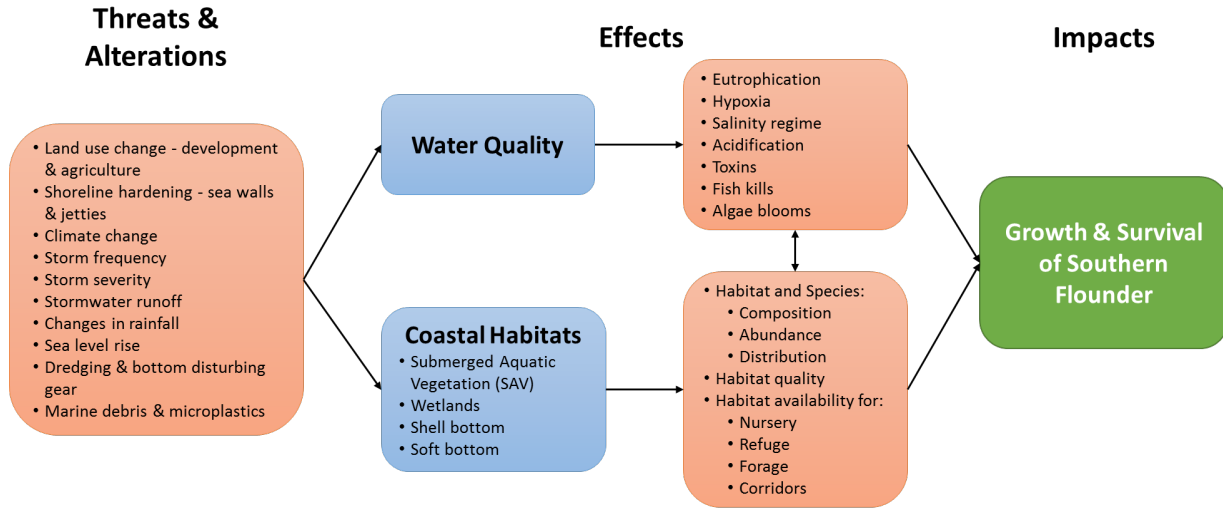


Figure 9. Effects of threats and alterations on water quality and coastal habitats and their ultimate impact on the growth and survival of southern flounder.

HABITAT DEGRADATION AND LOSS

Southern flounder migrate through the coastal ecosystem over their life cycle using multiple habitats. Many habitat types are particularly important as nursery, refuge, and forage habitats. Coastal inlets and ocean bottom also act as an important corridor from estuarine nursery habitat to ocean spawning areas. These and other potentially important flounder habitats are described in detail in the CHPP which can be found here: <https://deq.nc.gov/about/divisions/marine-fisheries/public-information-and-education/habitat-information/chpp> (NCDEQ 2016).

Additionally, research is underway by the division and universities to identify spawning areas and associated habitats for southern flounder in the ocean.

Portions of these habitats have been degraded or lost over time by a variety of anthropogenic (human caused) sources. It is difficult to quantify how habitat degradation may alter southern flounder population dynamics, but it is important to understand how habitat loss and condition controls the growth and survival of estuarine fish species. Protection and enhancement of these areas may be particularly important for growth and survival of juveniles to adult southern flounder. Key habitats for juvenile southern flounder in estuaries for foraging, refuge, and their growth to adults include: submerged aquatic vegetation (SAV), wetlands, shell bottom, and soft bottom (Table 1; Rozas and Odum 1987; Burke et al. 1991; Mitsch and Gosselink 1993; Walsh et al. 1999; Graff and Middleton 2001; Nañez-James et al. 2009; Meyer 2011; Furey 2012; Furey and Rooker 2013; Scyphers et al. 2015; Dance and Rooker 2015).

When southern flounder reach spawning sizes, both inlets and ocean bottoms become critical habitats. Adults move to offshore ocean spawning grounds during the fall and winter to complete their life cycle. Larvae spawned offshore are transported into the estuarine system by nearshore and tidal currents entering the estuary through coastal inlets before settling in preferred estuarine habitats. It is believed that some adult southern flounder return through the inlets to the estuaries and rivers after spawning; however, some adult flounder are thought to remain in the ocean after spawning (Watterson and Alexander 2004; Taylor et al. 2008). The proportion of the adult

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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spawning stock remaining in the ocean versus those returning to the estuaries is unknown. For more information on the importance of inlets on the southern flounder populations, see the *Inlet Corridors* issue paper.

WATER QUALITY DEGRADATION

Good water quality is essential, both for supporting the various life stages of southern flounder (Table 1) and maintaining their habitats. Naturally occurring and human caused activities can alter the preferred salinity or temperature conditions, elevate toxins, nutrients, turbidity, as well as lower dissolved oxygen levels which can degrade water quality.

Table 1. Water quality parameter ranges and habitats associated with different life stages of southern flounder.

Life Stage	Salinity (ppt)	Temperature (°C)	Dissolved Oxygen (mg/L)	Associated Habitats	Related literature
Adult	0–36	4–35	Greater than 5.0	Entire estuary and ocean	Reagan and Wingo 1985; Farmer et al. 2013; NCDEQ 2016
Larvae	9–36	16–35	Greater than 3.7	Inlet and ocean water column, estuarine soft bottom	Williams and Duebler 1968; Reagan and Wingo 1985; Burke et al. 1991; Moustakas et al. 2004; NCDEQ 2016
Juveniles	0.02–35	16–35	Greater than 3.7	Wetlands, SAV, shell bottom, soft bottom	Reagan and Wingo 1985; Taylor et al. 2000; Taylor and Miller 2001; Del Toro-Silva et al. 2008; Nañez-James et al. 2009; Lowe et al. 2011; Farmer et al. 2013; NCDEQ 2016

More detailed information on water quality degradation, including the topics of hypoxia, toxins, and temperature in North Carolina and the effect on fish stocks can be found through the NCDWR guides (NCDWQ 2000, 2008) and the CHPP (NCDEQ 2016).

GEAR IMPACTS ON HABITAT

Bottom disturbing fishing gear can impact ecosystem function through habitat degradation. Static (or non-mobile) gear used in a fishery tends to have a lesser impact on habitat compared to mobile gear, as the amount of area affected by the static gear tends to be insignificant when compared to that of the mobile gear (Rogers et al. 1998). Both bottom disturbing and static gears can have impacts of bycatch while in operation and can have negative impacts if the gear is abandoned or lost.

The primary gears used in the southern flounder commercial fishery are pound nets, gill nets, and gigs. In the recreational fishery hook-and-line and gigs are the primary gears. Other gears that may harvest southern flounder as incidental catch include hard crab and peeler pots, crab and shrimp trawls, channel nets, fyke nets, and haul seines. Most gears that interact with southern

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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flounder are considered static gear (Barnette 2001; NCDEQ 2016), thus, in general fishing gear targeting flounder have minimal impact on habitat.

BYCATCH AND DISCARDS OF NON-TARGET SPECIES

Finfish and shellfish species may be caught as incidental bycatch in fisheries targeting southern flounder and may be retained or discarded as a result of economic, regulatory, or personal considerations. For discussion on bycatch and discards of southern flounder from the commercial and recreational fisheries, see the *Description of the Fisheries* section.

Other Finfish Species

From 2013 to 2017, annual southern flounder gill net trips landed 162,141 pounds (24%) of fish other than flounder (incidental catch), while these same trips averaged 520,227 pounds (76%) of southern flounder. Four species, or groups of species, comprised over 77% of the incidental catch by weight: red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*), catfishes, and sheepshead (*Archosargus probatocephalus*). Over 40 additional species, including spotted seatrout (*Cynoscion nebulosus*), bluefish (*Pomatomus saltatrix*), striped mullet (*Mugil cephalus*), and striped bass (*Morone saxatilis*) comprised the remaining 23% of the catch.

Six species comprised approximately 76% of the observed discards (live and dead; by number): Atlantic menhaden (*Brevoortia tyrannus*), blue crab (*Callinectes sapidus*), common carp (*Cyprinus carpio*), cownose rays (*Rhinoptera bonasus*), red drum, and Atlantic stingrays (*Dasyatis sabina*). Additionally, southern flounder make up 10% of the overall discards from the southern flounder gill net fishery (for further discussion see the *Description of the Fishery* section). An additional 135 species make up the remaining 14% of discarded catch, including bluefish, Atlantic croaker (*Micropogonias undulatus*), and horseshoe crab (*Limulus polyphemus*). From June through October (2013–2017) greater than 75% of all gill net trips made were targeted flounder trips.

Over 70% of the landings from flounder pound nets were southern flounder from 2013 to 2017. Summer and Gulf flounders comprised approximately 2% of the harvest during the same time frame. Other species commonly captured included black drum, harvest fish (*Peprilus alepidotus*), and red drum. More than thirty additional species including sheepshead, butterfish (*Peprilus triacanthus*), and catfish made up the remaining catch; with none of these species individually exceeding 1% of the total catch. Mortality of non-target species discarded from pound nets is likely minimal, provided fishing practices are such that non-harvested fish are handled carefully and released immediately.

Gigging for southern flounder results in very little bycatch of non-flounder species since fish are gilled by sight. Other flounder species, such as Gulf and summer flounder, are subject to the same size restrictions and may be taken in fishing operations targeting southern flounder. Giggers in both the recreational and commercial fisheries can be prone to gig undersized flounder, resulting in some regulatory discards of these other flounder species.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

Protected Species

Protected species (sometimes referred to as “protected resources”) is a broad term that encompasses a range of organisms that are protected by federal or state statutes because their populations are at risk or vulnerable to risk of extinction. Federal statutes include the Endangered Species Act (ESA), Marine Mammal Protection Act, and the Migratory Bird Treaty Act. Of the federally protected species, the following are known or suspected to be incidentally taken in the southern flounder fishery: sea turtle species, sturgeon species, common bottlenose dolphin (*Tursiops truncatus*), and various bird species. There may be additional protected species that occasionally occur in estuarine waters and rarely interact with the southern flounder fisheries. The division currently has two Incidental Take Permits (ITP; Section 10(a)(1)(B) of the ESA) that establish legal take thresholds for sea turtles and Atlantic sturgeon (*Acipenser oxyrinchus*) in estuarine gill nets (NMFS 2013, 2014). As part of the ITPs, the division operates an observer program to monitor take levels and implement adaptive management measures based on those levels (for the most recent annual reports see Byrd et al. 2020a, 2020b).

The bottlenose dolphin is the predominant marine mammal in North Carolina estuarine waters (Hayes et al. 2018). Incidental takes of bottlenose dolphins in ocean gill nets have been documented by federal fisheries observers (Lyssikatos and Garrison 2018). Evidence of incidental takes in estuarine and ocean gill nets has been documented on bottlenose dolphin strandings; however, the level of bycatch in estuarine gill nets is unknown (Byrd et al. 2014; Byrd and Hohn 2017). State-wide observer coverage of estuarine gill nets (ITP year 2014–present) conducted by the division documented only one incidental take of a bottlenose dolphin (small-mesh; McConnaughey et al. 2019). Entanglement of bottlenose dolphins in North Carolina pound nets is thought to be uncommon, but the NMFS recovered one dead bottlenose dolphin entangled in a pound net during 2008 (Byrd et al. 2014).

North Carolina has a great diversity of birds, including migratory waterbirds (Potter et al. 1980). Within North Carolina estuarine waters, there are several species of birds that may be unintentionally caught in the southern flounder gill-net fishery. Bycatch estimates for the estuarine gill-net fishery are not available, though Warden (2010) documented bycatch of common loons (*Gavia immer*) and red-throated loons (*G. stellate*) in ocean-side and estuarine gill nets operating from Maine to North Carolina. Gill-net interactions with waterbirds have been documented in several division sampling programs; however, in-depth studies are needed to determine quantifiable bycatch estimates in the estuarine gill-net fishery and the levels of impact.

CLIMATE CHANGE AND RESILIENCY

Extreme weather events have always occurred, but scientists anticipate that changes to North Carolina’s climate in this century will be larger than anything experienced historically (Kunkel et al. 2020). It is predicted that average annual temperatures will continue to increase, sea level will continue to rise, the intensity of hurricanes will increase, total annual precipitation from hurricanes and severe thunderstorms will increase resulting in increased flooding events, while severe droughts will also likely increase due to higher temperatures (Kunkel et al. 2020). Flood events can flush contaminated nutrient-rich runoff into estuaries causing degraded water quality. Runoff from flood events can cause eutrophication resulting in fish kills due to hypoxia, algal

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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blooms, and alteration of the salinity regime. Flood events can also cause erosion of shorelines resulting in loss of important coastal habitats, such as SAV, shell bottom, and wetlands, that are critical to southern flounder throughout their life history. Potential increases in extreme weather events could have an inverse effect on the recruitment and survival of southern flounder in the estuarine system.

Increasing temperatures will also impact the distribution of finfish and invertebrate populations and the coastal habitats they use. It has been predicted that hundreds of finfish and invertebrate species will be forced to move northward due to increasing temperatures caused by climate change (Morley et al. 2018). North Carolina already exhibits one of the greatest northward shifts in commercial fishing effort, with average vessel landings occurring 24 km further north each year (Dubik et al. 2019). Studies have shown that the sex determination of southern flounder is sensitive to water temperatures during larval development. When southern flounder were grown in high and low water temperatures, a higher proportion of males were produced while a midrange water temperature produced a sex ratio closer to 1:1 (Luckenbach et al. 2003, 2009; Montalvo et al. 2012). Honeycutt et al. (2019) found the more southerly habitats of North Carolina exhibited warmer temperatures and consistently produced higher proportions of males in wild populations (up to 94%), indicating latitudinal variation in sex ratios. With trends in increasing water temperatures, this is an important factor in the understanding of population dynamics of southern flounder.

The repeated impacts and compounding losses from the effects of climate change can be catastrophic not only to the coastal communities, but to coastal habitats and the fisheries they support. While the risks and hazards associated with climate change and extreme weather events cannot be completely eliminated, the effects can be decreased by improving coastal resilience, which can be broken down into two parts: 1) community resiliency – the ability of a community to withstand, respond to, and recover from a disruption, and 2) ecosystem resiliency – the ability of the natural environment to withstand, respond to, and recover from a disruption, such as hurricanes, tropical storms, and flooding. A resilient ecosystem can bounce back from disturbances over time compared to resistant ecosystems, whose function may not be able to recover with repeated disturbances. Building a more resilient coastal community and ecosystem will help ensure the persistence of coastal habitats critical to the life history of southern flounder and many other species (NCDEQ 2016, 2020).

HABITAT AND WATER QUALITY PROTECTION

The Fishery Reform Act statutes require that a CHPP be drafted by the NCDEQ and reviewed every five years (G.S. 143B-279.8). The CHPP is intended as a resource and guide compiled by NCDEQ staff to assist the Marine Fisheries, Environmental Management, and Coastal Resources commissions develop goals and recommendations for the continued protection and enhancement of fishery habitats of North Carolina. Habitat recommendations related to fishery management can be addressed directly by the NCMFC. The NCMFC has passed rules that provide protection for southern flounder habitat including the prohibition of bottom-disturbing gear in specific areas, designation of sensitive fish habitat, such as nursery areas and SAV beds, with applicable gear restrictions. Habitat recommendations not under NCMFC authority (e.g., water quality management, shoreline development) can be addressed by the other commissions through the

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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CHPP process. The CHPP helps to ensure consistent actions among these commissions as well as their supporting NCDEQ divisions. The CHPP also summarizes the economic and ecological value of coastal habitats to North Carolina, their status, and potential threats to their sustainability (NCDEQ 2016).

DESCRIPTION OF THE FISHERIES

Additional in-depth analyses and discussion of North Carolina's commercial and recreational southern flounder fisheries can be found in earlier versions of the Southern Flounder FMP (NCDMF 2005, 2013, 2017, 2019); all documents are available on the division website at: <https://deq.nc.gov/about/divisions/marine-fisheries/public-information-and-education/managing-fisheries/fmp>. Additionally, the License and Statistics Annual Report (NCDMF 2020) produced by the division can be found at: <https://deq.nc.gov/about/divisions/marine-fisheries/science-and-statistics/fisheries-statistics>.

The socio-economic information presented here is about the fishery as of 2017 and is not intended to be used to predict potential impacts from management changes. This and other information pertaining to FMP's are included to help inform decision-makers regarding the long-term viability of the state's commercially and recreationally significant species or fisheries. For a detailed explanation of the methodology used to estimate the economic impacts, please refer to the division's License and Statistics Section Annual Report (NCDMF 2020).

COMMERCIAL FISHERY

Southern flounder supports one of the largest and most valuable commercial fisheries in North Carolina, accounting for landings of 1.39 million pounds with a dockside value of \$5.66 million in 2017. Historically, North Carolina has accounted for approximately 99% of annual southern flounder commercial landings from the U.S. South Atlantic coast since 1978 (Figure 10). Southern flounder have been harvested commercially since the 1800s in North Carolina, with the earliest documented landings reported in 1889 (Chestnut and Davis 1975). The average commercial fisherman in the southern flounder fishery is a middle-aged Caucasian male with more than 50% of their income coming from commercial fishing (Diaby 2000, 2001; Chevront 2002, 2003; Chevront and Neal 2004; Crosson 2010; Hadley 2012; Hadley and Wiegand 2014; Stemle and Wiegand 2017; Gambill and Bianchi 2019).

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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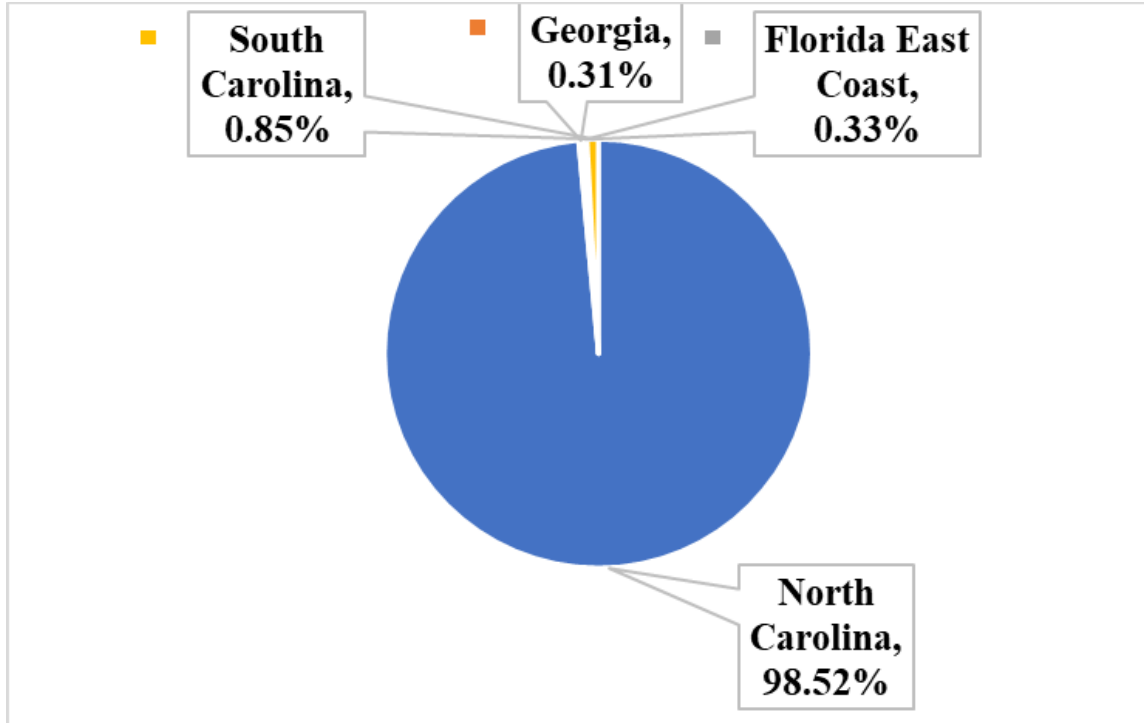


Figure 10. Average contribution to U.S. South Atlantic coast southern flounder commercial landings by state, 1978–2017. (Source: NOAA Fisheries Annual Commercial Landing Statistics and North Carolina Trip Ticket Program)
*Percentages may not total 100% due to rounding.

Another flounder species, the summer flounder, is also harvested in North Carolina. The commercial fisheries for summer and southern flounder differ in terms of where they operate and the gears they use. For example, summer flounder occur primarily in the ocean from North Carolina to Massachusetts where they are harvested primarily with trawl gear. Commercial fisheries for southern flounder occur almost exclusively in the estuaries where they are harvested with a greater variety of gears, primarily gill nets, pound nets, and gigs.

In North Carolina, landings of southern flounder increased steadily in the mid-1970s, peaking in the mid-1990s before declining to nearly 1.4 million pounds in 2017 (Figure 11). Trends in southern flounder landings were influenced, in part, by management restrictions, including a quota implemented for summer flounder in the mid-1980s to early 1990s and restrictions in the anchored large-mesh gill-net fishery to reduce incidental takes of sea turtles starting in 2000. These restrictions decreased the harvest of summer flounder, which had historically accounted for most of the flounder landings in North Carolina. Concurrently with decreased summer flounder harvest, the southern flounder fishery expanded through growth in the pound net fishery and development of a fall large-mesh gill-net fishery in Pamlico Sound. These changes resulted in southern flounder ranking as the top commercially landed flounder species until 2014, when summer flounder regained the top spot.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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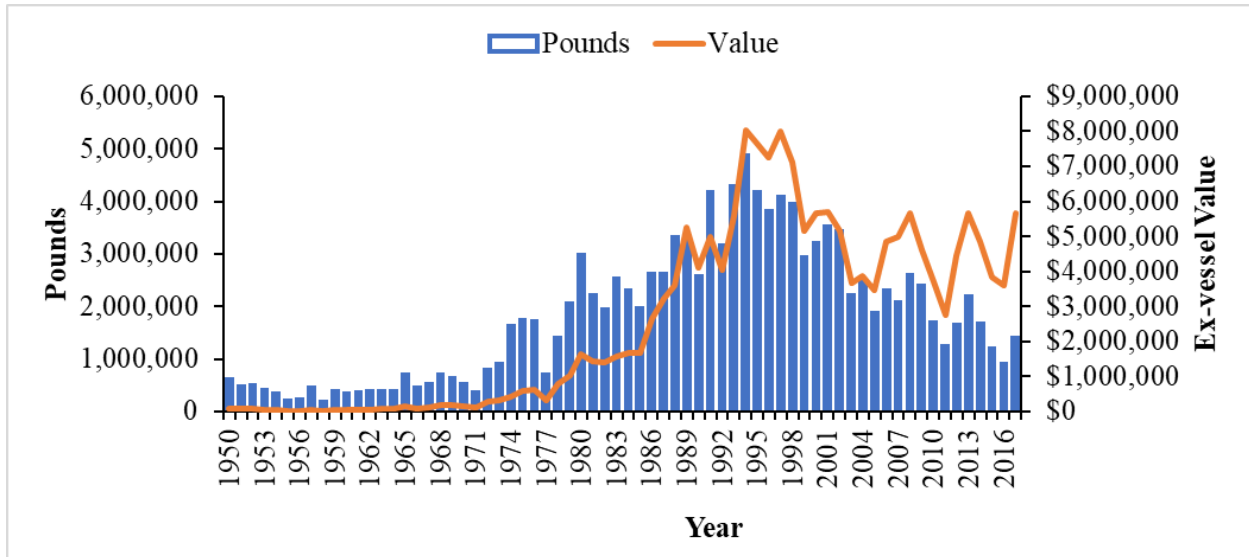


Figure 11. North Carolina annual southern flounder commercial landings and ex-vessel value, 1950–2017. (Source: North Carolina Trip Ticket Program)

Commercial Fishery Data Collection

Data used to describe the commercial fisheries for southern flounder comes from four sources: NMFS, the Atlantic Coast Cooperative Statistics Program (ACCSP), the North Carolina trip ticket program (NCTTP), and the North Carolina fishery-dependent sampling program. The data from NMFS includes historical data prior to 1978 and the data from ACCSP includes landings statistics collected from 1978 to 1993. Data prior to 1994 were collected on a voluntary basis with varying methodologies.

The NCTTP was implemented in 1994 to more accurately monitor commercial landings and fishing effort. Through the NCTTP, the division requires dealers purchasing finfish and/or shellfish from commercial fishermen to submit trip tickets that include information about the catch (e.g., species landed, pounds, gear, waterbody). Commercial fishermen are required to hold a Standard Commercial Fishing License (SCFL) or a Retired Standard Commercial Fishing License (RSCFL) to land southern flounder commercially in North Carolina. For commercial fishermen to sell their catch directly to consumers, they are required to possess a dealer's license and submit their own trip tickets. The combined number of SCFLs and RSCFLs issued during fiscal years 2008 through 2017 ranged from a low of 6,296 in 2017 to a high of 6,861 in 2008 (NCDMF 2020). The number of seafood dealers reporting landings of southern flounder has ranged from 249 in 2012 to 189 in 2016. Finally, the fishery-dependent sampling program has been ongoing since 1982. This program collects data at fish houses by sampling the catch and recording fishery characteristics, which allows the size and age distribution of southern flounder to be characterized for each of the major gears and fisheries that harvest southern flounder.

Annual Landings and Value

Flounder landings reported through the NCTTP are not tabulated by species. Data from the fishery-dependent sampling program indicate that southern flounder make up less than one

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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percent of the catch from ocean waters, while summer flounder and Gulf flounder account for approximately two percent or less of the flounder harvested from internal waters (NCDMF, unpublished data). Therefore, it is assumed in this analysis that all flounder harvested from estuarine waters are southern flounder, while all flounder taken from the ocean are summer flounder.

Unless otherwise noted, data presented in this section are from the NCTTP from 2008 to 2017. Trends are shown for the dockside (ex-vessel) value; harvest volume is presented in pounds.

Commercial landings of southern flounder were highly variable with a low in the time series in 2016 since the peak in 1994 (Figure 11). Landings have been impacted by environmental conditions, such as hurricanes, and changes in management strategies. Southern flounder may be graded into five market categories: jumbo, large, medium, mixed, and small.

Dockside price per pound of southern flounder is influenced by several factors, including fish size and market. For example, the sushi and sashimi market have had the maximum price per pound in the past. It is important to note that the price-per-pound of southern flounder has increased over time, as average prices have shifted from roughly \$2 per pound to \$4 per pound across the time series. As the total poundage of southern flounder landings has decreased over time, ex-vessel values have remained relatively consistent, with the exception of 2011 when portions of the pound net fishery was disproportionately impacted by severe weather (Table 2; NCDMF 2020).

Table 2. North Carolina commercial southern flounder landings in pounds and value, 2008–2017. (Source: North Carolina Trip Ticket Program)

Year	Harvest	Reported Dockside Value	Reported Dockside Price Per Pound	Inflation Adjusted Dockside Value	Inflation Adjusted Dockside Price per Pound
2008	2,602,390	\$5,650,295	\$2.17	\$6,500,664	\$2.50
2009	2,396,240	\$4,609,932	\$1.92	\$5,350,287	\$2.23
2010	1,689,557	\$3,695,889	\$2.19	\$4,086,544	\$2.42
2011	1,247,450	\$2,753,128	\$2.21	\$2,832,693	\$2.27
2012	1,646,137	\$4,451,482	\$2.70	\$4,600,162	\$2.79
2013	2,186,391	\$5,673,190	\$2.59	\$5,921,675	\$2.71
2014	1,673,511	\$4,839,672	\$2.89	\$4,833,380	\$2.89
2015	1,202,885	\$3,823,567	\$3.18	\$3,908,832	\$3.25
2016	897,765	\$3,610,533	\$4.02	\$3,731,125	\$4.16
2017	1,394,617	\$5,655,751	\$4.06	\$5,655,751	\$4.06
Average	1,693,694	\$4,476,344	\$2.64	\$4,742,111	\$2.80

Landings by Gear

Historically, southern flounder were harvested commercially in North Carolina using pound nets, seines, gill nets, and gigs (Chestnut and Davis 1975); all but seines remain as primary gears (Lee

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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et al. 2018). The use of gigs in the southern flounder fishery does not require a specific permit. However, a Pound Net Permit is required to use a pound net, including those used to harvest southern flounder. The average number of issued permits between 2008 and 2017 was 285 [range: 267 (2012) to 304 (2008); Table 3].

Table 3. Number of commercial pound net permits by year of expiration and estuarine gill net permits by license year (July 1 to June 30). (Source: Fisheries Information Network)

Year (Expiration Year or License Year)	Pound Net Permits Issued	Estuarine Gill Net Permits Issued
2008	304	
2009	299	
2010	296	
2011	293	
2012	267	
2013	271	
2014	285	
2015	271	2,674
2016	283	2,897
2017	278	2,672
Average	285	2,748

As of 2015, an Estuarine Gill Net Permit is required to fish with anchored gill-net gear in North Carolina’s estuaries. The permits are used to facilitate observer coverage, which is a requirement of ITPs (Section 10(a)(1)(B) of the ESA) for sea turtles and Atlantic sturgeon (NMFS 2013, 2014). The lowest number of permits possessed during a license year was 2,672 in 2017 and the highest was 2,897 in 2016 (Table 3).

Pound nets and gill nets have been the dominant gears, with gill nets leading harvest from the early 1990s through 2013. Recent declines in gill-net landings can most likely be attributed to increased regulations on the large-mesh anchored gill-net fishery. The third most used gear for southern flounder in recent years is the gig, with gig harvest increasing since 2008 (Table 4). Landings from other gears account for approximately two percent of the total landings and include crab and peeler pots, crab and shrimp trawls, hook-and-line, fyke nets, and haul seines (Table 4).

Characterization of Trips

The annual number of commercial trips reporting landings of southern flounder averaged over 20,000 during 2008 to 2017 with a peak in 2009 (Table 5). The predominate gear by number of trips and participants is the anchored large-mesh gill-net fishery, followed by gigs and pound nets, respectively (Table 5). Although large-mesh gill nets account for the largest volume of trips per year, the average landings per trip is 61 pounds, which is less than the average landings per trip for pound nets of 377 pounds.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4. Annual commercial southern flounder landings in pounds by gear type, 2008–2017. Numbers in parentheses are the percent of the total landings for each gear in a given year. (Source: North Carolina Trip Ticket Program)

Year	Gill Net	Pound Net	Gigs	Other	Total
2008	1,770,204 (68%)	685,546 (26%)	82,846 (3%)	63,793 (2%)	2,602,390
2009	1,658,074 (69%)	591,534 (25%)	84,303 (4%)	62,329 (3%)	2,396,240
2010	958,271 (57%)	571,151 (34%)	128,081 (8%)	32,054 (2%)	1,689,557
2011	652,810 (52%)	464,546 (37%)	113,414 (9%)	16,680 (1%)	1,247,450
2012	879,373 (53%)	569,388 (35%)	149,387 (9%)	47,989 (3%)	1,646,137
2013	1,096,060 (50%)	924,887 (42%)	118,489 (5%)	46,955 (2%)	2,186,391
2014	659,394 (39%)	860,216 (51%)	135,273 (8%)	18,628 (1%)	1,673,511
2015	392,339 (33%)	667,847 (56%)	130,277 (11%)	12,422 (1%)	1,202,885
2016	361,570 (40%)	398,258 (44%)	126,983 (14%)	10,953 (1%)	897,765
2017	552,292 (40%)	697,814 (50%)	136,094 (10%)	8,416 (1%)	1,394,617
Average	898,039 (53%)	643,119 (38%)	120,515 (7%)	32,022 (2%)	1,693,694

*Percentages may not total 100% due to rounding.

Table 5. Annual trips, average landings per trip (APT), and number of participants (#PAR) by gear type in the commercial southern flounder fishery, 2008–2017. (Source: North Carolina Trip Ticket Program)

Year	Trips ¹ / APT / #PAR ²	Pound Net			
		Gill Net Trips/ APT/ #PAR	Trips / APT / #PAR	Gig Trips / APT / #PAR	Other Trips / APT / #PAR
2008	28,966 / 90 / 1,235	23,493 / 75 / 924	1,508 / 455 / 83	1,459 / 57 / 140	2,510 / 25 / 413
2009	29,395 / 82 / 1,299	23,691 / 70 / 992	1,746 / 339 / 85	1,450 / 58 / 143	2,510 / 25 / 426
2010	20,408 / 83 / 1,182	15,134 / 63 / 837	1,610 / 355 / 84	2,283 / 56 / 226	1,384 / 23 / 329
2011	15,810 / 79 / 1,039	11,403 / 57 / 759	1,370 / 339 / 63	2,076 / 55 / 212	963 / 17 / 250
2012	20,926 / 79 / 1,202	14,713 / 60 / 855	1,754 / 325 / 84	3,000 / 50 / 288	1,462 / 33 / 291
2013	23,579 / 93 / 1,286	16,968 / 65 / 933	2,111 / 438 / 82	2,408 / 49 / 270	2,094 / 22 / 343
2014	18,121 / 92 / 1,222	11,778 / 56 / 799	1,806 / 476 / 88	2,655 / 51 / 316	1,887 / 10 / 373
2015	13,880 / 87 / 1,029	8,465 / 46 / 674	1,803 / 370 / 81	2,616 / 50 / 307	1,002 / 12 / 249
2016	13,336 / 67 / 945	8,422 / 43 / 591	1,423 / 280 / 77	2,657 / 48 / 323	838 / 13 / 227
2017	17,963 / 78 / 1,048	12,363 / 45 / 713	1,908 / 366 / 88	2,752 / 49 / 310	943 / 9 / 237
Average	20,238 / 84 / 1,149	14,643 / 61 / 808	1,704 / 377 / 82	2,336 / 52 / 254	1,559 / 21 / 314

¹ The number of trips, average landings per trip, and number of participants are from all trips that recorded southern flounder across all gear types including pound nets, gill nets, gigs, and other.

² The annual number of participants cannot be summed by gear as many individuals fish multiple gears per trip.

The greater number of participants in the gill-net and gig fisheries may be reflective of the relative lower cost of gear compared to the monetary investment required for pound nets. Effort using other gears has occasionally represented the second highest number of trips in a given year, but the average pounds per trip are low (Table 5). Unlike the major gears, southern flounder

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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catch from other gears is incidental rather than targeted (for further information see below in the *Discards and Bycatch of Southern Flounder* section). The number of trips and participants in the fishery can be dependent on the weather as well as management regulations.

Landings by Season and Waterbody

Commercial southern flounder landings and average dockside value, as well as the average price per pound in North Carolina, vary by season. The southern flounder commercial fishery typically begins with the gig fishery in the early summer in the southern part of the state (Core Sound south) as fish availability is high and good weather allows for increased water clarity necessary for giggers to see flounder when operating at night. During the late summer months, the gill net fishery intercepts the southern flounder that overwintered in the estuaries and have grown to legal size. Gill net harvest typically begins in the western portions of the river systems in Pamlico and Albemarle sounds shifting downstream and eastward as the fish migrate (NCDMF 2019; see the *Achieving Sustainable Harvest* issue paper).

During the fall, flounder migrate into the ocean to spawn, influencing both the harvest in the gill net and pound net fisheries. Although gill nets and gigs are mobile gears that can follow fish, the fall migration coincides with peak harvest for gill nets and pound nets. Pound nets are a passive gear that rely on the migration to be productive. Therefore, the flounder pound net fishery is not active until the fall migration begins. For pound nets, harvest typically begins in Currituck Sound in late August and early September following a north to south migration pattern, with Core Sound harvesting flounder through November after the northern portion of the fishery has ended (NCDMF 2019; see the *Achieving Sustainable Harvest* issue paper).

Data from the NCTTP include the waterbody in which the majority of the catch was caught during each trip. The Albemarle Sound Region (includes Albemarle, Croatan, Roanoke, and Currituck sounds as well as Alligator, Chowan, Pasquotank, Perquimans, and Roanoke rivers, and Back Bay) and the Pamlico Sound Region (includes Pamlico Sound and Neuse, Pamlico, Pungo, and Bay rivers) accounted for 76% of the total southern flounder harvest from 2008 to 2017 (Table 6). During this time period, the average real dockside value was marginally greater in the Pamlico Sound Region. Real prices account for inflation by adjusting all values to a pre-determined base-year, allowing prices across different years to reflect the same monetary value.

Commercial Discards and Bycatch of Southern Flounder

Since 2016, the minimum size limit to harvest southern flounder in the commercial fishery has been 15 inches TL. Management measures, such as yardage restrictions, soak times, minimum mesh size requirements, and pound net escape panels, are used to minimize discards (NCDMF 2019). Any undersized southern flounder that are caught must be immediately returned to the water (regulatory discard). Discards of undersized flounder primarily occur from gill nets, pound nets, gigs, and shrimp trawls. In addition to regulatory discards, some legal-sized fish are discarded because they may not be marketable due to the presence of injuries or sores (unmarketable discards).

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

Table 6. Commercial southern flounder landings (millions of pounds) and average dockside price per pound by area, 2008–2017. Numbers in parentheses are the percent of the total landings for each area for a given year. (Source: North Carolina Trip Ticket Program)

Year	Albemarle Sound Region	Pamlico Sound Region	Core Sound and South	Statewide
2008	1.2 (44%) / \$2.15	0.8 (31%) / \$2.23	0.6 (25%) / \$2.13	2.7 / \$2.17
2009	1.1 (44%) / \$1.91	0.9 (37%) / \$1.95	0.5 (20%) / \$1.90	2.5 / \$1.92
2010	0.4 (27%) / \$2.14	0.9 (51%) / \$2.23	0.4 (23%) / \$2.14	1.7 / \$2.19
2011	0.1 (7%) / \$2.15	0.8 (63%) / \$2.20	0.4 (30%) / \$2.23	1.3 / \$2.21
2012	0.7 (40%) / \$2.68	0.6 (37%) / \$2.77	0.4 (23%) / \$2.64	1.7 / \$2.70
2013	0.9 (40%) / \$2.48	0.9 (43%) / \$2.69	0.4 (17%) / \$2.62	2.2 / \$2.59
2014	0.5 (32%) / \$2.84	0.8 (48%) / \$2.90	0.3 (20%) / \$2.97	1.6 / \$2.89
2015	0.3 (28%) / \$3.15	0.5 (44%) / \$3.17	0.3 (28%) / \$3.21	1.1 / \$3.18
2016	0.2 (20%) / \$3.99	0.4 (50%) / \$4.04	0.3 (30%) / \$4.02	0.9 / \$4.02
2017	0.3 (23%) / \$4.02	0.7 (50%) / \$4.08	0.4 (27%) / \$2.23	1.4 / \$4.06
Average	0.6 (33%) / \$2.75	0.7 (44%) / \$2.89	0.4 (23%) / \$2.79	1.7 / \$2.79

*Percentages may not total 100% due to rounding.

Pound Nets

Data are not available to estimate discards or post-release mortality of southern flounder from commercial pound nets. However, this fishery is known to have discards (unmarketable and regulatory). While the magnitude is unknown, post-release mortality is assumed to be relatively low. Pound nets capture fish by entrapment, as opposed to gilling or entanglement, so southern flounder discards, when culled in a timely and careful manner, can be released with a high likelihood of survival. Additionally, pound nets that are permitted as a “flounder pound net” are required to have escape panels. The escape panels consist of large-mesh [a minimum of 5.75-inch stretch mesh (ISM)] webbing and must be placed in all four bottom corners of the pound. The required minimum mesh size in the panel is adequate to allow a large portion of undersized southern flounder to escape while larger legal sized flounder are retained (Brown 2014; NCDMF 2017).

Gill Nets

Gill-net bycatch of undersized and unmarketable southern flounder commonly occurs in both large-mesh and small-mesh anchored estuarine gill nets. Since January 2016, gill nets landing southern flounder have been required to have a minimum stretched mesh size of six inches to minimize bycatch of sub-legal southern flounder. Commercial gill-net discards are monitored through onboard observers in the estuarine gill-net fishery.

Discard data from the observer program were used to calculate estimates of bycatch, both at-net mortality and post-release mortality, including years prior to the origination of the observer program. These estimates were incorporated into the most recent stock assessment (Flowers et al.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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2019). Commercial southern flounder dead discard estimates (fish dead at time net was fished) ranged from a low of just over 4,179 fish in 2017 to over 87,410 fish in 1994 (Figure 12). In addition to the dead discards encountered at the net, post-release or delayed mortality (assumed to be 23% in stock assessment, Lee et al. 2018) associated with the release of live discards ranged from a low of 5,003 fish in 2011 to a high of 40,441 fish in 2008.

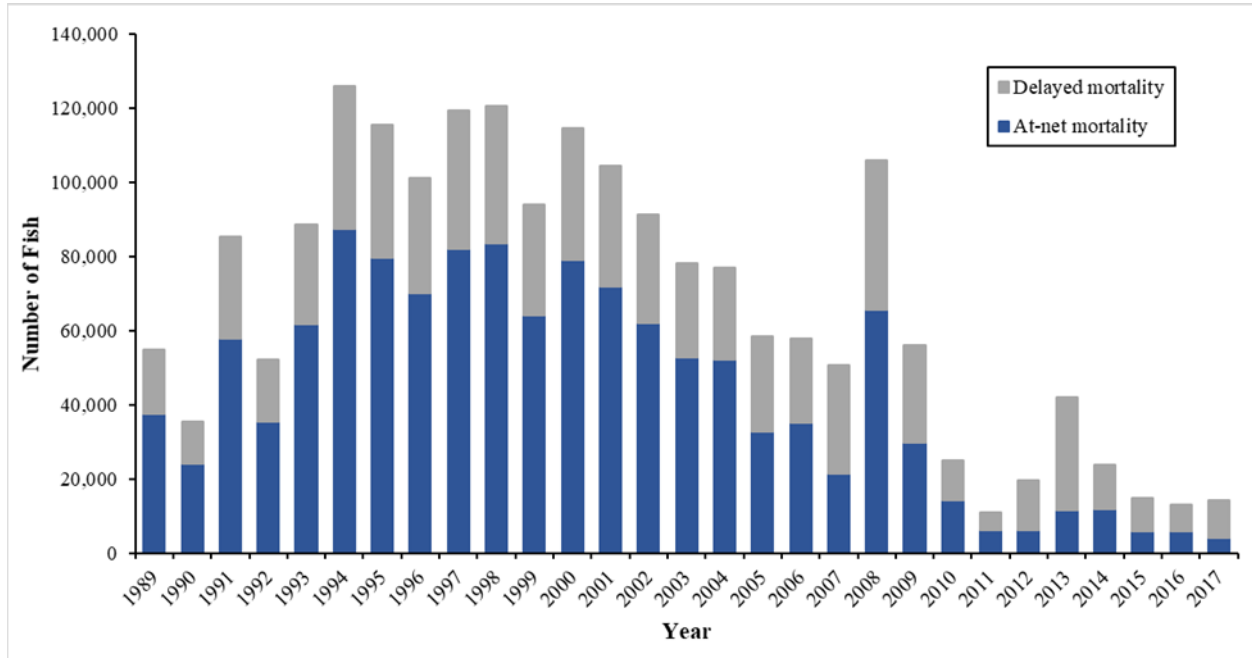


Figure 12. Estimated number of dead discards associated with the North Carolina commercial estuarine gill net fishery, 1989-2017.

Gigs

Due to size limits, regulatory discards in this fishery occur and post-release mortality is assumed to be 100%. Discard estimates in the commercial gig fishery are unknown.

Other Gears (Non-Target)

Marketable legal southern flounder from other gears (e.g., crab and peeler pots, crab and shrimp trawls, channel nets, fyke nets, and haul seines) that are retained (incidental catch) from these gears makes up less than 2% of the total commercial landings and has declined over the last 10 years (Table 7, Figure 13). From 2008 to 2017, approximately 55% of southern flounder harvested as incidental catch came from the crab and shrimp pot fishery, with landings from the shrimp and crab trawl fishery making up the second largest portion of southern flounder sold as bycatch. Since 2014, landings from trawls have been slightly higher than pots.

The portion of bycatch that is returned to the sea (discarded catch) due to economic, legal, or personal considerations is more difficult to quantify. Discard data are not available for many of the non-targeted fisheries that catch southern flounder. However, studies indicate that flounder species are captured as bycatch in the blue crab pot fishery, with a survival rate exceeding 85%

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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(Doxey 2000; Thorpe et al. 2005). Currently, there are no management measures requiring the use of bycatch reduction devices in crab pots; however, the use of these devices in a tidal marsh creek in Virginia has been shown to be highly effective at excluding fish as bycatch (Morris et al. 2011).

Table 7. Pounds of southern flounder landed as bycatch in commercial non-major (“Other”) gears, 2008–2017.

Year	Gear					Total Bycatch Landings	Total Commercial Landings
	Pots (crab & shrimp)	Trawls (crab & shrimp)	Fyke Nets	Channel Nets	Misc.		
2008	34,158	21,379	903	463	5,385	62,288	2,602,390
2009	29,091	28,874	654	32	2,046	60,697	2,396,240
2010	17,493	10,073	179	853	1,045	29,643	1,689,557
2011	5,275	8,963	38	162	795	15,232	1,247,450
2012	39,602	4,647	66	783	513	45,611	1,646,137
2013	30,080	13,549	292	395	331	44,646	2,186,391
2014	5,883	9,425	389	309	552	16,556	1,673,511
2015	2,256	3,451	4,538	215	207	10,666	1,202,885
2016	2,265	5,138	1,128	155	441	9,127	897,765
2017	2,492	3,429	80	161	552	6,714	1,394,617
Total	168,595	108,929	8,267	3,525	11,864	301,180	16,936,944
Percentage of Bycatch Only Landings	56	36	3	1	4	100	
Percentage of Total Commercial Landings	1	1	0	0	0	2	100

In North Carolina’s shrimp trawl fishery, southern flounder represented 1% to 33% of the regulatory discards in the estuarine otter and skimmer trawls and ocean shrimp trawl fishery (Brown 2009, 2010a, 2010b, 2015, 2016; Brown et al. 2019). In an effort to minimize the discard of sublegal flounder in the shrimp trawl fishery, the 2006 Shrimp FMP initiated management measures limiting the total combined headrope length to 90 ft in the mouths of the Pamlico and Neuse Rivers and all of Bay River, as well as restricting the use of otter and crab trawls above the Highway 172 Bridge in the New River (NCDMF 2015). More recently, the NCMFC voted to require fishermen to use one of four gear combinations in the Pamlico Sound and portions of Pamlico, Bay, and Neuse rivers, which were tested by an industry workgroup and achieved at least a 40% reduction of finfish bycatch (NCDMF 2018; Brown et al. 2019).

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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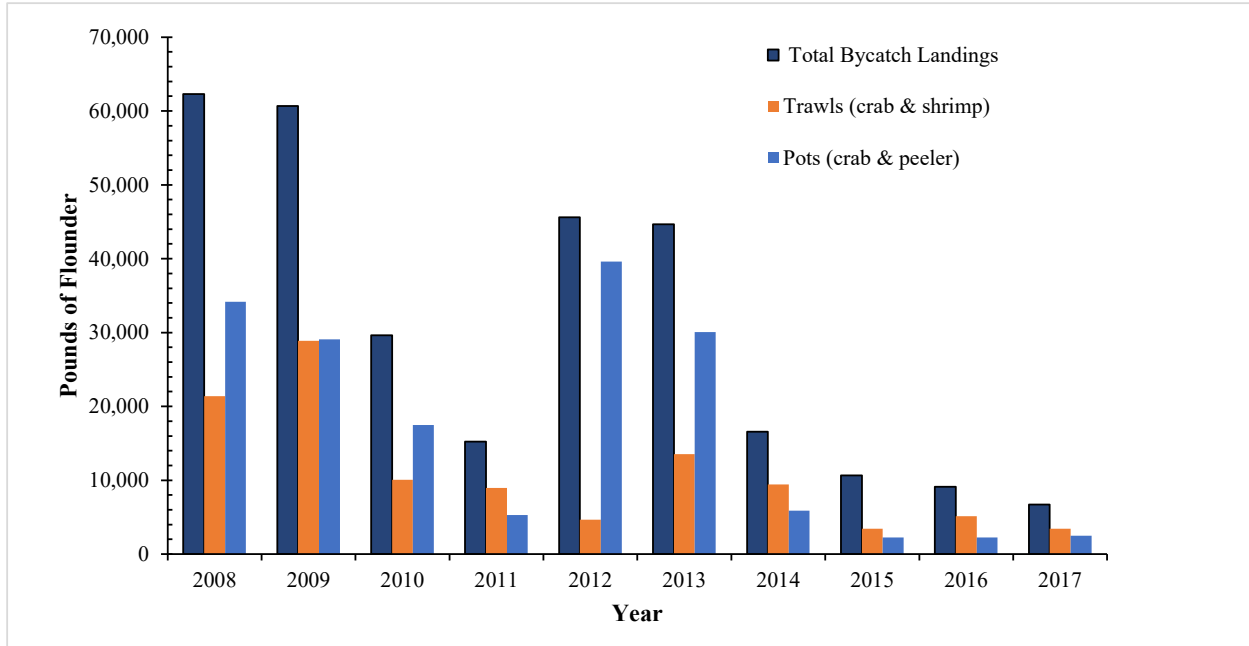


Figure 13. Pounds of southern flounder harvested as bycatch from commercial crab and peeler pots, crab and shrimp trawls, channel nets, fyke nets, and haul seines, 2008–2017. (Source: North Carolina Trip Ticket Program)

Discard data from North Carolina’s shrimp trawl observer program were used to help estimate bycatch rates of southern flounder in the U.S. South Atlantic shrimp trawl fishery. Results indicate a general decline in bycatch of southern flounder as well as fishing effort from 1989 to 2017. Discards from the shrimp trawl fishery were found to contribute minimally to the overall catch and were not found to bias the results of the 2019 stock assessment for southern flounder in the South Atlantic (Lee et al. 2018; Flowers et al. 2019).

Summary of Economic Impact of Commercial Fishing

As one of the largest commercial fisheries in the state, the southern flounder fishery is a strong economic driver for the industry. From 2008 to 2017, the average southern flounder fishery consistently included over 1,000 participants except for 2016 (Table 8). Additionally, during this period the ex-vessel value of southern flounder harvest was, on average, 5% of the total value of all commercial seafood landings in the state (NCDMF 2020).

More broadly, an economic impact assessment of the commercial southern flounder fishery helps demonstrate its influence on the state economy. Using IMPLAN modeling software along with expenditure estimates from National Oceanic and Atmospheric Administration’s (NOAA) 2016 Fisheries Economics of the U.S. (FEUS) report, the indirect impacts of the southern flounder fishery to the state economy at-large can be estimated (IMPLAN 2013). For a detailed explanation of the methodology used to estimate the economic impacts refer to the division’s License and Statistics Section Annual Report (NCDMF 2020).

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

Table 8. Economic impacts associated with commercial southern flounder fishery in North Carolina, 2008–2017. Data below represent the actual effort data from southern flounder harvest, along with the estimated economic impacts to North Carolina using IMPLAN statistical software. Data from the 2016 NOAA Fisheries Economics of the U.S. report, along with internal division survey data, are also used to generate estimates. Note: impact estimates across categories are not additive.

Year	Pounds Landed	Ex-vessel Value	Participants	Estimated Sales Impact	Estimated Income Impacts	Estimated Employment Impact	Estimated Value Added Impact
2008	2,602,390	\$5,650,295	1,235	\$25,473,137	\$10,483,954	1,544	\$19,654,727
2009	2,396,240	\$4,609,932	1,299	\$20,547,716	\$8,550,927	1,545	\$16,161,407
2010	1,689,557	\$3,695,889	1,182	\$15,743,327	\$6,531,811	1,380	\$12,223,365
2011	1,247,450	\$2,753,128	1,039	\$11,771,643	\$4,884,958	1,186	\$9,140,235
2012	1,646,137	\$4,451,482	1,202	\$18,795,084	\$7,827,308	1,440	\$14,613,360
2013	2,186,391	\$5,673,190	1,286	\$23,172,478	\$9,654,261	1,591	\$17,977,144
2014	1,673,511	\$4,839,672	1,222	\$19,547,618	\$8,134,986	1,482	\$15,109,459
2015	1,202,885	\$3,823,567	1,029	\$15,852,258	\$6,621,987	1,235	\$12,379,619
2016	897,765	\$3,610,533	945	\$10,724,064	\$6,301,409	1,129	\$11,716,727
2017	1,394,617	\$5,655,751	1,048	\$20,489,984	\$9,494,322	1,335	\$17,676,161
Average	1,693,694	\$4,476,342	1,149	\$18,211,731	\$7,848,592	1,387	\$14,665,220

The impact estimates of the commercial southern flounder fishery from 2008 to 2017, taking into account ex-vessel revenues, participants, NOAA FEUS expenditure modifiers, and division socioeconomic survey data are shown in Table 8. Overall, the large economic impact of southern flounder to the state’s commercial fishing industry is also reflected in its effect on the state economy. Total impacts vary slightly year-to-year, though these values remain relatively consistent from a state-impact perspective. Additionally, it should be noted that the economic activity generated by commercial southern flounder fishing supports over 1,000 additional full- and part-time jobs in the state.

Lastly, within the direct impacts that effort and production have on the value of the commercial flounder industry, there are several other factors that can dictate the total economic impact of this fishery at any time, both on a broader market level and individual product level. As a popular seafood across the country, the value of flounder in North Carolina is influenced by broader trends of supply and demand. There is a wide range of competitive substitutes for North Carolina flounder, including flounder caught in other states, as well as seafood products with comparatively similar properties, such as halibut (*Hippoglossus spp.*) or sole (*Solea spp.*). Because of this, the value of flounder in North Carolina is not just influenced by the availability of the product in-state, but also the regulations, seasons, and effort for the harvest of flounder and substitute products across the world. However, as flounder is such a popular fish with a number of available substitutes, it is difficult to accurately track how supply of other products directly influences prices in the state.

In addition to the broader dynamics of supply and demand that can influence North Carolina’s flounder market, there are also specific factors that can adjust product value on different time

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

scales. Method of catch can often influence prices, as consumers will seek product caught with gears that are perceived as more environmentally friendly, or gears that produce higher-quality flounder (Asche and Guillen 2012). This can lead to increased prices on flounder caught with certain gears.

Additionally, enterprise-level marketing can often impact product value. Both fishermen and dealers have the ability to market their business and product how they wish. When marketing strategies are successful, prices can be raised and value can increase, though this is on an individual level and demonstrates the volatility within the market. Such changes in value can be demonstrated by the positive effects that local product branding and direct-to-consumer strategies have produced in North Carolina (NCREDC 2013; Stoll et al. 2015). While these are just two examples of the variety of factors that can influence the value of North Carolina's flounder industry, they help demonstrate the complicated dynamics at play, as well as the fact that many factors driving the price of flounder are not dictated by fishery managers, but by consumers and producers within the market itself.

RECREATIONAL FISHERY

Southern flounder, or flounder species in general, are one of the most sought-after recreational species in North Carolina. Southern flounder are taken by recreational anglers using hook and line, gigs, and gill nets. Southern flounder are caught year-round, but most southern flounder harvest occurs during the summer and fall. Depending on the season, anglers fish for southern flounder in inland and coastal waters, including the surf, inlets, and nearshore waters of the Atlantic Ocean along live bottom reefs and wrecks. It should be noted that southern, summer, and Gulf flounder are currently managed as an aggregate fishery for the recreational sector. Additional discussion on species-specific management and implications of management as an aggregate can be found in the *Increased Recreational Access* issue paper.

In North Carolina, recreational landings and effort statistics for southern flounder are obtained through three fishery dependent survey programs; the Marine Recreational Information Program (MRIP), the Gig Mail Survey, and the Recreational Commercial Gear License (RCGL) Survey. A RCGL allows the use of limited amounts of commercial fishing gear in coastal fishing waters for recreational purposes. These surveys produce estimates of effort and catch with an associated measure of variability (proportional standard error; PSE). As with the commercial fishery, southern, summer, and Gulf flounder are all encountered through MRIP, the Gig Mail Survey, and the RCGL Survey.

Recreational Fishery Data Collection

Marine Recreational Information Program (MRIP)

The MRIP is a national program administered through NOAA Fisheries that uses several surveys to obtain catch and effort data at a regional level. The Access Point Angler Intercept Survey (APAIS) provides the catch rates and species composition from anglers fishing in estuarine or marine waters (not freshwater). Anglers who have completed a fishing trip are intercepted and interviewed to gather catch and demographic data, including fishing mode (charter boat,

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private/rental boat, beach/bank, and man-made structures), area fished, and wave (each two-month sampling period).

The MRIP implemented the Fishing Effort Survey (FES) in 2018, an improved methodology of the prior effort survey (Coastal Household Telephone Survey). The data from the APAIS and FES are combined to provide estimates of the total number of fish caught, released, and harvested. Additionally, information is collected on the weight of the harvest, total number of trips, and the number of people participating in marine recreational fishing. For additional information on MRIP see <https://www.fisheries.noaa.gov/topic/recreational-fishing-data>.

Flounder landings reported through MRIP are available to the species level through direct observation; however, releases are not observed and therefore are only available at the genus level, which includes southern, summer, and Gulf flounder. To properly estimate species level releases, a ratio of flounder species is obtained from the observed catch through MRIP and applied to the unobserved releases at the corresponding time of year, wave, and fishing area. For further information on species composition and discussion see the *Increased Recreational Access* issue paper.

Mail Surveys: Gig Survey and Recreational Commercial Gear License Survey

Gears other than hook and line, such as flounder gigs and the recreational use of commercial gear, are under-represented within MRIP sampling. The division implemented the RCGL Survey in 2002 and the Coastal Angling Program (CAP) Recreational Giggling Mail Survey in 2010. For additional information on these Giggling Mail Survey see the License and Statistics Annual Report at <https://deq.nc.gov/about/divisions/marine-fisheries/science-and-statistics/fisheries-statistics>.

The implementation of a mandatory recreational saltwater fishing license in 2007 (Coastal Recreational Fishing License, CRFL) for the harvest of all finfish provides an opportunity to survey participation in gigging at the time of license purchase. The ongoing Gig Mail Survey began in 2010 to collect data on effort and catch. For the gig survey, no observed catch is available, thus harvest is estimated at the genus level and includes all three flounder species. For further information on species composition and discussion see the *Increased Recreational Access* issue paper.

For eight years (2001-2008), two mail surveys of RCGL holders were conducted. Effort information such as seasonal activity, trip number estimates, and monetary expenditures were categorized by gear type and recorded. Additionally, species-specific information such as catch (both harvested and discarded) and target species was also obtained (NCDMF 2009).

Hook-and-Line Fishery

Regulatory measures have strongly influenced the species composition of flounder harvested recreationally in North Carolina. Summer flounder dominated harvest until a size limit change from 13 to 14 inches TL in 2002 redistributed the species composition towards southern flounder. In 2011, a 15-inch TL size limit for the recreational fishery was implemented for all

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waters within North Carolina, which resulted in a downward trend for both southern and summer flounder (Figure 14). North Carolina represents the second largest proportion of recreationally harvested southern flounder in the U.S. South Atlantic using hook-and-line gear (Figure 15).

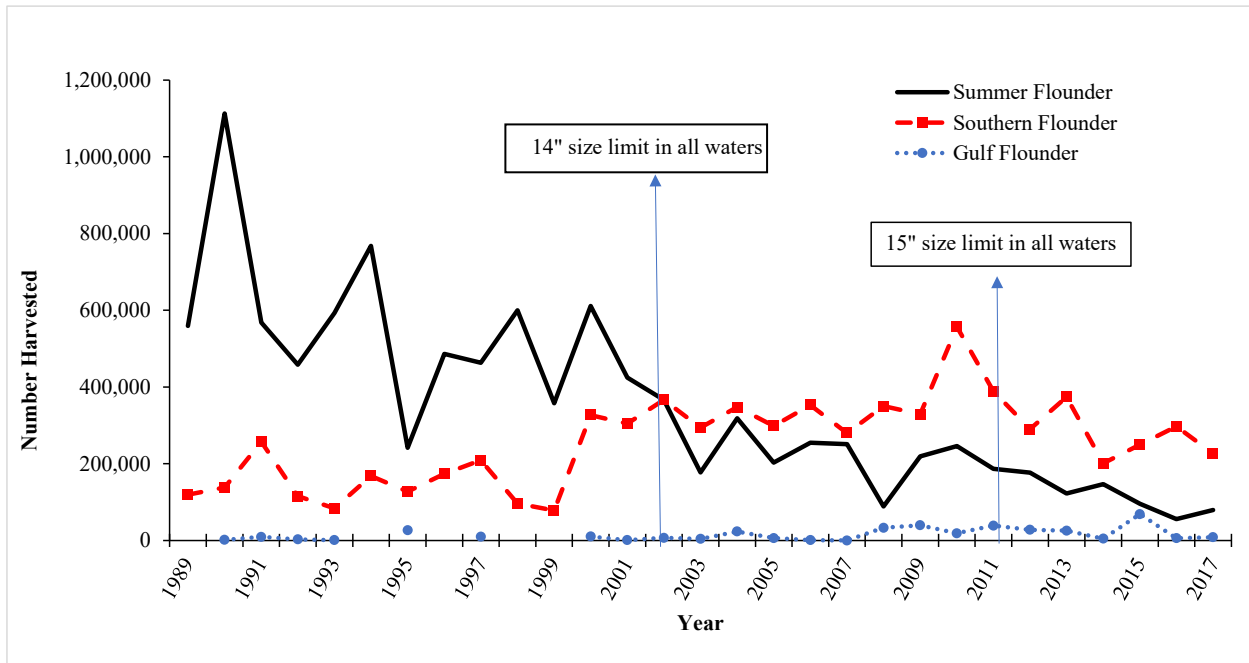


Figure 14. Distribution of flounder species harvested recreationally in North Carolina, 1989–2017. (Source: Marine Recreational Information Program)

In the North Carolina recreational hook-and-line fishery, flounder species have been the most often reported target species in 20 of the last 37 years (Figure 16). Many flounder are also taken during trips when anglers are targeting other species, such as spotted seatrout and red drum. The recreational hook-and-line fishery accounted for 89% of total recreational flounder harvest in 2017.

Anglers catch southern flounder using an array of artificial and natural baits. Preferred artificial baits include soft bodied lures of various colors and shapes fished on the bottom. Bottom fishing using natural live baits (mullet, menhaden, mud minnows, and shrimp) is popular and productive, as well. The recreational harvest of southern flounder exhibits a distinct seasonality that is concentrated between May and October (Figure 17).

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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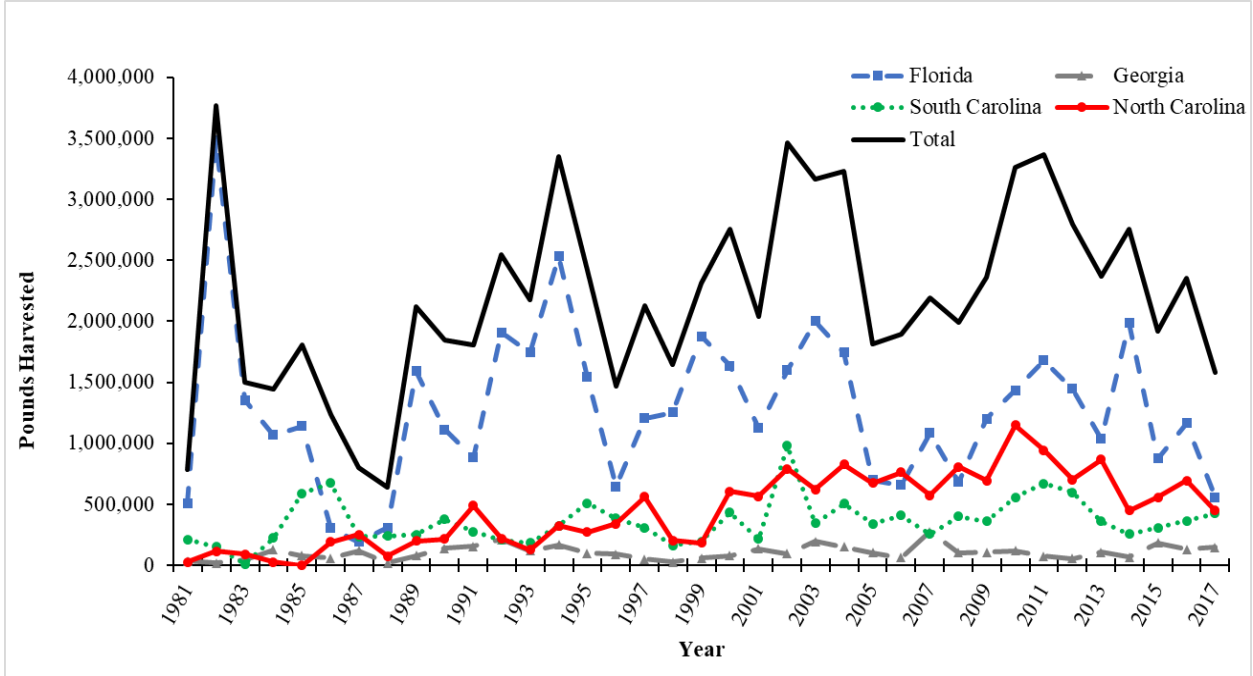


Figure 15. Hook-and-line recreational harvest of southern flounder (in pounds) estimated by MRIP for North Carolina through the east coast of Florida, 1981–2017. (Source: Marine Recreational Information Program)

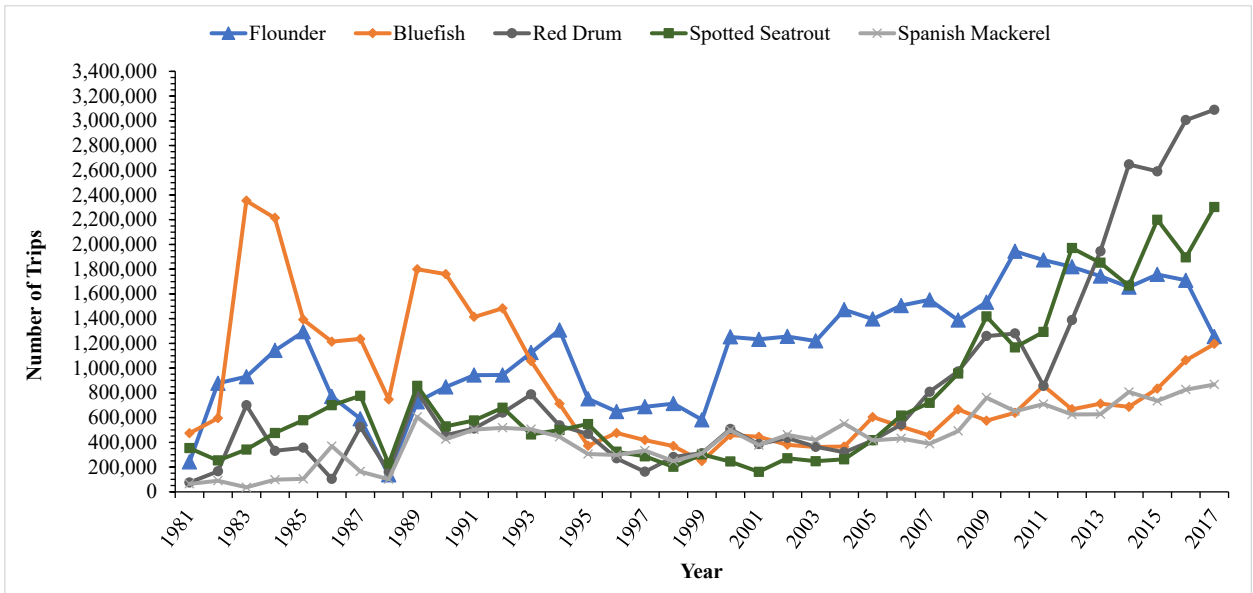


Figure 16. Recreational hook-and-line trips targeting five top species in North Carolina 1981–2017. (Source: Marine Recreational Information Program)

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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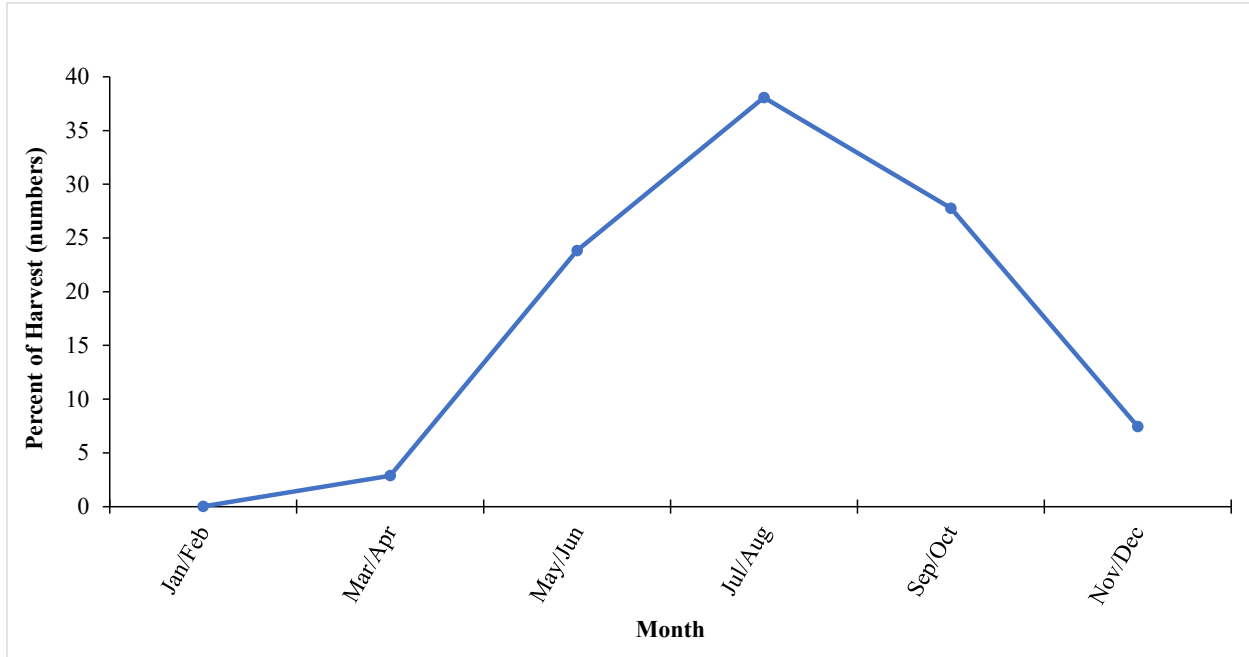


Figure 17. Seasonality of southern flounder recreational harvest in North Carolina, 1981–2017. (Source: Marine Recreational Information Program)

For further information on recreational landings see the *Achieving Sustainable Harvest* and the *Increased Recreational Access* issue papers.

Gig Fishery

The recreational gig fishery accounted for 11% of total recreational flounder harvest in 2017. Effort estimates for 2008 through 2017 ranged from 13,524 to 25,666 trips annually, while harvest estimates ranged from 24,136 to 54,419 fish. Spatially, over 87% of giggering trips originated from Carteret County and south. Like the hook-and-line fishery, an increase in giggering trips was observed from May through October with a peak in harvest in the summer. For a more detailed description of the recreational gig fishery see the License and Statistics Annual Report and the *Achieving Sustainable Harvest* issue paper.

RCGL Fishery

Data on RCGL gears are only available from 2002 to 2008 due to funding being cut for the RCGL survey. Among the allowed gears, large-mesh gill nets comprised 74% of southern flounder harvest, with small-mesh gill nets (21%), crab pots (4%), and shrimp trawls (1%) constituting the remainder (NCDMF 2009). The number of flounder species (southern, summer, and Gulf) harvested between 2002 and 2008 ranged from 18,414 to 53,785 fish or 100,514 pounds in 2002 down to 37,315 pounds in 2008. The number of licensed individuals participating in the RCGL fishery has steadily decreased from approximately 6,000 in 2000 to 1,800 in 2017 (Figure 18). This is the best indicator currently available of declining effort in the RCGL fishery. For additional information on licenses see the License and Statistics Annual

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Report or for RCGL survey analysis see the 2009 License and Statistics Annual Report (NCDMF 2009).

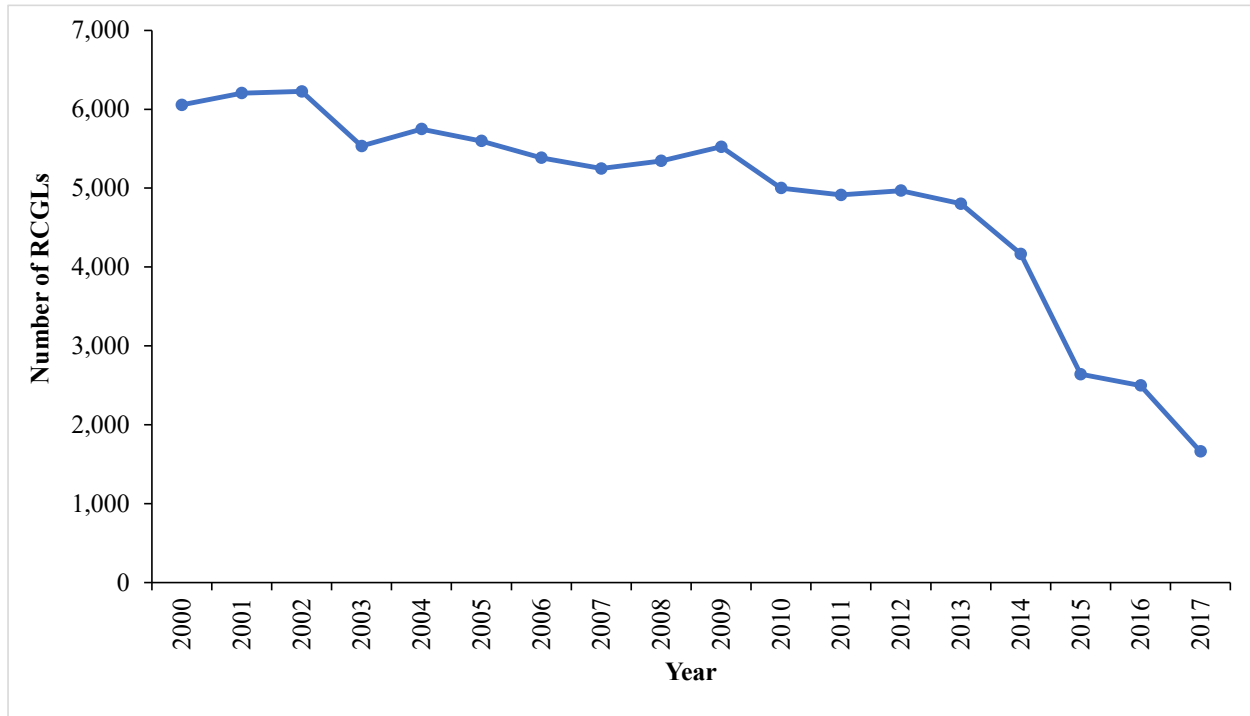


Figure 18. The number of Recreational Commercial Gear Licenses (RCGL) issued 2000–2017. (Source: NCDMF License and Statistics Annual Report)

Recreational Discards and Bycatch of Southern Flounder

The minimum size limit to harvest southern flounder is 15 inches TL. Any southern flounder not legal for harvest must be immediately returned to the water. Primary gears used by recreational fishermen that capture southern flounder include hook-and-line and gigs.

Hook-and-line is the primary gear for taking southern flounder for recreational purposes in North Carolina. North Carolina represents the largest recreational proportion of released flounder in the U.S. South Atlantic (Figure 19). This is driven by the aforementioned regulatory measures. Specifically, the increase in size limit to 15 inches TL in 2011 resulted in a ratio of nine discarded fish for every one fish harvested in North Carolina (Figure 19). In contrast, a 12-inch TL size limit in Florida was allowed prior to March 2021 and the ratio of discard to harvest to was approximately 1:1.

The stock assessment assumes a post-release mortality for hook-and-line released southern flounder of 9% (See Section 2.1.4 in Flowers et al. 2019, <https://files.nc.gov/ncdeq/Marine-Fisheries/fisheries-management/southern-flounder/2019-4-sarSouthernFlounder.pdf>). The post-release mortality and magnitude of discards in this fishery make these removals a major contributor to the overall fishing mortality being experienced by this stock. In recent years, post-release mortality associated with recreational releases is nearly equal to the number of removals from recreational harvest.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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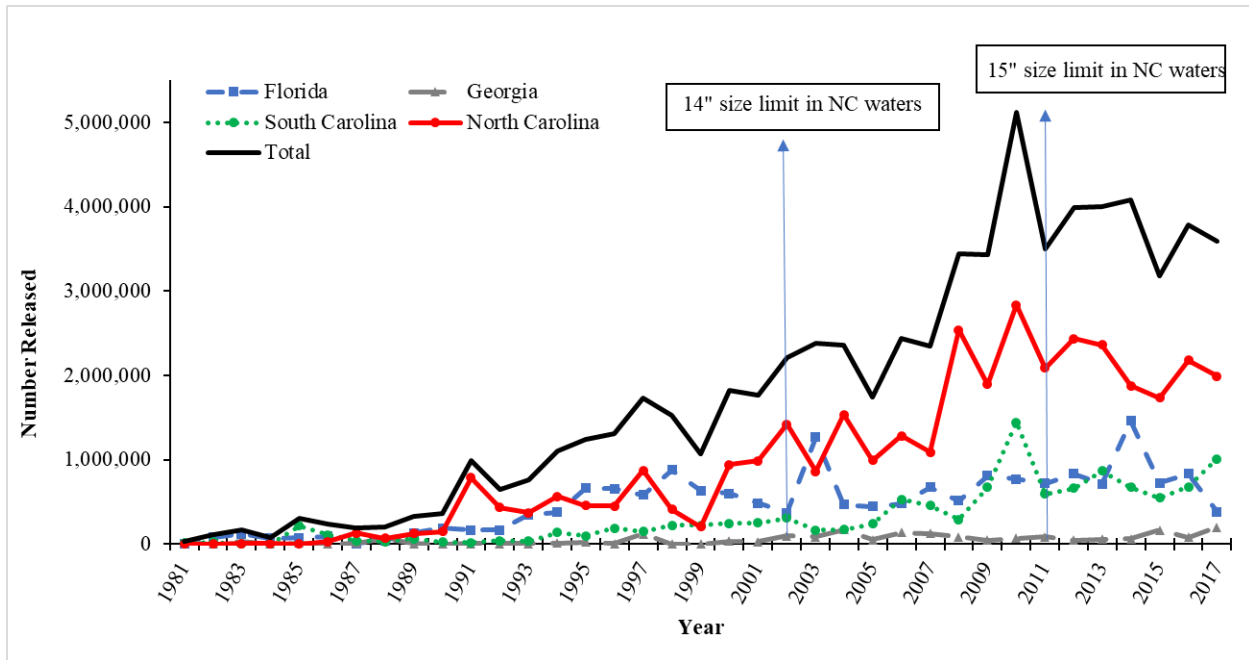


Figure 19. Ratio of the number of southern flounder released compared to harvested in the recreational hook-and-line fishery as estimated through MRIP for North Carolina through the east coast of Florida, 1981–2017. (Source: Marine Recreational Information Program)

In the recreational gig fishery, discard estimates are available from 2010 to 2017 through a division-led mail survey on recreational flounder gigging. This survey estimates the number of trips, as well as southern flounder harvest and discards (See Section 2.1.5 in Flowers et al. 2019, <https://files.nc.gov/ncdeq/Marine-Fisheries/fisheries-management/southern-flounder/2019-4-sarSouthernFlounder.pdf>). Discard estimates ranged from 655 to 9,726 fish annually and represent only a small portion (less than 1%) of the overall removals from the recreational fishery.

Between 2002 and 2008, the number of discarded flounder species from RCGL gears ranged from approximately 15,000 to 52,000 fish (NCDMF 2009). Large- and small-mesh gill nets contributed 58.9% of discards throughout the time series. Despite making up a small portion of the overall trips (4.8%) and harvest (1.2%), shrimp trawls disproportionately contributed to discards of southern flounder. Flounder discards from shrimp trawls ranged from 15.1 to 51.2% and averaged 31.7% of all flounder discards from RCGL gears for the time series (NCDMF 2009).

Demographic Characteristics

The average angler participating in recreational harvest of southern flounder in North Carolina is a male older than 47 (NCDMF, unpublished data). Anglers targeting or harvesting southern flounder represented all 100 North Carolina counties, all 50 states, and the District of Columbia (Table 9). Anglers harvest southern flounder by three different modes: shore; for-hire boats; and

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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private boats. Private boat anglers harvest the largest volume of southern flounder in the recreational fishery (Figure 20). Due to low sample sizes and high PSE, southern flounder data from the for-hire industry are limited. Data indicate that the for-hire fleet capture flounder at a higher rate than the recreational fishery suggesting that impact on a per angler basis tends to be higher by the for-hire industry.

Table 9. Contribution of North Carolina counties and other states to recreational flounder fisheries according to three sources of data: Access Point Angler Intercept Survey (APAIS), Recreational Commercial Gear License Survey (RCGL), and Gig Mail Survey.

Categories	APAIS		RCGL		Gig Mail Survey	
	Counties/States	%	Counties/States	%	Counties/States	%
Top 10 Counties	New Hanover	11.3	Craven	9.3	Wake	7.61
	Dare	6.4	Carteret	7.4	New Hanover	6.94
	Brunswick	6.1	New Hanover	6.9	Carteret	5.56
	Carteret	4.5	Beaufort	6.1	Onslow	4.64
	Wake	3.8	Brunswick	5.9	Brunswick	3.98
	Onslow	3.2	Wake	5.2	Johnston	3.08
	Pitt	2.2	Pitt	4.8	Pender	3.07
	Craven	2.1	Onslow	4.3	Craven	2.99
	Pender	2.1	Pamlico	4.1	Guilford	2.63
	Guilford	1.8	Dare	3.7	Dare	2.58
Top 5 Other States	Virginia	10.3	Florida	0.2	Virginia	2.39
	Pennsylvania	2.9	Pennsylvania	0.2	South Carolina	1.06
	Maryland	2.3	Tennessee	0.2	Pennsylvania	0.48
	South Carolina	1.0	California	0.2	Maryland	0.34
	New Jersey	0.9			Georgia	0.20

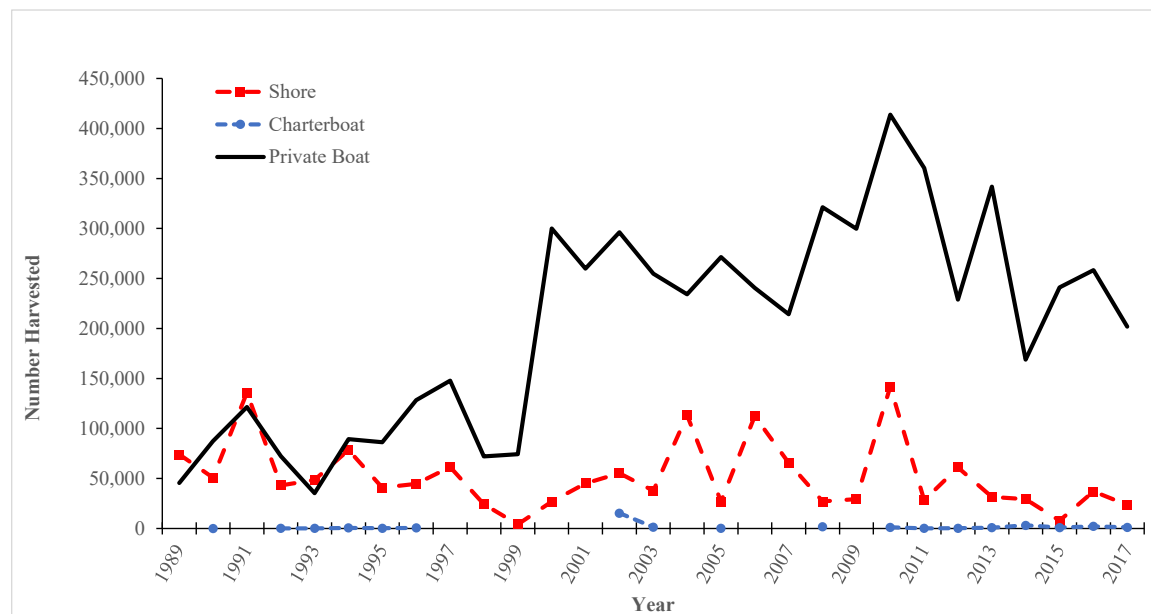


Figure 20. Number of southern flounder harvested in the recreational fishery by MRIP mode, 1989–2017. (Source: Marine Recreational Information Program)

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Summary of Economic Impact of Recreational Fishing

The economic impact estimates presented for southern flounder recreational fishing represent the economic activity generated from trip expenditures. These estimates are a product of annual trip estimations originating from the NOAA Fisheries MRIP effort data by area and by mode (i.e., shore, for-hire, private/rental vessel, and man-made), and trip expenditures estimates from the division economics program biennial socioeconomic survey of CRFL license holders (Dumas et al. 2009; Crosson 2010; Hadley 2012; Stemle and Condon 2017). The product of these estimates gives us an annual estimate of trip expenditures made by all licensed anglers for a given year. For this analysis, a recreational flounder trip is defined as a fishing trip for which any flounder was the primary or secondary target species by the angler, or if southern flounder was caught during that trip.

Additionally, these data are used to generate state-level economic impact estimates of recreational flounder fishing in North Carolina. Using IMPLAN statistical software, these direct expenditure estimates from recreational flounder fishing produce indirect output impacts to the state economy across four categories: sales, labor income, value-added impacts, and employment (IMPLAN 2013). Additionally, all imputed expenditure estimates are adjusted for inflation based on 2016 prices, as this was the most recent year of expenditure survey data. For a detailed explanation of the methodology used to estimate the economic impacts please refer to the division's License and Statistics Section Annual Report, which can be found at: <https://deq.nc.gov/about/divisions/marine-fisheries/science-and-statistics/fisheries-statistics>.

Aside from a spike in 2008 and a dip in 2017, recreational flounder effort is relatively stable over time (Table 10). With this, the economic impact from this fishery is also stable over time, as recreational flounder angling represents a sizeable contribution to the state economy. The top industries impacted by recreational southern flounder fishing in terms of output sales and employment are retail gasoline stores, retail sporting goods stores, retail food and beverage stores, real estate, and wholesale trade businesses.

It should be noted that not included in these estimates, but often presented in the division's overall recreational impacts models, are the durable good impacts from economic activity associated with the consumption of durable goods (e.g., rods and reels, other fishing related equipment, boats, vehicles, and second homes). Durable goods represent goods that have multi-year life spans and are not immediately consumable. Some equipment related to fishing is considered durable goods, however, we cannot estimate the durable goods expense of anglers for a given species. Durable goods expenses and impacts are estimated on an annual basis and serve to supplement angler expenditures outside of trip-based estimates.

Lastly, due to the size and popularity of recreational flounder fishing in North Carolina, changes in access to this fishery may lead to tangible, yet unquantifiable impacts to the value of other sport fisheries (Scheld et al. 2020). Broadly, participants target or catch flounder more than other recreational species due to higher personal satisfaction gained from fishing for this species over others in North Carolina. However, it is unknown whether this benefit from flounder fishing would transfer to other fisheries if effort restrictions were put in place. There is a possibility that when faced with reduced access to flounder fishing, some anglers may choose to not fish at all,

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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rather than seek out new target species. Alternatively, the utility of flounder fishing may not be significantly greater than other species, and anglers would target other species more frequently.

Table 10. Economic impacts associated with recreational southern flounder fishing in North Carolina from 2008–2017. Impacts are generated using IMPLAN statistical software and division recreational survey data. Trips are defined as a fishing trip for which any flounder is the primary or secondary target, or if southern flounder was caught during that trip. All job impacts represent both part- and full-time jobs. Note: impact estimates across categories are not additive.

Year	Estimated Total Flounder Trips	Trip Expenditures	Estimated Sales Impact	Estimated Income Impact	Estimated Employment Impact	Estimated Value-Added Impact
2008	2,701,930	\$403,612,123	\$376,417,686	\$135,957,566	3,292	\$205,722,681
2009	1,482,500	\$215,695,683	\$200,699,372	\$72,448,738	1,770	\$109,870,023
2010	1,877,504	\$280,546,465	\$262,481,379	\$95,039,325	2,312	\$143,569,612
2011	1,796,204	\$283,056,149	\$250,861,698	\$90,609,485	2,212	\$137,255,698
2012	1,744,458	\$277,772,559	\$244,156,371	\$88,393,860	2,159	\$133,589,470
2013	1,707,904	\$273,226,860	\$238,202,597	\$86,449,024	2,105	\$130,332,132
2014	1,639,593	\$269,763,604	\$229,373,566	\$83,466,334	2,027	\$125,444,042
2015	1,708,499	\$279,669,886	\$228,724,518	\$83,228,735	2,037	\$125,250,995
2016	1,714,200	\$279,905,674	\$232,116,853	\$84,789,195	2,079	\$127,093,283
2017	1,250,216	\$210,976,279	\$171,358,430	\$62,652,077	1,532	\$93,793,106
Average	1,762,301	\$277,422,528	\$243,439,247	\$88,303,434	2,153	\$133,192,104

Through this complicated dynamic, the value and economic impact of other recreational species may increase or decrease based on this concept of per-species utility. However, while it is important to acknowledge how flounder management may economically impact other fisheries, this interaction is not fully understood, and, therefore, it cannot be determined how the value of other recreational species would shift with changes in access to flounder.

SUMMARY OF FISHERIES CONCLUSION

Both the commercial and recreational fisheries combine to create a very dynamic southern flounder fishery in North Carolina with a combined economic value of over 600 million dollars to the state of North Carolina. Effort and harvest in the commercial fishery have continuously declined from nearly 42,475 trips in 1994 to 17,963 trips in 2017 and landings from over 4.8 million pounds in 1994 down to roughly 1.4 million pounds in 2017 (Figure 21).

The recreational sector has seen an increase in both effort and harvest and a major increase in releases since 1994, with trips remaining relatively steady from 1.31 million trips in 1994 to 1.25 million trips in 2017 and harvest increasing from 300,000 pounds in 1994 to 400,000 pounds in 2017 with over one-million pounds harvested in 2010 (Figure 21). Recreational releases have also increased through the years from 209,956 fish in 1999 to over 1.9 million fish released in 2017. Additional information describing discards is in the *Stock Assessment of Southern Flounder (Paralichthys lethostigma) in the U.S. South Atlantic, 1989-2017*, available at

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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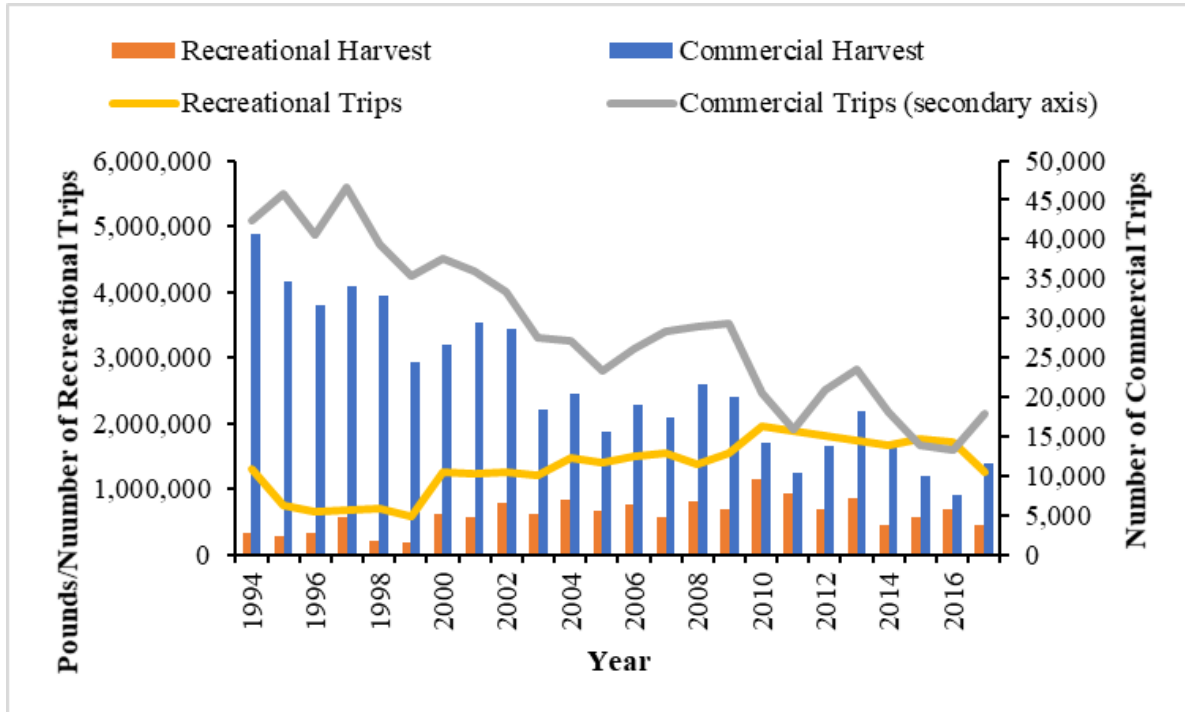


Figure 21. Commercial and recreational harvest (measured in pounds) and effort (measured in trips) from the N.C. Southern Flounder Fishery, 1994–2017. Recreational landings and trips do not include recreational commercial gear or the gig fishery due to data limitations. (Source: North Carolina Trip Ticket Program and Marine Recreational Information Program)

An in-depth analysis and discussion of North Carolina’s commercial and recreational southern flounder fisheries can be found in earlier versions of the Southern Flounder FMP (NCDMF 2005, 2013, 2017, 2019); and 2018 and 2019 Southern Flounder Stock Assessments (Lee et al. 2018; Flowers et al. 2019); all documents are available on the division website at: <https://deq.nc.gov/about/divisions/marine-fisheries/public-information-and-education/managing-fisheries/fmp>, the License and Statistics Annual Report produced by the division which can be found at: <https://deq.nc.gov/about/divisions/marine-fisheries/science-and-statistics/fisheries-statistics>, or the *Achieving Sustainable Harvest* issue paper included in this FMP.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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PROPOSED MANAGEMENT STRATEGIES UNDER SOUTHERN FLOUNDER AMENDMENT 3

See Appendix 4: Issue Papers and Appendix 5: Proposed Rules

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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RESEARCH RECOMMENDATIONS

The research recommendations listed below are offered by the PDT and the stock assessment working group to improve future management strategies and stock assessments of the South Atlantic southern flounder stock. Those recommendations followed by an asterisk (*) were identified as the top five high priority research recommendations and are discussed further below. Otherwise, recommendations within each category, High (H), Medium (M), Low (L), are not listed in order of importance.

Biological/Stock Assessment/Fishery

- H - Conduct studies to quantify fecundity and fecundity-size/age relationships in Atlantic southern flounder. *
- H - Improve estimates of the discard (B2) component (catches, lengths, and ages) for southern flounder from MRIP (underway). *
- H - Expand, improve, or add fisheries-independent surveys of the ocean component of the Stock. *
- H - Determine locations of spawning aggregations of southern flounder (underway). *
- H - Complete an age validation study using known age fish. *
- H - Research and evaluate data on the sub-legal fish in the recreational fishery as it relates to potential future reductions in minimum size limits (underway).
- M - Promote data sharing and research cooperation across the South Atlantic southern flounder range (North Carolina, South Carolina, Georgia, and Florida).
- M - Further research on factors that impact release mortality of southern flounder in the recreational hook-and-line fishery.
- M - Research on deep hooking events of different hook types and sizes on southern flounder.
- M - Coast-wide at-sea observations of the flounder pound net fishery.
- M - Develop a survey that will provide estimates of harvest and discards for the recreational gig fisheries in North Carolina, South Carolina, Georgia, and Florida.
- M - Develop a survey that will provide estimates of harvest and discards from gears used to capture southern flounder for personal consumption.
- M - Collect additional discard data (ages, species ratio, lengths, fates) from other gears (in addition to gill nets) targeting southern flounder (pound net, gigs, hook and line, trawls).
- M - Expand, improve, or add inshore and offshore surveys of southern flounder to develop indices for future stock assessments.
- M - Collect age and maturity data from the fisheries-independent South East Area Monitoring and Assessment Program (SEAMAP) Trawl Survey given its broad spatial scale and potential to characterize offshore fish.
- M - Conduct studies to better understand ocean residency of southern flounder.
- M - Consider the application of areas-as-fleets models in future stock assessments given the potential spatial variation (among states) in fishery selectivity and fleet behavior in the southern flounder fishery.
- M - Consider the application of a spatial model to account for inshore and ocean components of the stock as well as movements among states.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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- M - Work to reconcile different state-level/regional surveys to better explain differences in trends.
- M - Evaluate the utility of circle hooks in the southern flounder recreational hook-and-line fishery.
- L - Develop a recreational catch per unit effort (CPUE; e.g., from MRIP intercepts or the Southeast Regional Headboat Survey if sufficient catches are available using a species guild approach to identify trips, from headboat logbooks, etc.) as a complement to the more localized fishery independent indices.
- L - Explore reconstructing historical catch and catch-at-length data prior to 1989 to provide more contrast in the removals data.
- L - Study potential species interactions among Paralichthid flounders to explain differences in population trends where they overlap.
- L - Explore potential impacts stocking may have on the southern flounder population and the costs associated with implementing a stocking program.
- L - Continued otolith microchemistry research to gain a better understanding of ocean residency of southern flounder (underway).
- L - Implement fishery dependent sampling of the commercial spear fishery for flounder in the ocean.
- L - Determine harvest estimates and implement fishery dependent sampling of the recreational spear fishery for flounder in the ocean.
- L - Further research on flatfish escapement devices in crab pots that minimize undersized flounder bycatch and maximize the retention of marketable blue crabs.
- L - Expand tagging study to ocean component of the stock to estimate emigration, immigration, movement rates, and mortality rates throughout the stock's range.
- L - Develop protocol for archiving and sharing data on gonads for microscopic observation of maturity stage of southern flounder for North Carolina, South Carolina, Georgia, and Florida.
- L - Examine the variability of southern flounder maturity across its range and the effects this may have on the assessment model.
- L - Further research on the size distribution of southern flounder retained in pound nets with 5.75-ISM and 6-ISM escape panels.
- L - Research on the species composition and size distribution of fish and crustaceans that escape pound nets through 5.75-ISM and 6-ISM escape panels.
- L - Develop a survey that will estimate harvest and discards from commercial gears used for recreational purposes.
- L - Continue at-sea observations of the large-mesh gill-net fishery including acquiring biological data on harvest and discards (underway).
- L - Develop survey that better represents the for-hire industry.

Ecosystem

- M - Development of alternative gears to catch southern flounder (some research completed, more may be needed).
- L - Continued gear research in the design of gill nets and pound nets to minimize protected

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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species interactions (some research completed, more may be needed).

- L - Investigate the impacts of warming water temperature on the southern flounder stock.
- L - Develop a study that evaluates inlets and their relationship to southern flounder migration.
- L - Develop studies to investigate the impacts of emerging compounds on southern flounder.

Socio/Economic

- M - Study revenue variability and profitability of commercial southern flounder fishing in North Carolina based on catch characteristics.
- M - Generate a stated preference survey of North Carolina recreational anglers to understand perceived value of targeting southern flounder compared to other estuarine finfish species.

Research Recommendations Summary

The top five research priorities with an (*) identify data needs for continued improvements to the coast-wide stock assessment. Gaining a better understanding of the ocean component of the stock is critical and includes gathering information on the spawning locations, expanding and developing surveys to provide independent abundance trends for the ocean component of the stock, and conducting research to identify fecundity estimates for spawning females by length. Determining the age of fish is critical when estimating maturity and stock structure so verifying the ages of wild fish through an age validation study would provide additional precision. Finally, a large component of removals from this stock is fish released during recreational fishing activities. Many of these fish are not intercepted by port agents during sampling as they are not kept. It is critical that estimates of discards by size and species are available for the various flounder species across the species range.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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APPENDICES

APPENDIX 1. MANAGEMENT ISSUES CONSIDERED BUT NOT DEVELOPED

A scoping period to solicit input on management strategies for the Southern Flounder Fishery Management Plan Amendment 3 was held Dec. 4 through Dec. 18, 2019. During this time, members of the public were encouraged to provide written comments or verbal comments at one of three in-person scoping meetings held within the scoping period. In addition, the NCMFC was provided the opportunity to offer input on management strategies at its February 2020 business meeting. The division received many comments during this scoping period, but few were relevant to potential management strategies. Comments received that were focused on a management strategy included:

- Elimination of specific gear types for the harvest of southern flounder;
- Limiting entry in the flounder pound net fishery;
- Stocking of southern flounder;
- The use of circle hooks in the recreational flounder fishery; and
- Reducing bycatch of southern flounder in the shrimp trawl fishery.

These suggested strategies were reviewed by the division during development of Amendment 3 but are not included as fully developed issue papers. A description of the management strategy and rationale for not developing them are provided for each strategy below.

Elimination of Gears Including Gigs (both sectors), Gill Nets, and RCGL

The possible elimination of specific gears (i.e., gigs for one or both sectors, anchored large-mesh gill nets) for harvesting southern flounder for either the commercial or recreational fishery is statutorily granted to the NCMFC by G.S. 143B-289.52., Marine Fisheries Commission—powers and duties, which states the NCMFC “shall have the power and duty to authorize, license, regulate, prohibit, prescribe, or restrict all forms of marine and estuarine resources in coastal fishing waters with respect to time, place, character, or dimensions of any methods or equipment that may be employed in taking fish.” Such actions follow from the NCMFC’s charge to “adopt rules to be followed in the management, protection, preservation, and enhancement of the marine and estuarine resources within its jurisdiction....” (G.S. 143B-289.52). The division provides the best available data for a fishery (gear) to meet the mandate for producing a sustainable harvest of the southern flounder stock and to evaluate impacts to habitat. Each allowable gear is similarly presented regardless of its contribution to overall removals from the stock and the division does not presume any NCMFC changes in gear use, unless directed to do so by the NCMFC, which in this case initiated the development of the *Phasing Out Anchored Large-Mesh Gill Nets from the North Carolina Southern Flounder Fishery* issue paper.

Regulations involving the RCGL are found in G.S. 113-173 and Rule 15A NCAC 03O.0302 which authorizes certain commercial fishing gear for recreational use under a valid Recreational

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Commercial Gear License. A rule change by the NCMFC is required to alter the allowable gears used by RCGL license holders.

Limited Entry in the Pound Net Fishery

G.S. 113-182.1(g) provides narrowly constrained authority to the NCMFC to limit entry into a fishery states the following:

(g) To achieve sustainable harvest under a Fishery Management Plan, the Marine Fisheries Commission may include in the Plan a recommendation that the General Assembly limit the number of fishermen authorized to participate in the fishery. The Commission may recommend that the General Assembly limit participation in a fishery only if the Commission determines that sustainable harvest cannot otherwise be achieved. In determining whether to recommend that the General Assembly limit participation in a fishery, the Commission shall consider all of the following factors:

- (1) Current participation in and dependence on the fishery
- (2) Past fishing practices in the fishery
- (3) Economics of the fishery
- (4) Capability of fishing vessels used in the fishery to engage in other fisheries
- (5) Cultural and social factors relevant to the fishery and any affected fishing communities
- (6) Capacity of the fishery to support biological parameters
- (7) Equitable resolution of competing social and economic interests
- (8) Any other relevant considerations

Flounder pound nets are a stationary gear that funnel fish along a lead and into a pound (holding area) where they are removed while the fishermen slowly bunt the net. While fish are trapped in the pound, they remain in the water until harvest. This allows fishermen to be selective about fish they harvest or release. Flounder pound nets operate from upper Currituck Sound south through Core Sound. The southern flounder pound net fishery was the dominant gear landing southern flounder into the early 1990s when large-mesh gill nets became the dominate gear. Pound nets again became the top means of southern flounder harvest in 2014. This is likely due to increased regulatory burden on the large-mesh gill-net fishery.

During the last 10 years, the average number of pound net permits issued was 285, ranging from 267 to 304. To obtain a flounder pound net permit, an individual must complete an application package and the selected site goes through a review process including a public comment period. Unlike other gears, pound nets require an extensive monetary investment and many pound net fishermen have been building their stands for multiple generations. Due to the monetary investment, permitting process, and limited productive fishing areas, there has not been a sharp increase in pound net permits. While the possibility does exist that the number of pound net applications may rise in the future, there is no evidence that limited entry is the only way to achieve sustainable harvest, as required by state law in order to pursue.

Sustainable harvest in the southern flounder fishery is predicted to be achievable within 10 years of adoption of Amendment 3 through reductions in total removals for all fisheries and gears. As

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a result, this statute cannot be employed at this time to pursue limited entry. In addition, Amendment 3 proposes implementing a commercial quota on the harvest of southern flounder, thus the volume of pound nets operating in the fishery will not impact the volume of removals, just the rate at which the quota is harvested. Once the level of harvest has been met, the fishery closes. This closure is not impacted by the number of nets that are set, although the number of pound nets in use may shorten the time in which the quota is reached.

Stocking

Stock enhancement is the stocking of fish to enhance or improve the condition or distribution of a wild stock. North Carolina State University initiated a series of workshops on flounder stock enhancement in North Carolina in the mid-1990s. This effort brought together fish ecologists, culturists, and managers from around the world and was a good forum to discuss successes and failures in aquaculture and stock enhancement. A report of these conversations was developed and outlined several research priorities that should be investigated (Waters 1998), but few if any have been investigated leaving many of the questions unanswered. These unanswered questions leave data gaps that are critical in determining if stocking is appropriate at this time for achieving a self-sustaining southern flounder population.

While management actions for southern flounder have not had the expected response in rebuilding the spawning stock biomass to necessary levels to sustain the stock, not all strategies have been attempted. Amendment 3 will expand on conventional management strategies and employ a quota system for both the commercial and recreational southern flounder fisheries for the first time. Moving forward with Amendment 3 without including stocking as a management strategy does not prohibit researchers from investigating stocking strategies for southern flounder. If more information becomes available about stocking strategies, additional consideration may be warranted during a future review of this FMP.

Use of Circle Hooks in the Southern Flounder Fishery

The use of circle hooks for multiple species was addressed by the division as directed by the NCMFC. At its August 2019 business meeting, the NCMFC directed staff to provide information on the science supporting the use of circle hooks and bent barbed treble hooks and provide input on the efficacy of requiring their use. The NCMFC passed a motion at its May 2020 business meeting directing the division to “develop an issue paper for rulemaking to require the use of barbless non-offset circle hooks when hook size relates to 2/0 or larger while using natural bait. In addition, barbs on treble hooks would be required to be bent down.” The division developed the issue paper and presented management options to the NCMFC at their February 2021 business meeting. The NCMFC voted not to move forward with rule making but instead directed the division to consider circle hook requirements on a species-by-species basis through the fishery management plan process. After a review of available literature of the effect of circle hooks on southern flounder, there is minimal research available at the species level. Inferences could be made from available literature on summer flounder that found no difference in survival rates post-release for fish captured with circle or J-hooks (Malchof and Lucy 1998). Additionally, Stuntz and McKee (2006) concluded that angler education had a greater effect on post-release survival of fish than hook type and bait configuration. Due to the lack of available

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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literature on the effect of circle hook on southern flounder, a research recommendation was added to this FMP (see the *Research Recommendations* section).

Reducing Shrimp Trawl Bycatch

Management strategies to reduce the bycatch of non-target species in the shrimp trawl fishery as well as potential changes to existing shrimp management strategies are being examined as part of the ongoing development of Amendment 2 to the N.C. Shrimp FMP. The division determined that is the most appropriate plan to address shrimp trawl bycatch. Through the original Shrimp FMP (NCDMF 2006) and Amendment 1 (NCDMF 2015), the following were implemented that are having a positive impact on reducing southern flounder bycatch in shrimp trawls.

- Portions of Core Sound (banks side north of Drum Inlet to Wainwright Island), Intracoastal Waterway (Rich Inlet to Carolina Beach), as well as the bays adjacent to the Cape Fear River and Bald Head Island were closed to trawling.
- The use of otter trawls was prohibited upstream of the Highway 172 Bridge in the New River, limiting trawling to skimmer trawls.
- A maximum combined 90 ft. headrope length was implemented in the mouths of the Pamlico and Neuse rivers and all of Bay River to minimize southern flounder bycatch and protect critical habitat used by southern flounder.
- The requirement to use two bycatch reduction devices (BRD) in shrimp trawls and skimmer trawls was implemented.
- A maximum combined headrope length of 220 feet was established in all internal coastal waters where there was no existing maximum combined headrope requirements.
- The requirement to use one of four gear combinations tested by the industry workgroup that achieved at least 40% finfish bycatch was implemented in the Pamlico Sound and portions of Pamlico, Bay, and Neuse rivers (NCDMF 2018).
- Shrimp trawling was prohibited in the Intracoastal Waterway channel from the Sunset Beach Bridge to the South Carolina line, including the Shallotte River, Eastern Channel, and lower Calabash River to protect small shrimp and reduce bycatch (NCDMF 2021).

The division continues to work with commercial fishermen to develop new gear configurations to reduce bycatch in the shrimp trawl fishery as well as to characterize the fishery. While estimates of shrimp trawl bycatch are accounted for in the southern flounder stock assessment (Lee et al. 2018; Flowers et al. 2019) further actions to address bycatch of southern flounder from shrimp trawls is most appropriately handled through the ongoing development of Amendment 2 to the N.C. Shrimp FMP.

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APPENDIX 2. REGULATIONS OF OTHER STATES

Table 2.1. East coast and Gulf of Mexico southern flounder regulations by state as of July 2021.

State	Size Limit	Daily Bag Limit	Commercial Trip Limits	Seasons
North Carolina	15"	4 fish per person per day	None	Recreational: Aug. 16–Sep. 30: Commercial: Northern Sep. 15– Oct 1., Central Oct. 1–19, Southern Oct. 1–Oct. 21
South Carolina ¹	16"	5 per person per day—not to exceed 10 per boat per day	None	Open all year
Georgia	12"	15 per person per day	None	Open all year
Florida ²	14"	5 per person per day	Commercial trip and vessel limit 150 fish from Dec. 1–Oct. 14, and 50 fish from Oct 15.–Nov. 30; a federal waters trawl bycatch limit of 150 flounder/trip from Dec. 1– Oct. 14, and 50 fish/trip from Oct. 15–Nov. 30	Oct. 15–Nov. 30 recreational closed season
Alabama	14"	5 per person per day	40 per person or per vessel	Closed Nov. 1–30 for both commercial and recreational
Mississippi	12"	10 per person per day	None	Open all year
Louisiana	none	10 per person per day	None	Open all year
Texas	14"	5 per person per day with the exception of Nov. 1– Dec. 14 when it is 2 per person per day	None	Open all year with the exception of the gig fishery being closed from Nov. 1–30

¹South Carolina regulations effective July 1, 2021.

²Florida regulations effective March 1, 2021.

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APPENDIX 3. NORTH CAROLINA FISHERY MANAGEMENT

The N.C. General Assembly enacts fisheries statutes, or laws, and provides the NCMFC authority to adopt rules to implement those statutes in coastal and joint fishing waters. These rules are found in Chapters 03 and 18 of Title 15A of the N.C. Administrative Code. The following list, while not exhaustive, includes the primary rules used to manage the southern flounder fishery. In inland fishing waters, the N.C. Wildlife Resources Commission rule 15A NCAC 10C .0307 establishes the same recreational seasons, size limits, and bag limits for flounder as those established by NCMFC rules and proclamations issued by the Fisheries Director in adjacent joint and coastal fishing waters. Please refer to the N.C. Administrative Code for the full text of the rules at <http://reports.oah.state.nc.us/ncac.asp>.

In addition to adopting rules, the NCMFC has the authority to delegate to the Fisheries Director the ability to issue public notices, called proclamations, suspending or implementing particular commission rules that may be affected by variable conditions. The proclamation authority granted to the Fisheries Director in commission rules includes the ability to open and close seasons and fishing areas, set harvest and gear limits, and establish conditions governing various fishing activities. Rules that contain proclamation authority are marked by a diamond symbol (“◆”). Proclamations are not included in this document because they change frequently and are found at <https://deq.nc.gov/fisheries-management-proclamations>.

- 15A NCAC 03I. 0120 Possession or Transportation Limits Through State Waters; Sale of Native Species
Sets requirements for possession and transportation of species subject to state season, size, or harvest restrictions. Applies to management across species of flounder (i.e., southern, summer, and Gulf flounder).
- 15A NCAC 03J .0101 Fixed or Stationary Nets
Establishes where it is unlawful to set fixed or stationary nets.
- 15A NCAC 03J .0102 Nets or Net Stakes
Establishes where it is unlawful to use nets or net stakes.
- ◆ 15A NCAC 03J .0103 Gill Nets, Seines, Identification, Restrictions
Establishes requirements for the use of gill nets and seines, including proclamation authority for time, area, means and methods, and seasons.
- ◆ 15A NCAC 03J .0500 Pound Nets
Establishes requirements for pound net sets, including flounder pound net sets. Limited proclamation authority may be implemented only for escape panel requirements.
- ◆ 15A NCAC 03M .0503 Flounder
Contains proclamation authority that allows the Fisheries Director, within the bounds of the current Southern Flounder Fishery Management Plan (FMP), to specify size, season, area, quantity, and means and methods, and the

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*proclamation authority to require submission of statistical and biological data. This rule is the primary management tool to implement management measures, subject to variable conditions, and to implement adaptive management for the southern flounder fisheries **within the bounds of the current FMP.***

- ♦ 15A NCAC 03O .0500, Permits
Establishes procedures and requirements for permits, including eligibility and standard permit conditions such as reporting. Rule 15A NCAC 03O .0506, Special Permit Required for Specific Management Purposes, provides authority to require a new permit for quota monitoring in the southern flounder fishery.
- 15A NCAC 10C .0307, Flounder, Sea Trout, and Red Drum
Wildlife Resources Commission rule, as described above.

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APPENDIX 4. ISSUE PAPERS

APPENDIX 4.1. ACHIEVING SUSTAINABLE HARVEST IN THE NORTH CAROLINA SOUTHERN FLOUNDER FISHERY

I. ISSUE

Implement long-term management measures to achieve sustainable harvest in the North Carolina southern flounder fishery that end overfishing and rebuild the spawning stock.

II. ORIGINATION

The NCMFC adopted Amendment 2 to the Southern Flounder FMP in August 2019. Amendment 2 authorized the development of Amendment 3 to begin immediately in order to implement more comprehensive, long-term management measures. State law requires these management measures to achieve sustainable harvest in the southern flounder fishery (Fisheries Reform Act, G.S. 113-182.1).

III. BACKGROUND

The southern flounder is a demersal species found in the Atlantic Ocean and Gulf of Mexico from northern Mexico to Virginia. The biological unit stock for southern flounder inhabiting U.S. South Atlantic coastal waters includes waters of North Carolina, South Carolina, Georgia, and the east coast of Florida (see the *Introduction* and the *Description of the Stock* sections for more information on the management authority, distribution, and unit stock definition of southern flounder).

To address the coast-wide nature of the southern flounder stock, a comprehensive stock assessment was completed to determine the status of the stock using data from North Carolina through the east coast of Florida from 1989 through 2017 (Flowers et al. 2019). The assessment model indicated the stock was overfished and overfishing was occurring (Figure 3, Figure 5 in the *Description of the Stock* section). Projections were performed to determine the reduction in fishing mortality necessary to end overfishing and to rebuild the spawning stock biomass and end the overfished status.

Fishing mortality was estimated at the target of $F_{35\%}$ as 0.35 and the threshold of $F_{25\%}$ as 0.53. In 2017, F was 0.91, which is higher than the F threshold of 0.53 and indicates overfishing is occurring (Figure 5, in the *Description of the Stock* section). The probability that fishing mortality in 2017 was above the threshold value of 0.53 is 96%, whereas there is a 100% probability fishing mortality in 2017 was above the target value of 0.35.

The spawning stock biomass target ($SSB_{35\%}$) was estimated to be 5,452 metric tons (approximately 12.0 million pounds) and threshold ($SSB_{25\%}$) to be 3,900 metric tons (approximately 8.6 million pounds). In 2017, the estimated SSB was 1,031 metric tons (approximately 2.3 million pounds), which is lower than the SSB threshold of 3,900 metric tons and indicates the stock is overfished (Figure 3 in the *Description of the Stock* section). The probability that SSB in 2017 was below the threshold and target values (3,900 and 5,452 metric tons, respectively) is 100%.

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The General Statutes of North Carolina require that an FMP specify a time period not to exceed two years from the date of the adoption to end overfishing (G.S. 113-182.1). The statutes also require that a FMP specify a time period not to exceed 10 years from the date of adoption and at least a 50% probability to achieve a sustainable harvest. A sustainable harvest is attained when the stock is no longer overfished (G.S. 113-129). The statutes allow some exceptions to these stipulations related to biology, environmental conditions, or lack of sufficient data.

To meet statutory requirements, calculations were made to determine the reductions in total coast-wide removals (all fishery removals from each of the four states) necessary to end overfishing within two years and recover the stock from an overfished status within the 10-year period. Total removals are defined as the total pounds of landed southern flounder plus dead discards. Dead discards are comprised of fish that were dead upon retrieval of gear and not harvested and fish that were released alive that experience delayed mortality. For more information on projections and the resulting removal reductions refer to Amendment 2 or the 2019 updated stock assessment, which includes assumptions and computational details (Flowers et al. 2019; NCDMF 2019).

The projections are based on the conditions and restrictions such as minimum size limits for both the commercial and recreational fishery, current gear requirements, and selected soak time and daytime restrictions in effect at the time that resulted in the annual total removals. These measures, along with recruitment strength, environmental conditions, and fishing effort, influenced the fishery during the 2017 terminal year of the stock assessment which is the base year for reduction calculations. Any changes in these past conditions will have an undetermined impact on the projections and the rebuilding schedule.

As required by North Carolina law, a fishing mortality of 0.34 is needed to reach the SSB threshold by 2028 and end the overfished status (Figure 7 in the *Description of the Stock* section). This will require at a minimum a 52% reduction in total removals coast-wide. To increase the probability of success of rebuilding to the higher SSB target by 2028, fishing mortality would need to be lowered to 0.18 (Figure 8 in the *Description of the Stock* section). This will require a 72% reduction in total removals coast wide. A fishing mortality that falls between the identified target and threshold values meets the statutory requirements (e.g., 62%; Figure 4.1.1). All projections are associated with at least a 50% probability of achieving sustainable harvest for the fishery.

The management measures implemented in North Carolina from the original Southern Flounder FMP (NCDMF 2005), Amendment 1 (NCDMF 2013), and Supplement A to Amendment 1 (NCDMF 2017a) as modified by the Aug. 17, 2017 settlement agreement have not resulted in the necessary increase in SSB to end the stock's overfished status, thus continued reductions are necessary. In developing management measures for Amendment 2 and Amendment 3, the division applied the reductions only to North Carolina's portion of total removals. To account for North Carolina's portion of these reductions in the recreational and commercial fisheries, the identified reduction was applied to both the dead discards and landings, or total removals, for each sector of the North Carolina southern flounder fishery from the terminal year of the assessment (2017).

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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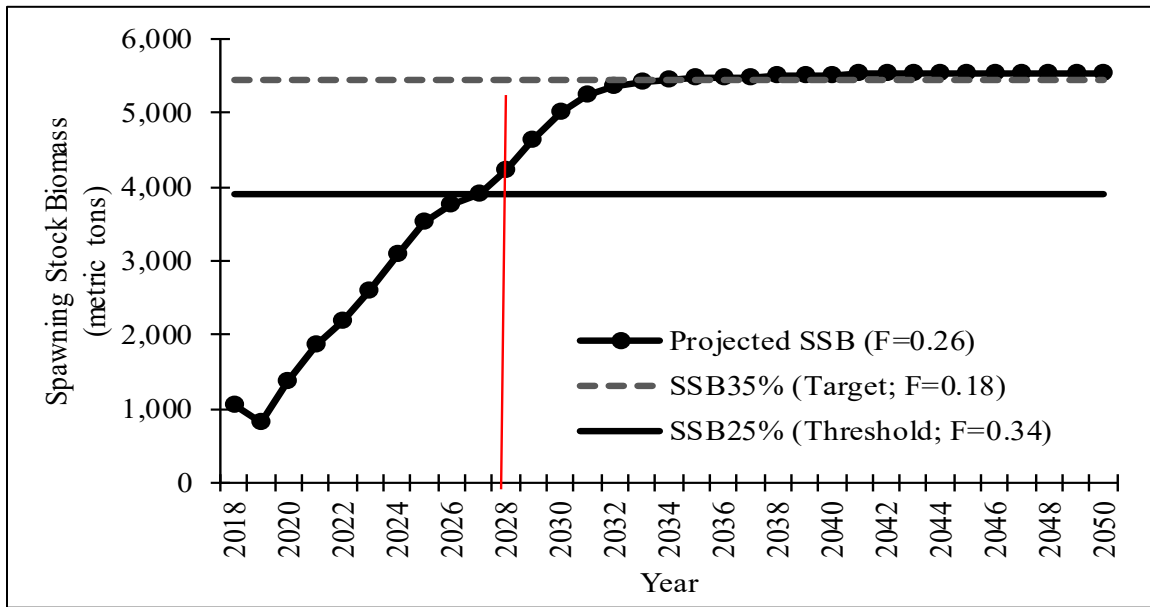


Figure 4.1.1. Predicted future spawning stock biomass (metric tons) assuming the fishing mortality value ($F=0.26$; 62% reduction in total removals) necessary to reach between the SSB_{Target} and $SSB_{Threshold}$ by 2028 (indicated by vertical red line). (Source: Flowers et al. 2019)

In 2017, total removal for all sectors including dead discards was 1,957,264 pounds; the commercial fishery accounted for 72.2% (including 0.9% dead discards) and the recreational fishery (hook-and-line and gigs) accounted for 27.9% (including 2.0% dead discards) of the total North Carolina removals (Figure 4.1.2). Additional options for allocations were requested by the NCMFC at its November 2020 business meeting. These options are presented in the *Recreational and Commercial Sector Allocation* issue paper and NCMFC preferred option was used to develop this *Achieving Sustainable Harvest* issue paper.

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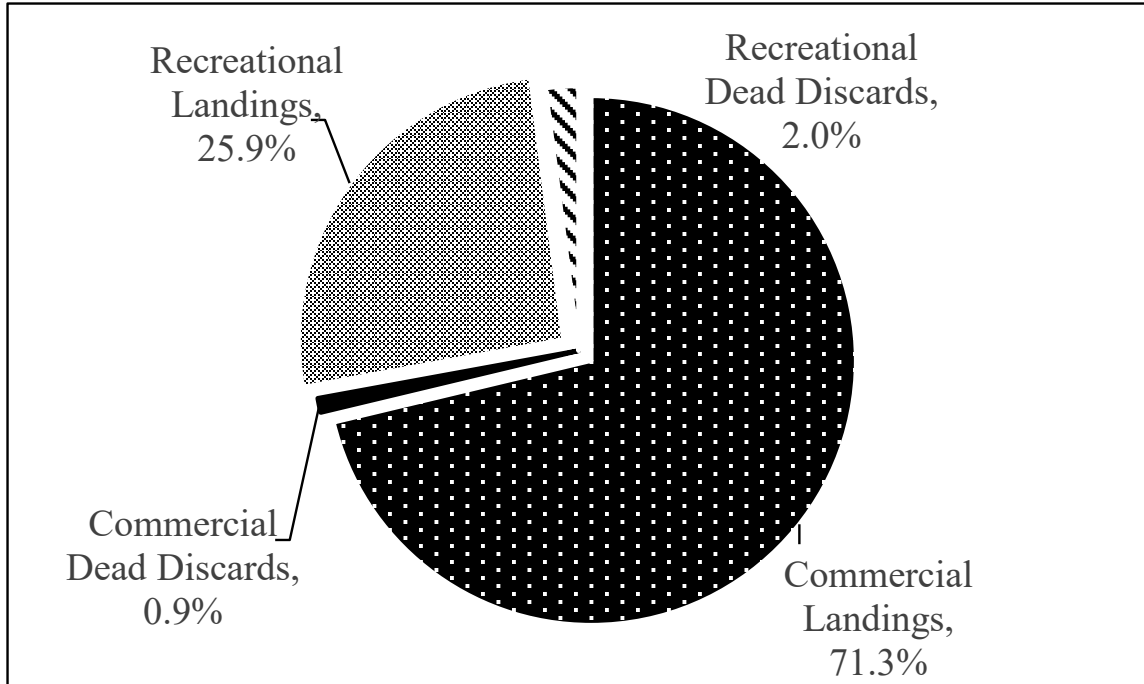


Figure 4.1.2. Contribution of the total removals (observed harvest and dead discards in percent pounds) for the commercial and recreational (hook-and-line and gig) fisheries in North Carolina, 2017. (Source: North Carolina Trip Ticket Program, Marine Recreational Information Program, NCDMF Gig Mail Survey)

In Amendment 3, the management measure proposed to meet sustainable harvest may be changed from a seasonal approach to a quota-based approach. This change does not alter analyses used to calculate reductions but does adjust the terminology used to describe the individual pieces used from Total Allowable Catch (TAC) to Total Allowable Landings (TAL) as landings are the quantifiable mechanism used to manage the quota. Reductions in discards will be accounted for at the end of the fishery as discards are not part of daily quota monitoring and will be added to the annual landings to create total catch and make sure the TAC is not exceeded. This approach differs slightly from Amendment 2. In each amendment, reductions were based on TAC, but as seasons were the selected management measure implemented through Amendment 2, the seasons accounted for estimated reductions in harvest and discards. Based on a fishing mortality that falls between the identified threshold (52% reduction) and target (72% reduction), the range in annual landings of southern flounder that could occur for all sectors is 912,603 pounds to 532,352 pounds, respectively (Table 4.1.1; Figures 4.1.3 and 4.1.4).

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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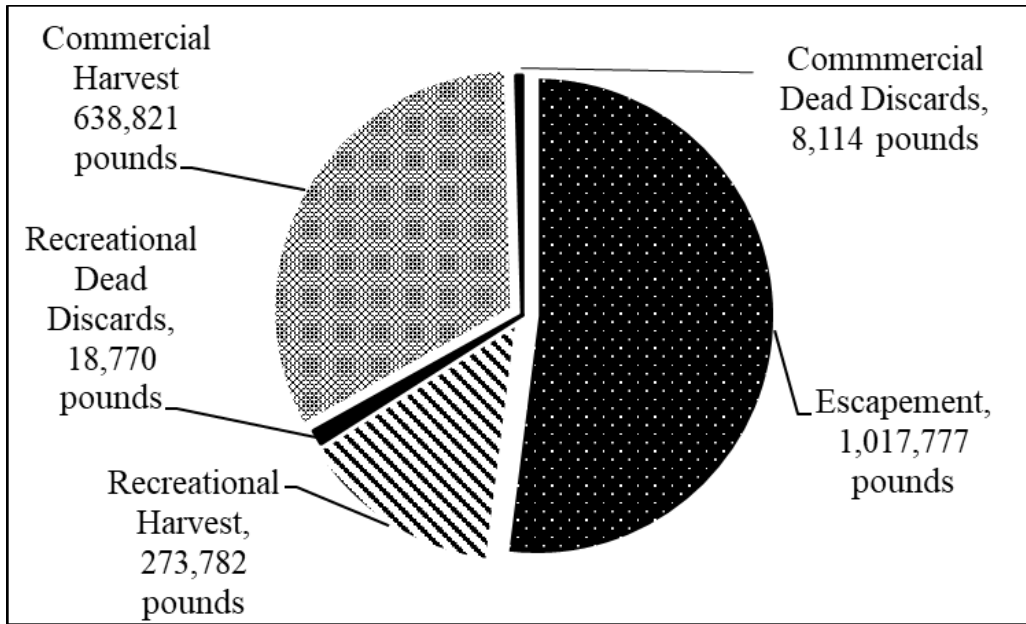


Figure 4.1.3. Estimated escapement of southern flounder (pounds) and contribution of the total removals for the commercial and recreational (hook-and-line and gig) fisheries in North Carolina, 2017, at a 52% reduction and a 70% commercial and 30% recreational allocation. (Source: North Carolina Trip Ticket Program, Marine Recreational Information Program, NCDMF Gig Mail Survey)

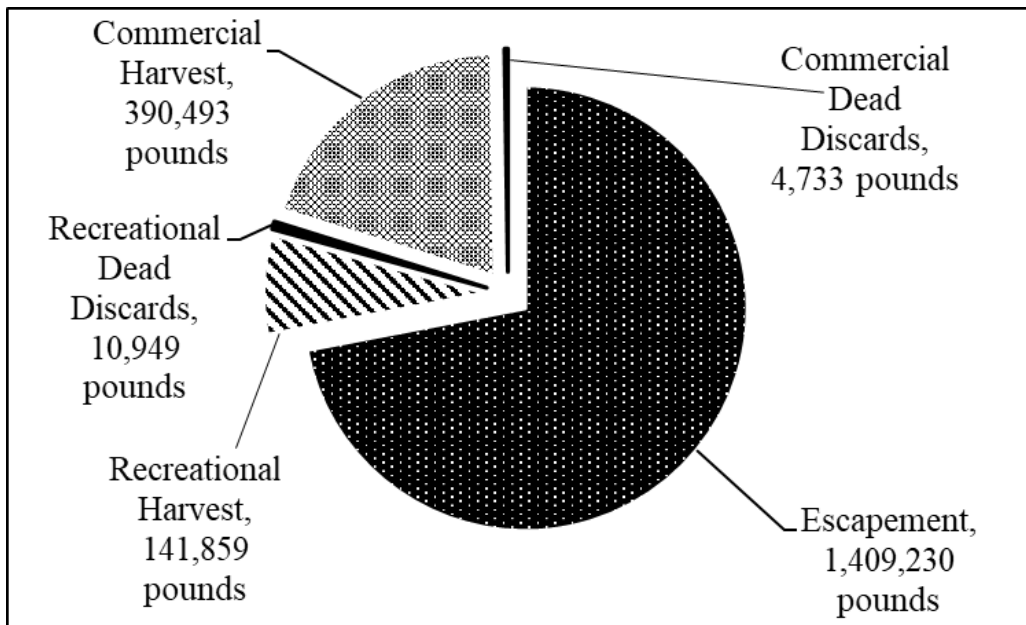


Figure 4.1.4. Estimated escapement of southern flounder (pounds) and contribution of the total removals for the commercial and recreational (hook-and-line and gig) fisheries in North Carolina, 2017, at a 72% reduction and a 70% commercial and 30% recreational allocation. (Source: North Carolina Trip Ticket Program, Marine Recreational Information Program, NCDMF Gig Mail Survey)

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.1.1. Southern flounder total allowable catch (TAC) and total allowable landings (TAL) in pounds needed to meet the necessary reductions for the overfishing threshold and SSB threshold and target of the commercial and recreational fisheries, following the NCMFC selection of a 70/30 allocation.

Percent Reduction from 2017 Terminal Year	Commercial Fisheries				Recreational Fisheries*				
	Total Allowable Catch	Dead Discards	Total Allowable Landings	Total Allowable Commercial Landings	Mobile Gears	Pound Nets	Total Allowable Recreational Landings	Hook and Line	Gigs
2017	1,957,264	56,008	1,901,256	1,330,879	664,957	665,922	570,377	507,877	62,500
52%	939,487	26,884	912,603	638,821	319,179	319,642	273,782	243,782	30,000
62%	743,760	21,283	722,477	505,734	252,684	253,050	216,743	192,993	23,750
72%	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500

*Recreational commercial gear harvest is unknown since 2008 and could not be quantified in the reductions.

Management measures (seasonal closures) implemented in Amendment 2 met the statutory requirements and were critical for reducing removals and initiating the rebuilding of the southern flounder stock. Seasonal closures do not enforce a maximum removal level on the fishery and only limit the time when targeted harvest can occur. Fishing effort can be more concentrated during the open season, potentially altering fishing behaviors from previous years that were used to estimate harvest windows; that is, fishing effort may increase during the open season and lead to higher than predicted removals. Though seasonal flexibility is provided to the NCDMF Fisheries Director by the NCMFC motion approving the adoption of Amendment 2, seasonal closures alone may not result in the needed increase in SSB even if maintained long term (NCDMF 2019). Consequently, the approval of Amendment 2 specified the development of Amendment 3 to begin immediately to implement more comprehensive, long-term management measures to achieve sustainable harvest. Management strategies implemented through Amendment 3 will not restart the time requirements set in Amendment 2 that are necessary to meet the statutory mandates.

Amendment 2 required a 62% reduction in 2019 and a 72% reduction from 2020 onward, both above the minimum 52% reduction that is statutorily required. Preliminary analysis of reductions achieved in 2019 from implementation of Amendment 2 management measures indicate an overall reduction of 35% was achieved or a 43% reduction in total removals for the commercial fishery and a 15% reduction in total removals for the recreational fishery. A level of reduction less than the required 62% was anticipated as the seasons did not begin until Sept. 4, 2019. The fisheries operated three quarters of the calendar year, as compared to estimates that were based on a closure beginning Jan. 1. While Amendment 2 did not meet the 62% reduction in 2019, the 35% reduction achieved was greater than the minimum of 31% to end overfishing. The 2020 landings and preliminary estimates of dead discards indicated a 52% reduction was achieved, exceeding the ending overfishing target and meeting the ending overfished threshold but not the 72% reductions approved under Amendment 2. Harvest exceeded the TAC to meet the 72% reduction for both the commercial and recreational fisheries.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Management measures for Amendment 3 will be selected and implemented from the allowable total removals (landings and dead discards) that are calculated based on the fishing mortality estimates of the terminal year (2017) of the stock assessment (Flowers et al. 2019). Quota-based management accounts for dead discards at the end of each sector's fishing year, therefore quota management is based on total allowable landings. Total allowable catch for the southern flounder fishery was reduced by 72%. Removing dead discards for each corresponding sector results in the estimated total allowable landings that can be removed through the southern flounder fishery. The total allowable landings were allocated 70% commercial and 30% recreational based on the NCMFC decision at the Feb. 2021 business meeting. At a special meeting in March 2021, the NCMFC amended the sector allocations to 70% commercial and 30% recreational in 2021 and 2022, 60% commercial and 40% recreational in 2023, and 50% commercial and 50% recreational in 2024 (see the *Recreational and Commercial Sector Allocations* issue paper for further discussion). While the motion included allocating the southern flounder fishery in 2021, allocations will not take effect until the final approval of Amendment 3; however, to keep consistent with the NCMFC motion 2021 allocations are presented below. The reductions are only applied to North Carolina's portion of total removals. Calculations to predict future harvest reductions depends on environmental parameters, recruitment, and fishing effort remaining similar to previous years, an assumption of the 2019 updated stock assessment. Any changes to these factors will impact the stock's response and whether the statutory requirement of sustainable harvest is achieved.

Building on the seasonal closures in Amendment 2, additional quantifiable and non-quantifiable management measures in Amendment 3 will serve to improve the overall southern flounder stock to reduce total removals and increase likelihood of improved southern flounder SSB and recruitment, while still providing flexibility for fishermen, when possible, in the timing of the harvest for the sectors. This issue paper required assumptions about the fishery to be made as a quota-based management strategy was developed. It evaluates management measures, in addition to seasonal closures, for a long-term approach by constraining harvest in the southern flounder fishery to achieve sustainable harvest in Amendment 3.

IV. AUTHORITY

North Carolina General Statutes

G.S. 113-134 RULES

G.S. 113-182 REGULATION OF FISHING AND FISHERIES

G.S. 113-182.1 FISHERY MANAGEMENT PLANS

G.S. 113-221.1 PROCLAMATIONS; EMERGENCY REVIEW

G.S. 143B-289.52 MARINE FISHERIES COMMISSION – POWERS AND DUTIES

North Carolina Marine Fisheries Commission Rules

15A NCAC 03H .0103 PROCLAMATIONS, GENERAL

15A NCAC 03M .0503 FLOUNDER

15A NCAC 03M .0512 COMPLIANCE WITH FISHERY MANAGEMENT PLANS

V. DISCUSSION

The N.C. Department of Environmental Quality and the division recognize the required reductions in the southern flounder fishery are significant but necessary to increase the

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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probability of successfully rebuilding this important recreational and commercial resource. A 72% reduction is used based on the following criteria for the discussion of potential management measures in Amendment 3.

- Amendment 2 required a 72% reduction from 2020 onward until adoption of Amendment 3.
- Projections for rebuilding are based on a minimum of a 50% probability of success. Adopting a reduction greater than the 52% minimum increases the likelihood of achieving the minimum necessary for rebuilding.
- The projections were made with the assumption that each state that participated in the coast-wide stock assessment would implement measures for the necessary reductions required to rebuild SSB. There are uncertainties surrounding the other states with implementing cooperative management and the timing of regulations if implemented. The reductions in Amendment 3 are only to North Carolina's portion of total removals through the time series of the assessment.
- The management measures implemented in North Carolina from the original Southern Flounder FMP (NCDMF 2005), Amendment 1 (NCDMF 2013), and Supplement A to Amendment 1 (NCDMF 2017a) as modified by the Aug. 17, 2017 settlement agreement has not resulted in the necessary increase in SSB to end the stock's overfished status, thus further reductions are necessary.

A fishing mortality that falls between the identified threshold (52% reduction; Figure 7 in the *Description of the Stock* section) and target (72% reduction; Figure 8 in the *Description of the Stock* section) meets the statutory requirements (Figure 4.1.1).

As the potential management measures for Amendment 3 are presented there are several assumptions and limitations provided in the background section of this paper that are important to take into consideration.

- To account for North Carolina's portion of these reductions in the recreational and commercial fisheries, the identified reduction was applied to both the dead discards and landings, or total removals, for each sector (commercial and recreational) of the North Carolina southern flounder fishery from the terminal year of the assessment (2017; Figure 4.1.2).
- Dead discards will be accounted for at the end of the fishery as dead discards are not part of daily quota monitoring and will be added to the landings to adjust the value to make sure the TAC is not exceeded. This approach differs slightly from Amendment 2, in each amendment reductions were based on TAC, but as seasons were the selected management measure implemented through Amendment 2, the seasons accounted for estimated reductions in harvest and dead discards.
- The projections for rebuilding necessary to end overfishing and the overfished status included the minimum size limits for both the commercial and recreational fishery, the current gear requirements, and selected soak time and daytime restrictions. These measures influenced the fishery during the terminal year of the stock assessment and any consideration of changes to those values should be viewed with caution as they will have an undetermined impact on the projections and the rebuilding schedule.
- The approval of Amendment 2 specified the development of Amendment 3 to begin immediately to implement comprehensive, long-term management measures to achieve

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

sustainable harvest. Management measures for Amendment 3 will be selected and implemented from the allowable total removals (landings and dead discards) that are calculated based on the fishing mortality estimates of the terminal year (2017) of the stock assessment.

- Additional quantifiable and non-quantifiable management measures to augment the seasonal closures will serve to improve the overall southern flounder stock to ensure total removals are reduced and southern flounder SSB and recruitment increase, while still providing flexibility for fishermen, when possible, in the timing of the harvest for the sectors. Quantifiable measures are calculable and count towards the requirements to end overfishing and rebuild the stock, while non-quantifiable measures serve as a buffer and help to prevent the expansion of harvest as the stock rebuilds.

MANAGEMENT CARRIED FORWARD

There are several management measures from Amendment 2 to carry forward into Amendment 3 to serve the purpose of addressing fishing behavior and potential changes in effort to minimize the possibility of catching southern flounder in a greater volume than predicted.

Management measures from the Southern Flounder FMP Amendment 2 that will be clarified and carried forward in Amendment 3 are:

- A minimum distance (area dependent) between gill-net and pound net sets, per NCMFC Rule 15A NCAC 03J .0103 (d);
- No greater than a recreational fishery four fish bag limit;
- A recreational minimum size limit of 15 inches TL;
- A commercial minimum size limit of 15 inches TL;
- A minimum mesh size of 6.0-ISM for anchored large-mesh gill nets used in the taking of flounder;
- A minimum mesh size of 5.75-ISM for pound net escape panels;
- Reduced commercial anchored large-mesh gill-net soak times to single overnight soaks where nets may be set no sooner than one hour before sunset and must be retrieved no later than one hour after sunrise the next morning;
- For anchored large-mesh gill nets with a stretched mesh length of 4.0 inches through 6.5 inches, maintain a maximum of 1,500-yards in Management Units A, B, and C and a maximum of 750-yards in Management Units D and E unless more restrictive yardage is specified through adaptive management or through the sea turtle or sturgeon ITPs;
- Removal of all commercial gears targeting southern flounder from the water (e.g., commercial and RCGL anchored large-mesh gill nets and gigs) or make them inoperable (flounder pound nets) in areas and during times outside of an open season with exceptions for commercial large-mesh gill-net fisheries that target American (*Alosa sapidissima*) and hickory shad (*A. mediocris*) and catfish species if these fisheries are only allowed to operate during times of the year and locations where bycatch of southern flounder is unlikely;
- Unlawful to use any method of retrieving live flounder from pound nets that cause injury to released fish (e.g., picks, gigs, spears, etc.); and

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

- Unlawful for the commercial fishery to possess any species of flounder harvested from the internal waters of the state during the closed southern flounder season.

QUANTIFIABLE AND NON-QUANTIFIABLE MANAGEMENT MEASURES

Both quantifiable and non-quantifiable management measures are presented to meet the North Carolina harvest reduction for southern flounder based on the terminal year of the stock assessment (2017). Quantifiable management measures include a quota for the commercial fishery, which relies on daily quota monitoring, and a quota implemented by seasons for the recreational fishery, which serves to constrain the recreational fishery within a quota; these measures relate specifically to the stock assessment total removals and are calculable.

Additional types of management measures that are non-quantifiable are likely to be effective in reducing mortality, but the resulting reduction cannot be determined using existing data sources. Examples of non-quantifiable measures explored in this paper include certain management measures carried forward from Amendment 2 as described above, as well as changes to trip limits in the commercial fisheries, changes to bag limits in the recreational fisheries, and a RCGL season. Additionally, a discussion of slot limits as a non-quantifiable management measure can be found in the *Implementing a Slot Limit in the Southern Flounder Fishery* issue paper. Such non-quantifiable measures are needed to prevent the expansion of harvest as the stock rebuilds, increasing the likelihood of rebuilding success; however, the magnitude of these management measures, as well as the possible response of the stock, is unknown.

QUANTIFIABLE MANAGEMENT MEASURES: QUOTA

For Amendment 3, a quota will be set so the TAL that establishes maximum fishing limits (in pounds) in a year for all participants does not exceed a pre-determined amount. A quota is a specified numerical harvest objective, the attainment of which causes closure of the fishery for that species (Blackhart et al. 2005). For the North Carolina southern flounder fisheries, the quota is measured in pounds of fish. The quota that meets the required reductions and the NCMFC allocation motion is a 548,034 pounds TAC which results in 532,352 pounds of TAL for management. This TAL will be further divided into commercial and recreational allocations based on a motion approved by the NCMFC in March 2021. The allocations will be 70% commercial and 30% recreational in 2021 and 2022, 60% commercial and 40% recreational in 2023, and 50% commercial and 50% recreational beginning in 2024. The TAL for each sector can be found in Table 4.1.2 and additional information on allocations can be found in the *Recreational and Commercial Sector Allocation* issue paper.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

Note: The purpose of this draft is to solicit input from the public and advisors and therefore it is subject to change

Table 4.1.2. Allocations for commercial and recreational fisheries and associated sub-allocations for each sector for the North Carolina Southern Flounder Fishery that maintains overall reductions of 72%.

Year	Allocation	Total Allowable Catch	Dead Discards	Total Allowable Landings	Commercial Fisheries	Recreational Fisheries*
					Total Allowable Commercial Landings	Total Allowable Recreational Landings
2021	70/30	548,034	15,682	532,352	372,646	159,706
2022	70/30	548,034	15,682	532,352	372,646	159,706
2023	60/40	548,034	15,682	532,352	319,411	212,941
2024	50/50	548,034	15,682	532,352	266,176	266,176

*RCGL gear removals not included in the Total Allowable Landings

When using a quota to manage a fishery, decisions need to be made on how to split or allocate the resource within each of the sectors and determine whether rollover of unused quota, payback of exceeded quota, or both will occur. Accountability measures implemented provide a means to manage the quota. A conservative approach benefits the resource by protecting any unharvested fish and not exceeding the TAC. This benefits the resource but may have consequences to user groups by shortening seasons or limiting access in some areas during subsequent years. A more liberal approach to accountability measures benefits the user groups by allowing harvest of any remaining allocation during subsequent years and not requiring paybacks for any harvest over an allocation but may have consequences to the resource.

Commercial Fisheries

For all commercial fisheries combined, the total allowable landings are 372,646 pounds of southern flounder for 2021 and 2022, 319,411 pounds in 2023, and 266,176 pounds beginning in 2024 (Table 4.1.2). This is the commercial allocation of the overall quota. To ensure the commercial allocation is not exceeded and provides all sectors continued access to the resource under these restrictions, further refinement maybe necessary to allow an annual harvest, to manage by areas, gears and opening dates. The division analyzed data to determine individual gear allocations for different areas and opening time frames, as well as data that combined some gears into one allocation for a given area. This analysis was undertaken with the understanding that increasing the complexity of management also increases the complexity of monitoring the quota, reducing the ability to effectively meet the targets to achieve sustainable harvest.

Commercial Gear Allocation

Given the large reduction needed to achieve sustainable harvest and the importance of each allocation staying within its allowed landings, it is most practical to separate the gears into two categories: pound nets and mobile gears (including gears that target southern flounder, primarily gigs and gill nets, and “other” gears that do not target southern flounder such as shrimp trawls, crab pots, and fyke nets). Using these two categories of mobile gears and pound nets also

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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provides flexibility by allowing fishermen to use multiple gears in a trip without having to separate catches unless a pound net is involved. Combining mobile gears into a single category prevents users from switching between the two categories or altering their behavior that may increase harvest. For example, if there is a closure for gill nets due to protected species interactions, the remaining allocation would be available for harvest using non-gill net gears within the mobile gear category. In addition, the NCMFC has requested the division evaluate phasing out large-mesh gill nets in the southern flounder fishery by the terminal year of the current sea turtle ITP, August 2023. If the NCMFC selects this as a management measure it may impact the sub-allocations for each gear category. More information can be found in the *Phasing out Large-Mesh Gill Nets in the North Carolina Southern Flounder Fishery* issue paper in Appendix 4.7.

All mobile gears have the capability to harvest southern flounder throughout the year, although there is variability in their use among the individual gears. Combining mobile gears into one allocation makes monitoring the daily harvest more efficient with less risk of exceeding the annual allocation. Based on the seasonality and movement of southern flounder, commercial gigs and “other” gears would likely benefit from opening in the late spring or early summer to maximize the economic benefit of the market at that time. The gig fishery could open in early summer and any remaining allocation would be available for harvest by gill nets and other gears at a specific opening date later in the fall. Consequences of the southern flounder gill-net fishery operating in the early spring or summer include at-net mortality, discards of non-marketable fish, as well as post-release mortality of undersized flounder.

The commercial southern flounder pound net fishery only has the capability to operate during the fall months, beginning in late August in Albemarle Sound and ending in late November in Core Sound. Allocating harvest to the pound net fishery outside of the fall migration would not be appropriate. Flounder pound nets are stationary gears and are only actively fishing when southern flounder are migrating to the ocean. The pound net gear is most susceptible to changes in average price per pound, as the market typically drops in value in October due to the opening of the summer flounder winter trawl fishery.

Commercial Gear Sub-Allocations

Due to the shift in allocation based on the March 2021 NCMFC motion, it is prudent to evaluate the sub-allocations for the commercial fishery. Presented below are three potential scenarios that account for the NCMFC approved allocation changes as well as changes to the sub-allocations for the commercial fishery sectors. The first scenario is showing the TAL by year for each sector based on historical landings and can be found in Table 4.1.3. A second scenario is to meet the NCMFC approved allocation and adjust the commercial sub-allocations so the pound net fishery maintains their current harvest estimate of 186,458 pounds. This scenario provides a level of harvest that maintains the fishery at a reduced level but accounts for the increased monetary investment of operating and maintaining the pound net gear. Sub-allocations for this scenario can be found in Table 4.1.4. A final scenario considered is to adjust the allocation and phase out large-mesh gill nets in the southern flounder fishery at the end of the current ITP in 2023 as proposed by the NCMFC. Under this scenario the sub-allocations remain consistent with the first scenario for 2021 and 2022 but beginning in 2023 half of the gill net landings are transferred to

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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the pound net gear category and the other half remaining with the mobile gear category (Table 4.1.5). This 50/50 transfer of gill net allocation is just one example and can be altered based on NCMFC, Advisory Committee, or public input.

Table 4.1.3. Allocations for the North Carolina Southern Flounder commercial and recreational fisheries and associated sub-allocations for each sector for the North Carolina Southern Flounder Fishery that maintains overall reductions of 72% and historical sub-allocations.

Year	Allocation				Commercial Fisheries			Recreational Fisheries*		
		Total Allowable Catch	Dead Discards	Total Allowable Landings	Total Allowable Commercial Landings	Mobile Gears	Pound Nets	Total Allowable Recreational Landings	Hook and Line	Gigs
2021	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2022	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2023	60/40	548,034	15,682	532,352	319,411	159,590	159,821	212,941	189,608	23,333
2024	50/50	548,034	15,682	532,352	266,176	132,992	133,184	266,176	237,010	29,166

*RCGL gear removals not included in the Total Allowable Landings

Table 4.1.4. Allocations for the North Carolina Southern Flounder commercial and recreational fisheries and associated sub-allocations for each sector that maintains overall reductions of 72% but maintains the current level of sub-allocation for the pound net fishery.

Year	Allocation				Commercial Fisheries			Recreational Fisheries*		
		Total Allowable Catch	Dead Discards	Total Allowable Landings	Total Allowable Commercial Landings	Mobile Gears	Pound Nets	Total Allowable Recreational Landings	Hook and Line	Gigs
2021	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2022	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2023	60/40	548,034	15,682	532,352	319,411	132,953	186,458	212,941	189,608	23,333
2024	50/50	548,034	15,682	532,352	266,176	79,718	186,458	266,176	237,010	29,166

*RCGL gear removals not included in the Total Allowable Landings

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.1.5. Allocations for the North Carolina Southern Flounder commercial and recreational fisheries and associated sub-allocations for each sector that maintains overall reductions of 72% but redistributes the gill net allocation equally between mobile and pound net gears.

Year	Allocation				Commercial Fisheries			Recreational Fisheries*		
		Total Allowable Catch	Dead Discards	Total Allowable Landings	Total Allowable Commercial Landings	Mobile Gears	Pound Nets	Total Allowable Recreational Landings	Hook and Line	Gigs
2021	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2022	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2023	60/40	548,034	15,682	532,352	319,411	99,102	220,309	212,941	189,608	23,333
2024	50/50	548,034	15,682	532,352	266,176	85,803	180,373	266,176	237,010	29,166

*RCGL gear removals not included in the Total Allowable Landings

Commercial Areas and Seasons Allocation

Because of the migratory nature of southern flounder, areas were investigated by the NCTTP waterbody locations to allow more equitable access by fishermen across the state with seasonal openings varying by area. As the weather begins to change during the fall, southern flounder migrate to estuarine waters in the south and east before moving into the ocean (Craig et al. 2015). The migration begins in the northern and western sounds and tributaries before it begins in the southern areas. As previously stated, increasing the complexity of management also increases the complexity of monitoring the quota, reducing the ability to effectively meet the targets; however, the benefit of this type of flexibility is the potential for staggered opening dates that will be determined by the Fisheries Director after consultation with user groups (more information on how the division will determine opening dates is available in the *Adaptive Management* issue paper). Staggering opening dates minimizes the chances of a “derby fishery,” which forces all participants to fish at the same time ultimately leading to a flooded market and lower prices. Altering opening dates allows for specific areas and gears to target southern flounder when they are accessible and most valuable to fishermen with the expectation that harvest is tracked daily so the total allowable landings are not exceeded.

Analysis indicates that gear and area combinations with no more than three areas statewide would provide the best chance of success of achieving sustainable harvest through daily quota monitoring. For some gear and area combinations, two areas would allow some flexibility to the sectors and make accountability more manageable.

Landings data for the southern flounder commercial fishery were reviewed using waterbody locations and gear type identified by the NCTTP to determine if natural breaks by area and gear occurred (NCDMF 2017b). Identification of natural breaks by waterbody and gear determines how finely the areas can be managed within each gear category. A natural break in commercial effort and landings occurs in several areas across the state, but for ease of enforcement and

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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knowledge of existing areas by fishermen, it is beneficial to use regulatory boundaries already in place.

Dividing mobile gears into two areas using current boundaries would result in a northern area from the North Carolina/Virginia border south to the B-D ITP boundary line in Core Sound (34° 48.2700' N latitude which runs approximately from the Club House on Core Banks westerly to a point on the shore at Davis near Marker "1") and a southern area from the 34° 48.2700' N latitude south to the North Carolina/South Carolina Border (Figure 4.1.5). Splitting mobile gears into three areas may best be approached with a northern area encompassing the Albemarle Sound and its tributaries including the Croatan and Roanoke sounds, a central area encompassing the Pamlico Sound and its tributaries, and a southern area encompassing all waters from Core Sound south (Figure 4.1.5).

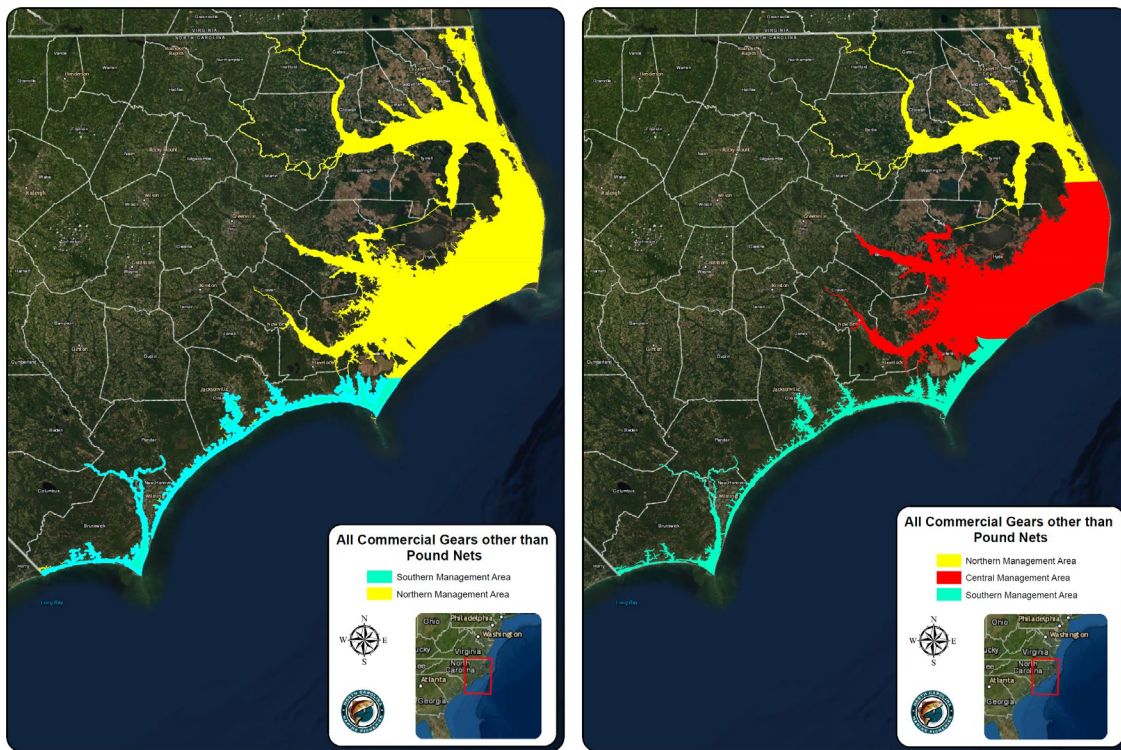


Figure 4.1.5. Boundary descriptions for two (left) and three (right) areas to consider for mobile gears. The three area boundaries are identical as seen for pound nets.

If the NCMFC selects to phase out large-mesh gill nets the boundary line for mobile gears can be re-evaluated or removed all together and create a single statewide fishery for mobile gears (Table 4.1.6). The ITP B-D boundary line was selected due to the inclusion of large-mesh gill nets under the mobile gear category to remain consistent with ITP boundary areas.

Dividing the state's pound net fishery into two areas may best be approached with a northern area from the North Carolina/Virginia border south to the 35° 46.3000' N latitude which runs approximately from the north end of Pea Island (old Coast Guard station) westerly to a point on the shore at Point Peter Canal and a southern area from 35° 46.3000' N latitude south to the North Carolina-South Carolina border (Figure 4.1.6). Three areas for the pound net fishery

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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would be consistent with areas already in place under Amendment 2 for this fishery and would be the same boundaries described for mobile gears (Figure 4.1.6).

Based on the determined allocations provided by the NCMFC, the division determined the annual commercial TAL allocation in 2021 and 2022 is 372,646 pounds (Table 4.1.1). This allocation will be reduced in 2023 to 60% (319,411 lb) and again in 2024 to 50% (266,176 lb) to meet the requirements outlined by the NCMFC (Table 4.1.2). Three options presenting associated pounds of available allocation by area and gear can be found in Tables 4.1.6, 4.1.7, and 4.1.8. Commercial landings for mobile gears were combined and allocated by waterbody, with the exception of landings from Core Sound. Due to Core Sound being split in two areas, 50% of the landings from Core Sound were counted towards the northern area and 50% were counted towards the southern area (Table 4.1.2; Tables 4.1.6-4.1.8). Commercial pound net landings were allocated to each waterbody within the areas.

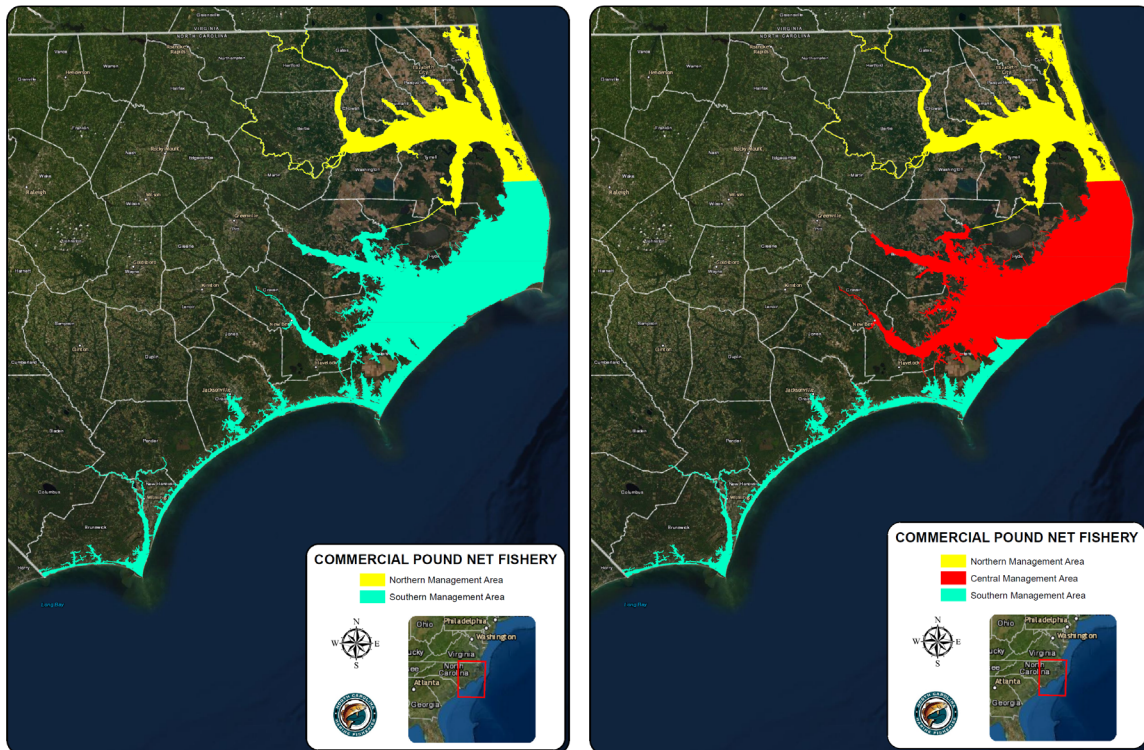


Figure 4.1.6. Boundary descriptions for two (left) and three (right) areas to consider for the pound net fishery. The three area boundaries are the same as mobile gears.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.1.6. Allocation for the North Carolina Southern Flounder commercial fishery and associated sub-allocations for each sector that maintains overall reductions of 72% and historical sub-allocations.

Commercial Gear	Allocation %	Area/Allocation (lb)			Total Allocation (lb)	Option
Mobile gears	70	Statewide 186,188			186,188	1.1B
	70	Northern 123,879	Southern 62,309		186,188	1.1A
	70	Northern 47,082	Central 65,355	Southern 73,751	186,188	1.1C
	60	Statewide 159,590			159,590	1.1B
	60	Northern 106,182	Southern 53,408		159,590	1.1A
	60	Northern 40,356	Central 56,018	Southern 63,216	159,590	1.1C
	50	Statewide 132,992			132,992	1.1B
	50	Northern 88,486	Southern 44,506		132,992	1.1A
	50	Northern 33,360	Central 46,682	Southern 52,680	132,992	1.1C
Pound nets	70	Statewide 186,458			186,458	1.2B
	70	Northern 37,900	Southern 146,758		186,458	1.2C
	70	Northern 39,700	Central 121,756	Southern 25,002	186,458	1.2A
	60	Statewide 159,821			159,821	1.2B
	60	Northern 34,028	Southern 125,793		159,821	1.2C
	60	Northern 34,028	Central 104,363	Southern 21,430	159,821	1.2A
	50	Statewide 133,184			133,184	1.2B
	50	Northern 28,357	Southern 104,827		133,184	1.2C
	50	Northern 28,357	Central 86,969	Southern 17,858	133,184	1.2A

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.1.7. Allocation for the North Carolina Southern Flounder commercial fishery and associated sub-allocations for each sector that maintains overall reductions of 72% but maintains the current level of sub-allocation for the pound net fishery.

Commercial Gear	Allocation %	Area/Allocation (lb)			Total Allocation (lb)	Option
Mobile gears	70	Statewide 186,188			186,188	1.1B
	70	Northern 123,879	Southern 62,309		186,188	1.1A
	70	Northern 47,082	Central 65,355	Southern 73,751	186,188	1.1C
	60	Statewide 132,593			132,953	1.1B
	60	Northern 88,460	Southern 44,493		132,953	1.1A
	60	Northern 33,621	Central 46,668	Southern 52,664	132,953	1.1C
	50	Statewide 79,718			79,718	1.1B
	50	Northern 53,040	Southern 26,678		79,718	1.1A
	50	Northern 20,159	Central 27,982	Southern 31,577	79,718	1.1C
Pound nets	70	Statewide 186,458			186,458	1.2B
	70	Northern 37,900	Southern 146,758		186,458	1.2C
	70	Northern 39,700	Central 121,756	Southern 25,002	186,458	1.2A
	60	Statewide 186,458			186,458	1.2B
	60	Northern 37,900	Southern 146,758		186,458	1.2C
	60	Northern 39,700	Central 121,756	Southern 25,002	186,458	1.2A
	50	Statewide 186,458			186,458	1.2B
	50	Northern 37,900	Southern 146,758		186,458	1.2C
	50	Northern 39,700	Central 121,756	Southern 25,002	186,458	1.2A

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.1.8. Allocation for the North Carolina Southern Flounder commercial fishery and associated sub-allocations for each sector that maintains overall reductions of 72% but redistributes the gill net allocation equally between mobile and pound net gears beginning in 2023 (shown in the 60% and 50% allocations).

Commercial Gear	Allocation %	Area/Allocation (lb)			Total Allocation (lb)	Option
Mobile gears	70	Statewide 186,188			186,188	1.1B
	70	Northern 186,188	Southern 186,458		186,188	1.1A
	70	Northern 47,082	Central 65,355	Southern 73,751	186,188	1.1C
	60	Statewide 99,102			99,102	1.1B
	60	Northern 65,937	Southern 33,165		99,102	1.1A
	60	Northern 25,060	Central 34,786	Southern 39,255	99,102	1.1C
	50	Statewide 85,803			85,803	1.1B
	50	Northern 57,089	Southern 28,714		85,803	1.1A
	50	Northern 21,697	Central 30,118	Southern 33,988	85,803	1.1C
Pound nets	70	Statewide 186,458			186,458	1.2B
	70	Northern 37,900	Southern 146,758		186,458	1.2C
	70	Northern 39,700	Central 121,756	Southern 25,002	186,458	1.2A
	60	Statewide 220,309			220,309	1.2B
	60	Northern 46,907	Southern 173,402		220,309	1.2C
	60	Northern 46,907	Central 143,861	Southern 29,541	220,309	1.2A
	50	Statewide 180,373			180,373	1.2B
	50	Northern 38,404	Southern 141,969		180,373	1.2C
	50	Northern 38,404	Central 117,783	Southern 24,186	180,373	1.2A

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Landings data for the southern flounder commercial fisheries were evaluated to determine how landings and price per pound fluctuated during the year. This helped to identify what time frames would allow for the most productive fishery while minimizing discard mortality and meeting the necessary reductions. Commercial landings remain low through the majority of the first half of the year and begin to increase in late summer and peak in October and early November (Figure 4.1.7).

Southern flounder landings vary by location, month, and gear but typically increase in the Albemarle Sound area (northern) in early September, Pamlico Sound (central) in mid-to-late September, and Core Sound and south (southern) by October. Due to these variations in seasonal landings by gear and area, landings were analyzed to show the weekly rate of harvest as a percent of the total average landings from 2008 to 2017 (Figures 4.1.8 and 4.1.9). This analysis shows harvest rates through the year for each gear category statewide and by area as identified in Figures 4.1.5 and 4.1.6. One exception is in the southern portion of the state where the commercial gig fishery harvests flounder beginning in early summer and drives the harvest in the summer for the southern area (Figure 4.1.8).

Combining all mobile gears into a single group would allow for flexibility in determining opening dates for gears within the larger category, possibly allowing a gig fishery to operate during these summer months when the fish are available. For example, a sub-allocation of 38,614 pounds of the mobile gear allocation can be set aside for gigs and other gears, excluding gill nets, for harvest beginning May 1 and operating until this sub-allocation is harvested. This sub-allocation is based on the commercial gig fishery portion of the mobile gears category but could change if the NCMFC selects to phase out large-mesh gill nets in the southern flounder fishery. Once this sub-allocation is met, the remaining harvest would be available for harvest during the fall fishery where all gears, excluding pound nets, would be able to harvest the remainder of the available allocation for mobile gears. It is important to note that this summer sub-allocation is not independent of the mobile gear allocation. All reporting from dealers during this period will be accounted to the mobile gear allocation. In addition to seasonal information, effort data, environmental changes, ITP constraints, and quota monitoring requirements all provided information for the division to select management areas, opening dates, and gear combinations.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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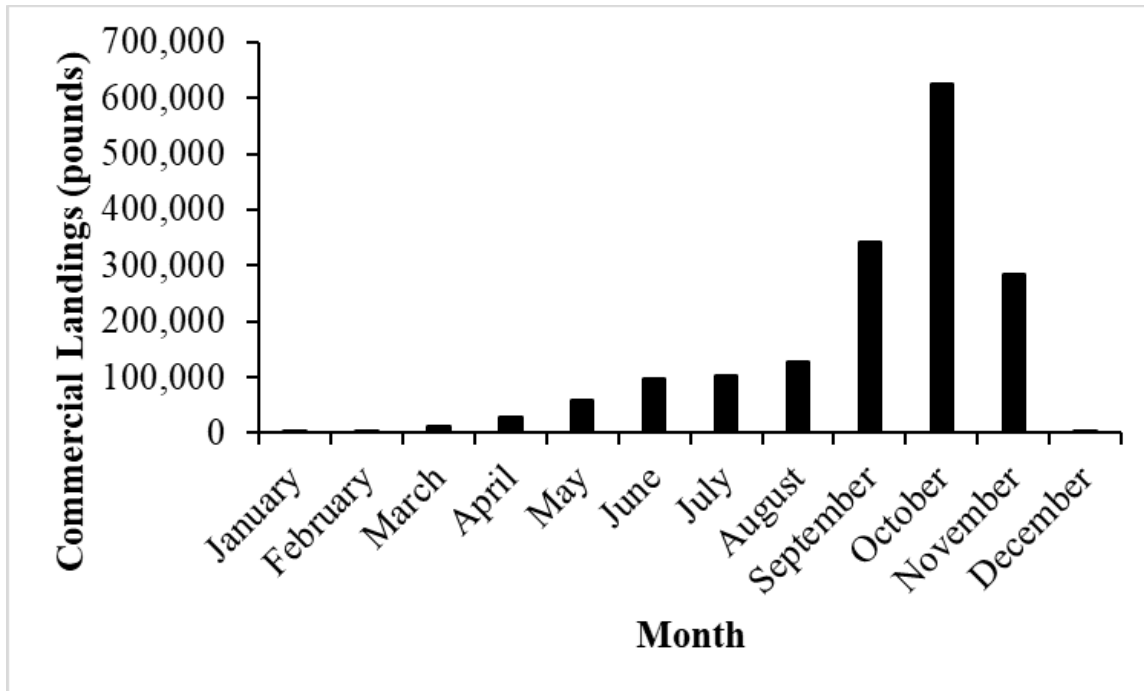


Figure 4.1.7. Average commercial southern flounder landings (pounds) by month in North Carolina, 2008-2017. (Source: North Carolina Trip Ticket Program)

Combining all mobile commercial gears into one category split between two areas of the state, with each area having its own mobile gear allocation, will provide the most flexibility to accommodate opening dates within an area based on southern flounder movements. Dividing the pound net fishery into three areas will allow the timing of the openings for this gear to be more relevant to their geographic locations. Because pound nets are stationary gear, areas to further split the allocation will accommodate some flexibility on opening dates based on southern flounder movements; however, there will be consequences of disproportionate impacts to individual areas and gears that should be noted within these added layers to the quota allocation.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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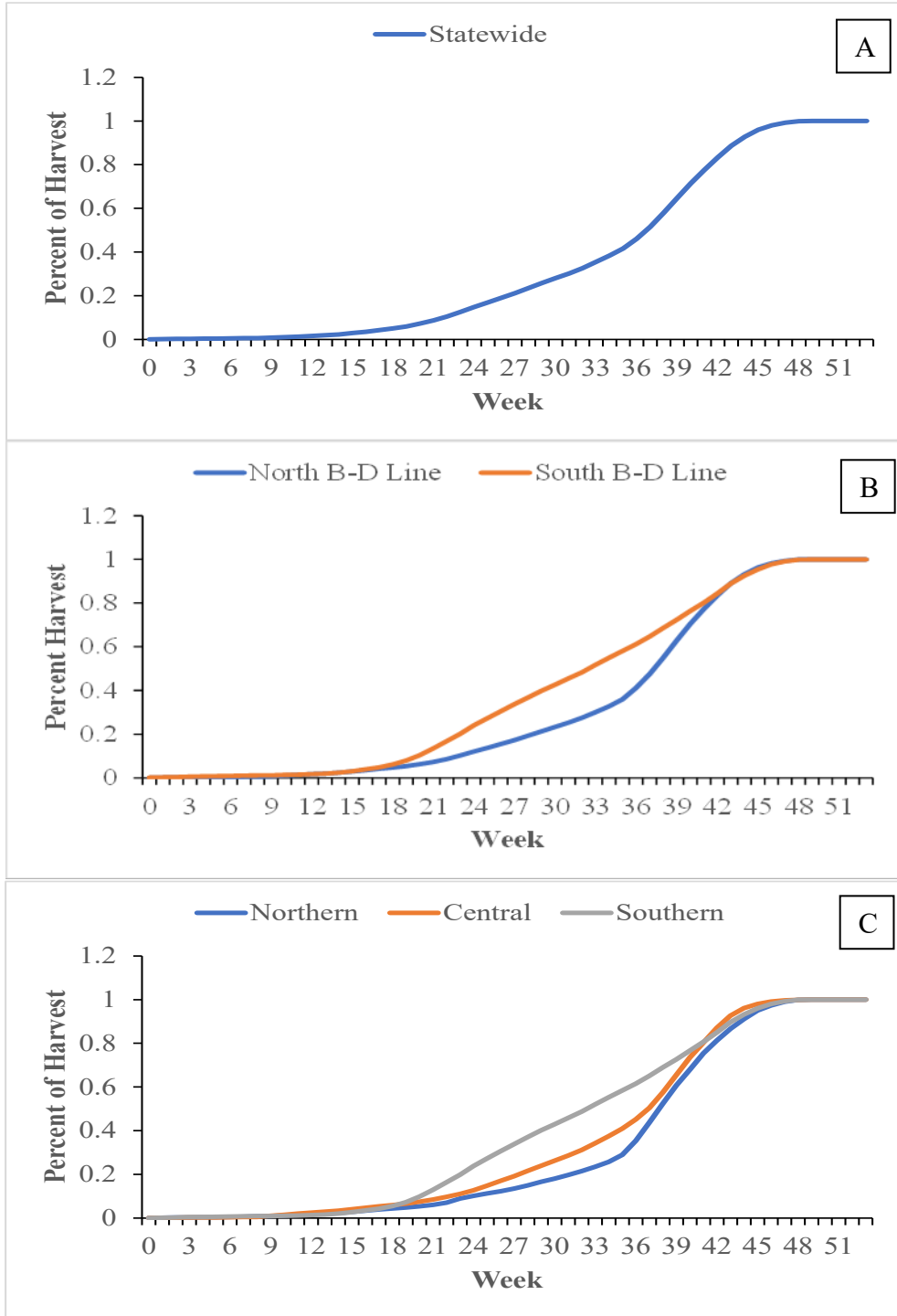


Figure 4.1.8. Average weekly harvest (in percent, 2008–2017) through the year from mobile gears statewide (A) and for two (B) and three (C) areas management scenarios as identified in Figure 4.1.5.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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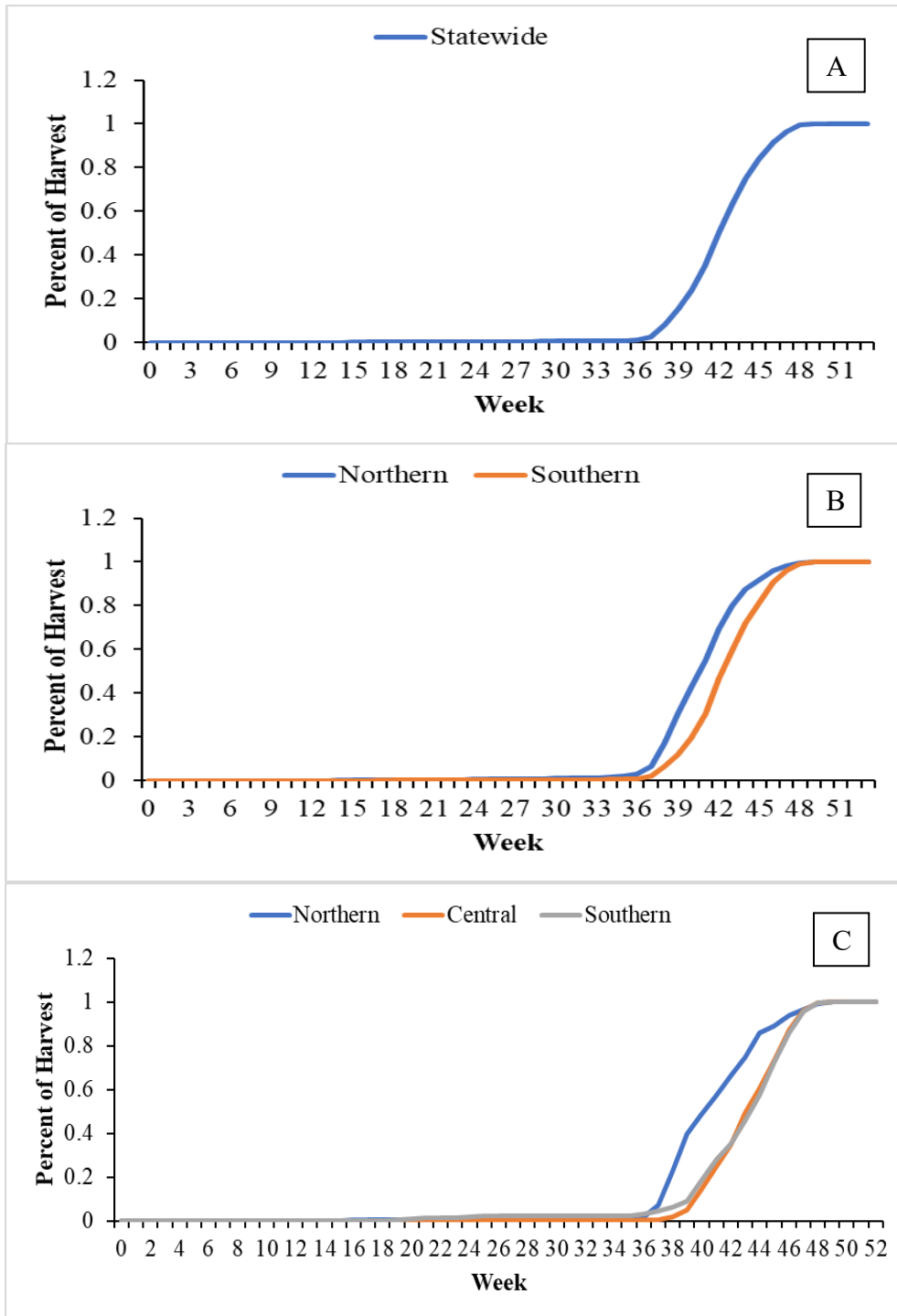


Figure 4.1.9. Average weekly harvest (in percent, 2008–2017) from the commercial pound net fishery statewide (A) and for two (B) and three (C) areas management scenarios as identified in Figure 4.1.6.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Commercial Accountability Measures

For the commercial fishery, if the combined TAL for all gear and area combinations are not exceeded at the end of a fishing year, accountability measures will not be applied. If the combined TAL are exceeded, paybacks due to overages of an allocation for a particular year from landings and dead discards would be applied to the responsible gear and area combination, meaning overages would be subtracted from the following year's allocation for that gear and area combination. These overages will be applied on a pound for pound basis. Any unused allocation or rollover would not be added to the subsequent year's allocation and would serve as a benefit to the resource and potentially decrease the time for rebuilding. The final total of pounds landed (including estimates of dead discards for the gill net fishery) from a year's harvest will be determined through verification of the quota monitoring forms and NCTTP landings data. It is important to restate that it is not the individual gear and area allocations that are driving management, rather it is the overall quota. The NCDMF will do what is necessary to maintain landings to meet the needs of rebuilding of the stock. Flexibility in managing each gear and area combination is necessary for the overall success of a quota system; see the *Adaptive Management* issue paper for further flexibility in developing long-term management measures.

Division staff will monitor the quota on a daily basis in order to prevent landings from becoming so large that the quota will be exceeded and the stock will continue to be overfished. When the sum of the daily reporting for an area and gear combination approaches approximately 80% of the allocated landings, the division will issue a proclamation immediately to close the gear and area combination to the harvest of southern flounder. The mechanism for closing the southern flounder commercial fishery is through G.S. 113-221.1 (b) and Rule 15A NCAC 03M .0503 that provide the Fisheries Director proclamation authority to immediately close a fishery that is monitored by a quota. Closure under this rule does not require a 48-hour notice and can be issued effective immediately. This may be necessary to prevent additional overfishing as certain gear-area combinations can harvest a large percentage of the commercial quota if left unchecked.

Daily quota monitoring of the commercial fisheries will be key in achieving a long-term sustainable harvest of the southern flounder stock. A quota in combination with area, season openings, and trip limits for some gears will also provide access to the fish as they migrate through the sounds and into the ocean and maintain some buffer to reduce the potential for overages in the quota.

If remaining allocation is available, the division may reopen the gear and area combination for a short window to provide opportunity to harvest the remaining allocation; however, if the remaining allocation is not practical to manage while ensuring an overage will not occur, the fishery in question will not be reopened. This reopening may include trip limits for gears where this type of management would not increase dead discards as an additional regulation to prevent any overage of the allocation.

For gears where trip limits are not a viable option, like gill nets, the division may open the fishery daily. Daily openings may prove futile in keeping landings within an allocation and may not be a good option to use; the remaining allocation could be made available for other gears

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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within the mobile gears category in this case; however, if the remaining allocation is not practical to manage while ensuring an overage will not occur, the fishery in question will not be reopened.

Recreational Fisheries

For the recreational fisheries, hook and line and gigs, the TAL will vary with 2021 and 2022 being 159,706 pounds, 2023 being 212,941 pounds and from 2024 onward the TAL will be 266,176 pounds (Table 4.1.9). These are the recreational allocations of the overall quota as determined by the NCMFC. To ensure the recreational allocation is not exceeded but provides both sectors continued access to the resource under these restrictions, the allocation will be further refined to allow an annual harvest of 89% of the recreational TAL for the hook-and-line fishery and 11% of the recreational TAL for the recreational gig fishery. The associated pounds can be found in Table 4.1.9. The ability to monitor a recreational quota in real time is possible with a well-designed creel survey specific to the species and covering the geographic range of harvest and gears. The division relies on the MRIP, in which southern flounder is a species encountered regularly in the hook-and-line recreational fishery. The survey design of MRIP does not allow for results on a daily or weekly basis. Instead, results are available by two-month waves, several months after the data are collected. As a result, historical catch data must be used to predict future catch rates. Once the level of harvest for each reduction value was identified, catch from the MRIP was analyzed by two-week increments (the finest level of detail available) and summed to determine seasonal dates the fishery could operate while meeting the necessary reduction (Table 4.1.10). Seasons may vary as the TAL increases from 30% in 2021 until 50% parity is reached in 2024. This will be determined through Adaptive Management, see the *Adaptive Management* issue paper,

Although the recreational hook-and-line fishery is monitored through the MRIP, this program does not collect necessary information to provide estimates for the recreational gig fishery. As a result, the division conducts an annual mail survey for gig fishery effort and harvest estimates (see the *Description of the Fisheries* section for additional details on MRIP and the Recreational Gig survey).

Recreational use of limited commercial fishing gears is allowed in North Carolina and is subject to the same reductions as the other recreational and commercial fisheries. RCGL holders primarily use large-mesh gill nets to harvest southern flounder but may occasionally harvest southern flounder from shrimp trawls and crab pots. The collection of RCGL harvest data has not occurred since 2008 and is not reliable for estimating reductions due to multiple management changes since the survey ended. See the section on the *Description of the Fisheries* for trends in the RCGL fishery.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.1.9. Southern flounder recreational fishery total allowable landings allocations in pounds by gear and total recreational allocation percentage.

Year	Allocation %	Recreational Gear		
		Hook-and-Line	Gig	Total
2021/2022	30	142,206	17,500	159,706
2023	40	189,608	23,333	212,941
2024	50	237,010	29,166	266,176

Table 4.1.10. Seasons identified to reach the TAL (142,206 pounds in 2021 and 2022, 189,608 pounds in 2023, and 237,010 pounds in 2024) of the NC recreational hook-and-line fishery quota in pounds at the current four fish bag limit based on average landings from 2008–2017. Seasons may vary as the TAL increases until 50% parity is reached and will be determined through Adaptive Management. (2020 landings for the recreational hook and line fishery for the Aug 16 – Sep. 30 season with a four-fish bag limit was 362,119 pounds).

Season	Landings (lb)			
	4-Fish Bag Limit	3-Fish Bag Limit	2-Fish Bag Limit	1-Fish Bag Limit
No closure	451,126	428,594	400,502	332,075
Apr 16–Jun 30	109,157	107,657	105,569	100,911
May 1–Jun 30	102,622	102,622	99,249	94,985
Jun 1–Jul 15	110,702	109,102	106,836	102,184
Aug 1–Sep 30	179,895	175,782	171,480	161,015
Aug 16–Sep 30	127,706	125,359	123,267	118,071
July 16–Sep. 30	222,360	216,583	210,150	194,024
June 16–Sep. 15	272,287	263,508	252,502	226,790
Aug 16-Oct 15	156,040	152,524	149,254	*141,382
Aug-16-Oct 30	177,680	173,505	169,590	159,554

*This season and bag limit does meet the harvest level of TAL but exceeds estimates at the TAC level.

The use of RCGL gear is only allowed when both the recreational and commercial fisheries are open for the particular gear, and the user can only harvest recreational limits. Due to these requirements, the only options available to regulate the harvest of flounder using a RCGL is to allow harvest during a period of time when the commercial and recreational fisheries are open simultaneously or prohibit the harvest of flounder using a RCGL.

The limitations in monitoring for the recreational southern flounder fisheries allows for less flexibility in management measures to ensure the recreational allocation is not exceeded. Final estimates of recreational harvest are not available until the season ends, so real time accounting of catch cannot be determined for underage or overage to the sector allocation. To complement a seasonal approach to the allocations, further non-quantifiable measures such as bag limits and

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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allowable RCGL harvest are considered, as maintaining the four-fish daily bag limit allows for harvest just above the maximum required within the current season. These additional management tools are needed to increase the likelihood of meeting required reductions in the recreational fisheries and are discussed below.

Further discussion on species-specific management measures is considered and presented in the *Increased Recreational Access* issue paper.

Recreational Season Allocation

The recreational hook-and-line fishery is allocated an increasing volume from 142,206 pounds in 2021 up to 237,010 pounds of southern flounder beginning in 2024 (Tables 4.1.1 and 4.1.9). With the current four-fish bag limit, the identified season of Aug. 16 through Sept. 30 meets the reductions when combined with the inability to provide estimates of gig harvest and discards at reduced bag levels and the potential additional harvest from an ocellated flounder season (see the *Increased Recreational Access* issue paper). While this seasonal approach does meet the reductions, changes to bag limits are discussed in detail later due the potential for increased angler success. Seasonal allocation results in a quota that is validated using MRIP landings only after the season has closed. In North Carolina, the previous years' MRIP landings are available by mid-April of the following year.

The recreational gig fishery is allocated an increasing volume from 17,500 pounds in 2021 up to 29,166 pounds of southern flounder beginning in 2024 (Table 4.1.9). It is necessary to maintain concurrent seasons for the recreational hook-and-line and gig fisheries to keep from undermining the success of achieving necessary reductions (Table 4.1.11). Allowing a gig fishery to operate longer than the recreational hook-and-line fishery would allow excess harvest from the gig fishery that would exceed the gig allocation. In addition, if the gig fishery and the hook-and-line fishery operated during independent seasons, anglers could alter their current behavior by participating in each of the seasons, increasing effort and harvest on an already limited allocation.

Table 4.1.11. Seasons identified to reach the initial TAL (17,500 lb in 2021 and 2022, 23,333 lb in 2023, and 29,166 lb in 2024) of the N.C. recreational gig fishery landings (observed harvest) at the current four-fish bag limit based on average landings from 2010–2017. Seasons may vary as the TAL increases until 50% parity is reached and will be determined through Adaptive Management. (2020 landings for the recreational gig fishery for the Aug 16 – Sep. 30 season with a four-fish bag limit was 26,475 pounds).

Season	Landings (lb)
No closure	85,688
Jul 1–Sep 30	33,532
Jul 16–Sep 30	28,060
Jul 1–Sep 15	27,711
Aug 1–Sep 30	22,587
Aug 16–Sep 30	17,115

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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When the recreational fishery is closed, recreational harvest of flounder in both internal and ocean waters will be unlawful as all flounder species (southern, summer, Gulf) are managed collectively in North Carolina. Other measures may be available to allow for species-specific management (see the *Increased Recreational Access* issue paper).

Recreational Accountability Measures

Accountability measures will also be necessary for the recreational hook-and-line and gig fisheries. The final recreational total catch will be determined by adding the total landings from the MRIP and gig surveys to the estimates of dead discards. To account for overages from landings and dead discards, the following year's recreational quota and season will be adjusted based on the results of the MRIP and gig mail surveys from the previous year. If the TAL for the recreational sector combined is not exceeded, then accountability measures will not be applied. If the TAL are exceeded, any overages to the TAL will be applied to the subsequent season (which includes both hook-and-line and gig gears). Using the conservative approach described in the commercial accountability measures, any remaining allocation will not be rolled over to subsequent years. These data are typically available by mid-April for the previous calendar year, can be calculated quickly, and are expected to be finalized prior the usual recreational season, assuming the season does not open prior to June 1. For the recreational fishery, final total of pounds harvested from a year's harvest, discard estimates, and estimates of number of trips will be determined through verification of the final MRIP and Gig Mail Survey.

An annual quota is the most appropriate tool for the recreational fisheries to maintain sustainable harvest, but it is more challenging to track every trip because harvest data are only available in two-month intervals with delays in verification. Instead, a season for the recreational fisheries that will maintain the allocation within its bounds may be the most reasonable approach. Due to a high level of discards in the recreational hook-and-line fishery, there is concern that the volume of discards can have a large direct impact on subsequent seasons if anglers continue to target and release southern flounder during closed seasons. Recreational hook-and-line discards are not monitored through a quota and are not available until after the season is complete. It is important to restate that it is not the individual gear allocations that are driving management, rather it is the overall quota. Additional measures can be implemented in concert to further refine harvest management to limit impacts due to overages while the fishery is recovering. This approach does limit angler access during periods of no harvest, but it does not stop the unintended consequences of large volumes of discards through indirect hooking while targeting other species or intentional catch and release discards. Unintended discards are a major source of removals in the southern flounder recreational fishery (Flowers et al. 2019; NCDMF 2019).

OTHER NON-QUANTIFIABLE MANAGEMENT MEASURES

Non-quantifiable measures are those that are not directly part of the stock assessment model and there is no way to measure the impact on the modeled fishing mortality. This does not mean that these non-quantifiable measures are not important to consider in management, they merely are not able to be included in the percent reduction needed to end overfishing/overfished status as statutorily required. If non-quantifiable measures are implemented, future stock assessments will indirectly reflect their effect on the fishery status. The non-quantifiable management measures

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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under consideration to control effort in the fishery include trip limits in the commercial fisheries and bag limits in the recreational fisheries. Because specific impacts on recruitment and overfishing cannot be calculated, relevant empirical data for the various measures are presented herein. Earlier in the discussion section, the management carried forward was described. In addition to those non-quantifiable management measures carried forward, there are other non-quantifiable management measures to consider.

Commercial Fisheries Trip Limits

In the southern flounder commercial fishery, the use of a trip limit may be useful to maintain the quota allocation in the gig and pound net fisheries but is not ideal for the gill-net fishery due to the potential for increased dead discards. Unlike gigs or pound nets where commercial fishermen can selectively harvest flounder or release captured flounder with a high rate of survival, gill nets, although selective for fish size, cannot select for volume of fish entangled. As a result, any fish entangled in a gill net that is over a trip limit would be released with a higher rate of discard mortality, increasing the pounds of removals and impacting the overall quota.

To calculate trip limits for the gig and pound net fisheries, average landings for the past 10 years by proposed areas were reviewed in conjunction with the numbers of trips with landings in varying poundage increments for each area based on the 10-year average for that fishery. For the gig fishery, a trip limit in numbers of fish, not pounds, is needed for the trip limit to be enforceable. To calculate this, the pounds harvested were converted to numbers of fish based on an average of 2.56 pounds per gigger fish as determined from commercial fish house sampling.

Trip limits for the commercial pound net and gig fisheries cannot be determined at this time because trip limits may change depending on the fishery and how many pounds are available to harvest. The Fisheries Director will determine the trip limit amounts dependent upon how close the fishery is to their allocation and what overall daily harvest amounts have already occurred in the season. Information is available to identify the volume of trips that remove southern flounder based on various intervals to provide some guidance (Tables 4.1.12 and 4.1.13). There are concerns with a trip limit for the pound net fishery, particularly if set too low. Because southern flounder can be held in pound nets, it is possible for fishermen to hold southern flounder until they can be landed. Multiple people can harvest from a single operation in order to land the fish available. If the pound net trip limit is set too low, safety becomes a consideration as well and fishermen may be forced to fish their sets in unfavorable weather conditions; currently, sets are fished on good weather days, not every day. Understanding these shortcomings in the pound net fishery, a trip limit would allow harvest of southern flounder while minimizing dead discards as discards from pound nets are assumed to have a high survival rate. Allowing the gig fishery additional landings within the allocation using trip limits on the remaining quota will allow harvest and minimize discards as the gig fisherman can stop harvesting fish when the daily limit is reached. A trip limit for the gill-net fishery creates additional discards, once their trip limit has been reached remaining gear soaking will capture fish in excess of the specified trip limit and be released with an estimated mortality of 23% (Lee et al. 2018). Additional information on trip limits can be found in the *Adaptive Management* issue paper.

Recreational Fisheries Bag Limits

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Potential changes to bag limits for all recreational gear were evaluated. Reductions in recreational bag limits may increase the likelihood of meeting required reductions as the stock rebuilds. The current daily bag limit for flounder is set at four fish; the average angler success rate for a single trip is one harvestable southern flounder (Figures 4.1.10 and 4.1.11). During 2017, recreational anglers released nine southern flounder for every one southern flounder that was harvested (Figure 19 in the *Description of the Fisheries* section). Angler success rates are tied to stock size (fish availability) and minimum size limits. As stock abundance increases during the rebuilding period, it is likely angler success will increase as well. If angler success improves, any gains achieved through limited open seasons will be lessened, limiting the actual recovery of the species. Harvest should be constrained using multiple measures in the recreational fisheries while rebuilding occurs.

Reducing the southern flounder bag limit would minimize the impacts of increased angler success on the rebuilding stock. Current data show that recreational anglers harvest 93% of the southern flounder total landings during trips where only one fish is harvested in a daily trip, although there is a four-fish daily bag limit in addition to the minimum size limit (Table 4.1.14). A reduction from four fish to three fish or from four fish to two fish daily bag limit does not curtail actual harvest (Table 4.1.14). Dropping the recreational bag limit for southern flounder to zero fish still results in dead discards of over 50,000 pounds for all identified potential season dates by anglers who are not targeting southern flounder and happen to catch and release some.

If angler success increases during the rebuilding time period, the volume of removals could increase relative to the original reduction calculations (Figure 4.1.11). If angler success doubles, which would be a two-fish daily harvest limit, paybacks from overharvest have the potential to severely curtail continued recreational angling opportunities as the stock recovers (Figure 4.1.12). Preliminary analyses of 2020 MRIP data indicate that angler success increased during the 2020 recreational season, when compared to 2015-2019, with the most notable increase with the number of anglers catching a single southern flounder. Limiting the potential future harvest during times of increased abundance will allow the stock to rebuild, making further bag limits necessary to constrain recreational harvest to meet the required reductions.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.1.12. Commercial southern flounder pound net trip limit scenarios (in pounds), including the number and cumulative of % trips, and % harvest within each trip limit bounds, September through November, 2008–2017. Note: Rounding of values may cause cumulative percentages to differ slightly.

Management Area										
Pounds Per Trip	Northern					Central				
	Number of Trips	% of Trips	Cumulative Trip %	% of Harvest	Cumulative Harvest %	Number of Trips	% of Trips	Cumulative Trip %	% of Harvest	Cumulative Harvest %
<251	1,633	65	65	8	8	4,173	51	51	11	11
251-500	291	12	77	8	16	1,533	19	70	14	24
501-750	159	6	83	7	24	794	10	80	12	36
751-1,000	86	3	87	6	29	518	6	86	11	47
1,001-1,250	63	3	89	5	34	315	4	90	9	56
1,251-1,500	43	2	91	5	39	212	3	93	7	63
1,501-2,000	66	3	93	8	47	252	3	96	11	74
2,001-3,000	63	3	96	11	59	209	3	98	12	86
3,001-4,000	36	1	97	10	68	76	1	99	6	92
4,001+	66	3	100	32	100	59	1	100	8	100
Average Pounds Per Trip	539					503				
Management Area										
Pounds Per Trip	Southern					Statewide				
	Number of Trips	% of Trips	Cumulative Trip %	% of Harvest	Cumulative Harvest %	Number of Trips	% of Trips	Cumulative Trip %	% of Harvest	Cumulative Harvest %
<251	1,850	66	66	18	18	7,656	57	57	11	11
251-500	420	15	81	15	33	2,244	17	74	13	24
501-750	197	7	88	13	46	1,150	9	82	11	35
751-1,000	123	4	92	12	57	727	5	88	10	45
1,001-1,250	63	2	94	7	64	441	3	91	8	52
1,251-1,500	40	1	96	6	70	295	2	93	6	59
1,501-2,000	48	2	98	9	78	366	3	96	10	69
2,001-3,000	40	1	99	10	89	312	2	98	12	81
3,001-4,000	20	1	100	7	96	132	1.0	99	7	88
4,001+	9	0	100	4	100	134	1.0	100	12	100
Average Pounds Per Trip	344					475				

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.1.13. Commercial southern flounder gig fishery trip limit scenarios (in number of fish), including the number and cumulative % of trips, and % of harvest within each trip scenario, 2008–2017. Note: Rounding of values may cause cumulative percentages to differ slightly.

Number of Fish	Number of Trips	% of Trips	Cumulative Trip %	% of Harvest	Cumulative Harvest %
25	17,288	74	74	44	44
50	4,504	19	94	33	77
75	941	4	98	12	89
100	324	1	99	6	95
125	92	0	100	2	97
150	32	0	100	1	98
175	19	0	100	1	99
200	23	0	100	1	100
Average Pounds Per Trip		52			

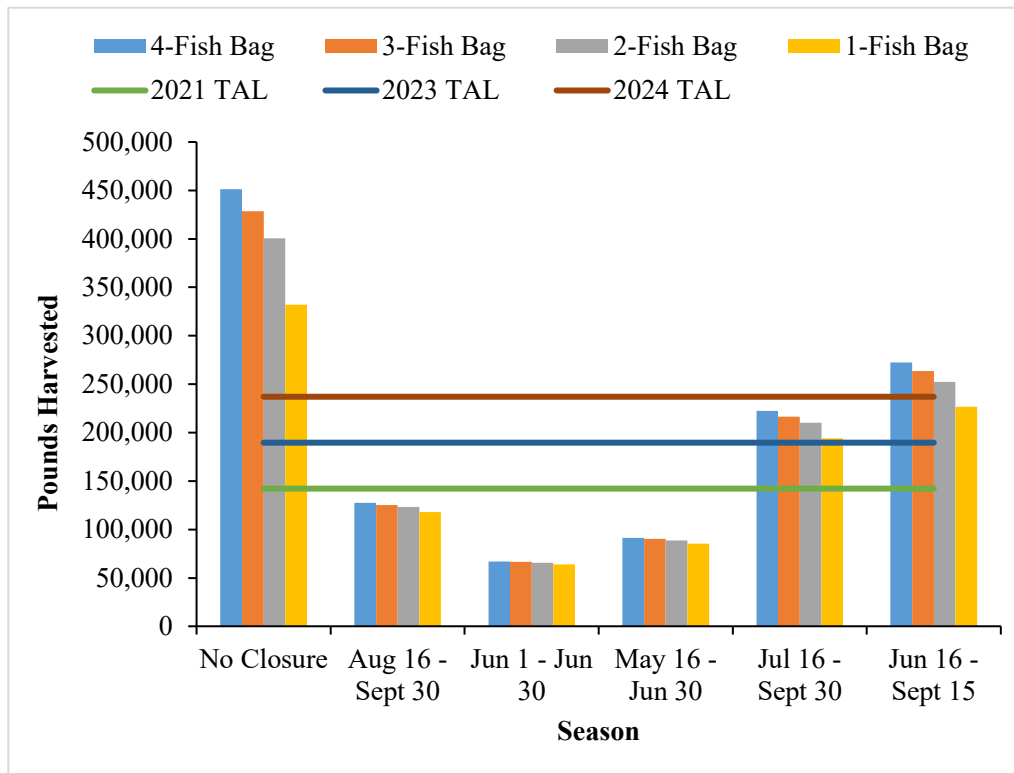


Figure 4.1.10. North Carolina southern flounder recreational fishing season relating to the increasing TAL (142,206 pounds in 2021 and 2022, 189,608 pounds in 2023, and 237,010 in 2024) and changes to the daily bag limit.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.1.14. Percent contribution of bag limit trips to total harvest of southern flounder for select seasons.

Percent Contribution of Bag Limit to Total Harvest				
Season	4-Fish Bag Limit	3-Fish Bag Limit	2-Fish Bag Limit	1-Fish Bag Limit
No Season	5%	6%	15%	74%
Aug 1 - Sept 30	2%	2%	6%	90%
Aug 16 - Sept 30	2%	2%	4%	93%
Jun 1 - Jun 30	1%	1%	2%	95%
Apr 1 - June 30	1%	2%	4%	92%
Apr 1 - Sep 30	4%	6%	13%	77%
Mar 1 - Apr 15	0%	0%	0%	100%
Sep 1 – Sep 30	1%	1%	2%	96%
Apr 16 - Jun 30	1%	2%	4%	92%
May 1 - Jun 30	1%	2%	4%	93%
May 16 - Jun 30	1%	2%	3%	94%

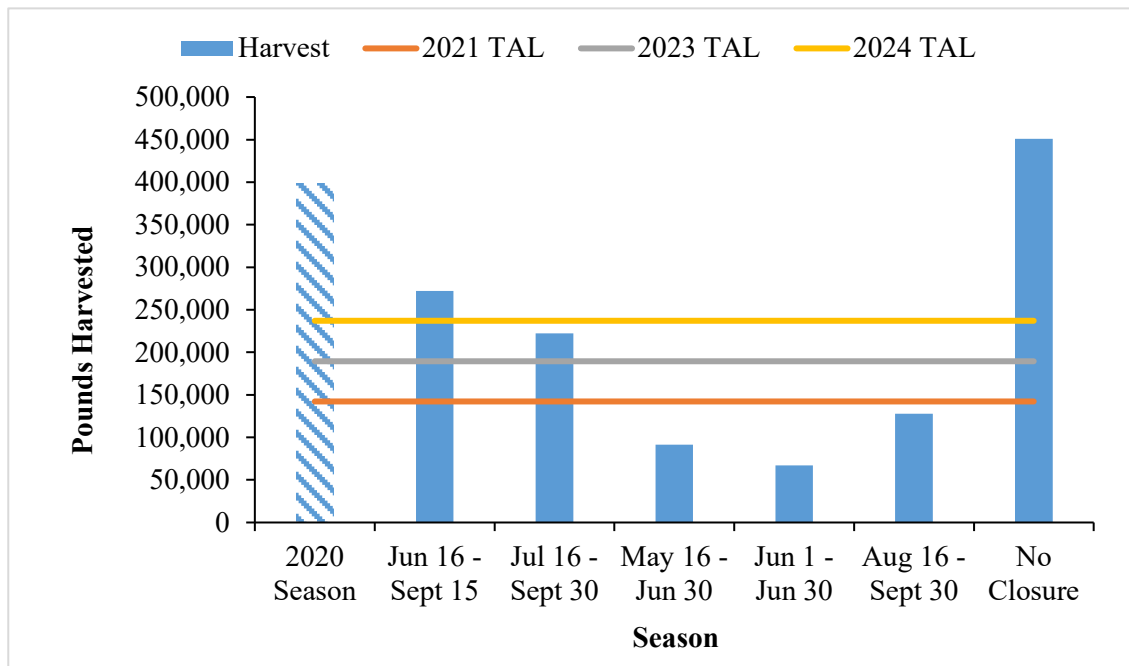


Figure 4.1.11. North Carolina southern flounder recreational fishing season relating to the increasing TAL (142,206 pounds in 2021 and 2022, 189,608 pounds in 2023, and 237,010 in 2024). The 2020 season was Aug. 16 through Sept. 30.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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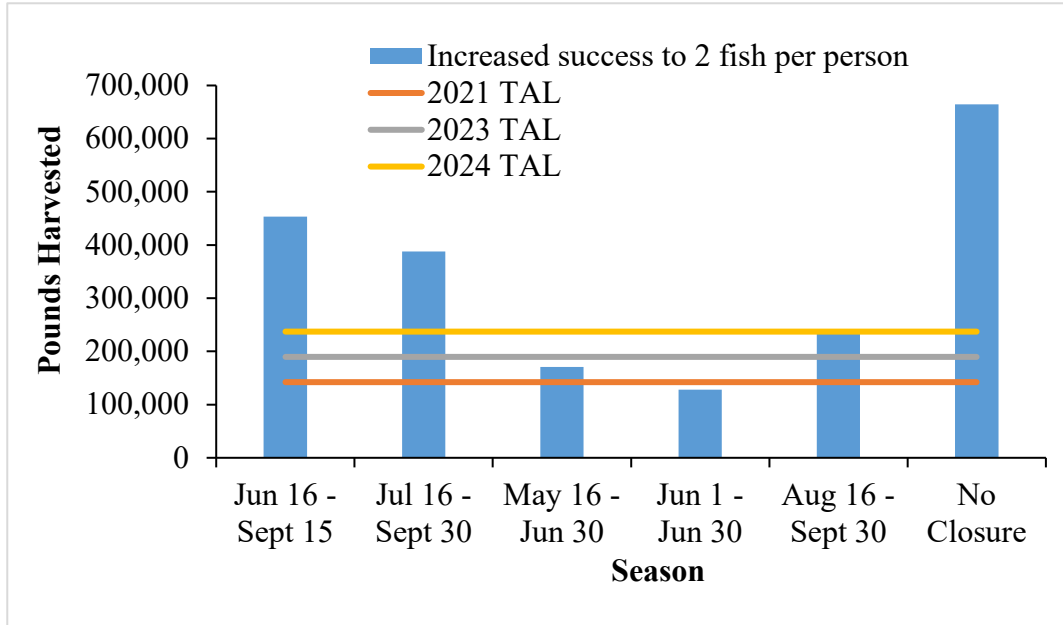


Figure 4.1.12. North Carolina southern flounder recreational fishing season relating to the increasing TAL (142,206 pounds in 2021 and 2022, 189,608 pounds in 2023, and 237,010 in 2024) anticipating angler success increasing to two fish per trip in the future.

Additional discussion of bag limits and the potential for increased angler opportunities through species-specific management of summer, southern, and Gulf flounder can be found in the *Increased Recreational Access* issue paper.

Recreational Commercial Gear

Recreational use of limited commercial fishing gears is allowed by law in North Carolina and is subject to the same reductions as the other recreational and commercial fisheries. Calculating reductions for the RCGL fishery is not possible because collection of RCGL harvest data has not occurred since 2008. Data collected in 2008 and prior may not be reliable for estimating reductions for Amendment 3 due to multiple management changes that have also occurred since the surveys ended. See the *Description of the Fisheries* section for trends in the RCGL fishery

Recreational gear license holders primarily use large-mesh gill nets to harvest southern flounder but may occasionally harvest southern flounder from shrimp trawls and crab pots. The use of commercial gears for recreational purposes is also only allowed during concurrently open recreational and commercial fishing seasons that allow the specific gear, and the user is only allowed harvest that does not exceed the recreational limits. Due to these requirements, the only measures available for harvest of flounder using a RCGL is during a period of time if and when the commercial and recreational fisheries are open simultaneously or prohibit the use of the RCGL for the harvest of southern flounder.

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The volume of removals cannot be estimated for RCGL gears, but the number of license holders has continually declined from 6,055 participants in 2000 to a low of 1,662 participants in 2017 (additional information on RCGL can be found in the *Description of the Fisheries* section). Amendment 2 provides minimal opportunity to fish RCGL gears targeting southern flounder when both the recreational and commercial seasons are open. In addition, if the bag limit for recreational harvest is reduced, the resulting change could also further limit the impacts of the RCGL fishery. If harvest of southern flounder is prohibited from RCGL gear, then an increase in discards will occur if these gears continue in targeting other non-flounder species.

CONCLUSION

Certain measures are better to attain the goal to maintain sustainable harvest at the much-reduced harvest levels than others, while other measures provide more flexibility to benefit the sectors both in access to the resource and for higher economic value. Below we expand on the key measures that are the most risk averse in that they have the highest likelihood of succeeding in maintaining sustainable harvest while providing some flexibility in access to the resource for all sectors in the fisheries.

A summary of the key decision choices that are discussed as potential management measures in this paper are found in Tables 4.1.15 and 4.1.16.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.1.15. Summary of quantifiable management measures for Amendment 3.

Management Option	Management Sub-option	Management Measure	Gear	# Management Areas	Description
1	1.1A	Commercial Quota	All gear other than pound nets	2	Division at the ITP B-D Boundary Line
1	1.1B	Commercial Quota	All gear other than pound nets	1	Statewide
1	1.1C	Commercial Quota	All gear other than pound nets	3	Same areas as Amendment 2
1	1.2A	Commercial Quota	Pound Nets	3	Same areas as Amendment 2
1	1.2B	Commercial Quota	Pound Nets	1	Statewide
1	1.2C	Commercial Quota	Pound Nets	2	Division at approximately Pea Island
2	2.1	Commercial Sub-Allocations	All commercial gears	N/A	2017 landings
2	2.2	Commercial Sub-Allocations	All commercial gears	N/A	Maintain current pound net allocation
2	2.3	Commercial Sub-Allocations	All commercial gears except gill nets	N/A	Allocate gill net harvest to mobile and pound net gears equally (50/50)
3	3	Recreational Quota (through season)	Hook-and- Line, Gigs	1	Statewide

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Table 4.1.16. Summary of non-quantifiable management measures for Amendment 3.

Management Option	Management sub-option	Management Measure	Description
4	4A	Commercial Fishery Trip Limits	Implement trip limits for pound nets and gigs only to maximize potential opportunities for reopening a fishery to harvest remaining allocation
4	4B	Commercial Fishery Trip Limits	Implement trip limits for all gears
4	4C	Commercial Fishery Trip Limits	Status quo, do not implement trip limits
5	5A	Recreational Fishery Bag Limits	Reduce recreational bag limit of flounder to one fish per person per day
5	5B	Recreational Fishery Bag Limits	Reduce recreational bag limit of flounder to no more than three fish per person per day
5	5C	Recreational Fishery Bag Limits	Reduce recreational bag limit of flounder to no more than two fish per person per day
5	5D	Recreational Fishery Bag Limits	Status quo, keep the recreational bag limit of flounder at no more than four fish per person per day
6	6A	Recreational Commercial Gear	Allow the RCGL to be used to harvest flounder only during a period of time when the commercial and recreational fisheries are both open
6	6B	Recreational Commercial Gear	Prohibit the use of RCGL to harvest southern flounder

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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VI. PROPOSED MANAGEMENT OPTIONS

Management Options

(+ potential positive impact of action)

(- potential negative impact of action)

Below are overarching positive (+) and negative (-) impacts for all options, specific impacts from an option may be found below that option.

- + May increase the abundance of female southern flounder helping to rebuild the spawning stock
- + Will impact both the commercial and recreational fisheries
- + No rule changes required
- Decreased harvest and economic impacts

Option 1. Implement A Quota for Mobile Gears and Pound Nets

The following positive and negative impacts apply to all of Option 1; specific impacts are listed under each sub-option.

- + Two gear categories reduce potential for increased error in dealer reporting
- + Allows individuals to fish and report multiple gears under the mobile gear category
- + Meets the requirements for rebuilding
- + If gill-net fishing is closed due to ITP, then allocation would be available to other gears in combined category
- + Would allow fishermen to explore alternate fishing gears to reduce bycatch
- +/- Could allow for different opening dates
- Seasonal selections may impact landings from certain gears and locations more than others
- The more gears and areas are divided, the more complex dealer reporting and division monitoring becomes and we will be less likely to meet targets

1.1A. Dividing the states mobile commercial gears into two areas using the ITP boundary line for management units B–D.

- + Meets requirements for reductions
- + Maintains consistency for gill-net ITP boundary lines
- + Allows flexibility in opening dates for each area
- +/- May shift fishing effort and alter behavior
- Some regions may be impacted more than others
- Some gears may be impacted more than others
- More areas make monitoring the daily landings more difficult

1.1B. A single statewide mobile commercial gear allocation that includes all coastal estuarine waters.

- + Single allocation area is easiest to monitor

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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- + Combing mobile gears makes reporting by dealers easier and reduces error
- + Equal access to commercial fishers
- + Meets requirements for reductions
- Seasonal selection may impede landings in certain locations

1.1C. Dividing the states mobile commercial gears into three areas (northern, central, and southern). The northern area would encompass the Albemarle Sound and its tributaries including the Croatan and Roanoke sounds, the central would encompass the Pamlico Sound and its tributaries, and the southern would encompass all waters from Core Sound south matching the boundaries described for the pound net fishery three-area option 2.2A.

- + Meets requirements for reductions
- Some regions may be impacted more than others
- Some gears may be impacted more than others
- Enforcement issues through increased boundaries not consistent with current ITP lines
- More areas make monitoring the daily landings more difficult
- More areas increase complexity for dealers daily reporting

1.2A. Dividing the state's pound net fishery into three areas maintaining consistency with areas in Amendment 2.

- + Meets requirements for reductions
- + Allows flexibility for different opening dates for each area
- + Maintains consistency with Amendment 2 boundaries
- Some regions may be impacted more than others
- Some fishers may have pound nets in multiple areas
- More areas make monitoring the daily landings more difficult

1.2B. A single statewide pound net allocation.

- + Meets requirements for reductions
- + Makes monitoring the daily landings easier
- No flexibility in opening dates
- Availability of fish varies across the state; may impact some areas more depending on when fishery is open

1.2C. Dividing the states pound net fishery into two-areas using the 35° 46.3000' N latitude.

- + Meets requirements for reductions
- Some fishermen may have pound nets in multiple areas
- Availability of fish varies across the state; may impact some areas more depending on when fishery is open

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Option 2. Commercial Sub-Allocations

Decisions on commercial sub-allocations may be influenced based on the option selected in Appendix 4.7: *Phasing out Large-Mesh Gill Nets from the NC Southern Flounder Fishery* issue paper.

- 2.1. Maintain overall reductions of 72% and 2017 sub-allocations (Table 4.1.6)
 - + Allows for all commercial gears to harvest southern flounder
 - + Meets the requirements for sustainable harvest
 - May reduce pound net sub-allocation to a level that is not economically viable
 - May reduce pound net sub-allocations to a level where daily quota monitoring may be problematic

- 2.2. Maintain overall reductions of 72% and the current level of sub-allocation for the pound net fishery (Table 4.1.7).
 - + Allows for all commercial gears to harvest southern flounder
 - + Meets the requirements for sustainable harvest
 - Reduces the available sub-allocation for mobile gears
 - Decreases the economic benefit of the commercial mobile gear fisheries

- 2.3. Maintain overall reductions of 72% and redistributes the gill net allocation equally between mobile and pound net gears beginning in 2023 (shown in the 60% and 50% allocations) (Table 4.1.8).
 - + Meets the requirements for sustainable harvest
 - + Increases the sub-allocations for remaining mobile gears and pound nets
 - + May increase the economic impact of the remaining gears
 - Does not allow for harvest of southern flounder using gill nets
 - Decreases the economic benefit of the commercial gill net fishery

Option 3. Recreational Quota

- + Meets requirements for reductions
- + Consistent with Amendment 2
- + Should limit removals and allow rebuilding of the stock
- + Allows for continued access to stock during rebuilding
- Several month delay to receive final estimates after season ends due to MRIP data availability
- Reduces access to anglers during closed seasons
- Difficult to account for angler behavior changes
- Does not stop indirect discards while targeting other species
- Does not limit future harvest during times of increased abundance from rebuilding

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Option 4. Commercial Fisheries Trip Limits

The following positive and negative impacts apply to all of option 4; specific impacts are listed under each sub-option.

- + Allows for maximizing available allocations
- + Meets requirements for reductions
- May create additional discards if the trip limits are set too low
- Any SCFL or RSCFL holder can fish a permitted pound net with permission; a single net could distribute fish to multiple SCFL/RSCFL holders that normally would not use that gear

4A. Implement trip limits for pound nets and gigs only to maximize reopening after reaching division closure threshold.

- + Can be effective for gears with limited discard mortality
- Any SCFL or RSCFL holder can fish a permitted pound net with permission; a single net could distribute fish to multiple SCFL/RSCFL holders that normally would not use that gear

4B. Implement trip limits for all commercial gears.

- + May limit harvest from non-targeted gears as the stock recovers
- + May alleviate concerns of a derby fishery
- Not effective for gears where discard mortality is high (gill nets)
- May force fishermen to fish in unfavorable weather

4C. Status quo, do not implement trip limits

- + Any quota not harvested would act as additional savings for the spawning stock biomass
- +/- Would not allow fisheries to re-open after closure due to approaching the TAL
- Economic impacts to the commercial sector would be greater if unable to harvest all of the TAL

Option 5. Recreational Fisheries Bag Limits

The following positive and negative impacts apply to all of Option 5; specific impacts are listed under each sub-option.

- + Meets requirements for reductions
- Decreases potential access to recreational anglers
- May increase discards

5A. Reduce recreational bag limit of flounder to one fish per person per day.

- + Provides the greatest chance of rebuilding and maintaining growth in the stock
- + May allow for quickest rebuilding of spawning stock biomass
- + May limit harvest during times of increased abundance from rebuilding
- May slow rebuilding if fish are continued to be harvested
- Would increase discards

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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5B. Reduce recreational bag limit of flounder to no more than three fish per person per day.

- + Reduces harvest for anglers who were successful at catching more than three flounder per trip
- Does not limit future harvest during times of increased abundance from rebuilding
- May delay rebuilding of spawning stock biomass

5C. Reduce recreational bag limit of flounder to no more than two fish per person per day.

- + Reduces harvest for anglers who were successful at catching more than two flounder per trip
- Does not limit future harvest during times of increased abundance from rebuilding
- May delay rebuilding of spawning stock biomass

5D. Status quo, keep the recreational bag limit of flounder at no more than four fish per person per day

- + Regulations are consistent with Amendment 2
- Does not limit future harvest during times of increased abundance from rebuilding
- May delay rebuilding of spawning stock biomass

Option 6. Recreational Commercial Gear

6A. Allow the RCGL to be used to harvest flounder only during a period of time when the commercial and recreational fisheries are both open.

- + Consistent with Amendment 2
- + Allows continued access to fishery
- Cannot account for harvest or discards from RCGL gear
- May increase discards if gear is allowed and bag limits are reduced
- Potential protected species interactions
- If allowed, there will be disparity among areas

6B. Prohibit the use of RCGL for the harvest of southern flounder.

- + Eliminates harvest from RGCL gears
- Cannot account for harvest or discards from RCGL gear
- Removes access to fishery for license holders
- May increase discards if species cannot be harvested but gear is still allowed

VII. RECOMMENDATIONS

*NCDMF Initial Recommendation**

The NCDMF initial recommendation is to set an annual harvest quota for the commercial and recreational sectors with further refinements in how the harvest will be constrained for each sector as follows:

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Commercial Fisheries:

- Combine mobile gears (gill nets, gigs, and “other” gears) into one gear category and maintain pound nets as their own separate commercial fishery (Option 1).
- Divide mobile gears into two areas using the ITP boundary line for management units B-D (Option 1.1A; Figure 4.1.5).
- Divide the pound net fishery into three areas maintaining consistency with areas in Amendment 2 (Option 1.2A; Figure 4.1.6).
- Maintain 72% reduction and current sub-allocation for the pound net fishery (Option 2.2)
- Implement trip limits for pound nets and gigs only to maximize reopening after reaching division closure threshold (Option 4A).

Recreational Fisheries:

- Implement seasons for the recreational gig and hook-and-line fisheries to constrain them to an annual quota (Option 3).
- Reduce the recreational bag limit of flounder to one fish per person per day (Option 5A).
- Do not allow harvest of southern flounder using RCGL (Option 6B).

**Includes management measures and clarifications in the carried forward from Amendment 2.*

VIII. LITERATURE CITED

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- Craig, J.K., W.E. Smith, F.S. Scharf, and J.P. Monaghan. 2015. Estuarine residency and migration of southern flounder inferred from conventional tag returns at multiple spatial scales. *Marine and Coastal Fisheries* 7:450–463.
- Flowers, A.M., S.D. Allen, A.L. Markwith, and L.M. Lee (editors). 2019. Stock assessment of southern flounder (*Paralichthys lethostigma*) in the South Atlantic, 1989–2017. Joint report of the North Carolina Division of Marine Fisheries, South Carolina Department of Natural Resources, Georgia Coastal Resources Division, Florida Fish and Wildlife Research Institute, University of North Carolina at Wilmington, and Louisiana State University. NCDMF SAP-SAR-2019-01. 213 p.
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AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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- NCDMF. 2017a. North Carolina southern flounder (*Paralichthys lethostigma*) fishery management plan: Supplement A to Amendment 1. North Carolina Division of Marine Fisheries, Morehead City, NC. 83 p.
- NCDMF. 2017b. North Carolina Division of Marine Fisheries Trip Ticket User Manual, Version 9. North Carolina Department of Environmental Quality, Division of Marine Fisheries, Morehead City, NC. 43 p.
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AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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APPENDIX 4.1.A. MANAGEMENT MEASURES AND STRATEGIES CONSIDERED BUT NOT DEVELOPED

Appendix 4.1.A was developed to provide additional data analysis and discussion on management measures and strategies that have been explored in this issue paper. These strategies do not have sufficient data necessary to support moving forward at this time but may provide research needs so they can be considered in future updates to the Southern Flounder Fishery Management Plan.

STATUS QUO

An option of “status quo,” which means continue only what is in Amendment 2, is not presented in this issue paper. Final adoption of Amendment 2 to the Southern Flounder Fishery Management Plan authorized development of Amendment 3 with more comprehensive management strategies.

LIMITED ENTRY

North Carolina G.S. 113-182.1 states the NCMFC can only recommend the General Assembly limit participation in a fishery if the NCMFC determines sustainable harvest in the fishery cannot otherwise be achieved. Sustainable harvest can be achieved without the use of limited entry; therefore, limited entry is not an option at this time. For further information see *Appendix 1: Management Issues Considered but Not Developed*.

DYNAMIC QUOTA

A dynamic quota refers to a total allowable catch that fluctuates among years relative to the abundance of the resource and fishing pressure. In the case of southern flounder, the quota for a given year would be primarily driven by the strength of the year classes being subjected to fishing pressure. As with the static quota, all of the same drawbacks, including issues with monitoring the landings on a daily basis and the high degree of variability in the daily landings, go along with implementing a dynamic quota. In addition, to adequately manage a dynamic quota, the division would need to determine if the fishery-independent surveys used to estimate recruitment in the 2019 stock assessment can accurately predict year-class strength for quota management purposes. The terminal year estimates of recruitment from stock assessments tend to be the most uncertain; the use of recruitment indices to determine a dynamic quota is not a viable possibility. Due to limited availability of real time data that is reflective of the southern flounder stock, a dynamic quota is not a viable management option.

CHANGES TO SIZE LIMITS

Calculations necessary for developing projections based on increasing the current minimum size limit, decreasing the current minimum size limit, or developing a slot limit cannot be calculated on an individual state basis. The current stock assessment does not include a spatial component and, as a result, the lack of this spatial component means all size limit changes would be relative to the entire stock of southern flounder. Currently, there are multiple minimum size limits in place across the unit stock, ranging from 12- to 15-inches TL. If an increase or decrease in the minimum size limit, or a slot limit, for N.C. waters is considered, it is necessary to note that calculations referencing reductions that affect the fishing mortality rates of spawning stock

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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biomass are not possible. Any changes made would be based on previous years' data for fish within North Carolina harvest estimates and may or may not have intended impacts on the rebuilding of the stock. It would not be possible to attribute changes to size limits as the cause of changes to stock size.

Using North Carolina harvest estimates, calculations were performed to determine what additional effect size limit changes would have on the TAL in North Carolina. As stated above, these calculations do not account for the entire unit stock and are only for guidance as the effect over the entire unit stock would be non-quantifiable. The discussion below addresses these effects, as well as potential drawbacks to increasing the minimum size. Slot limits and a decrease in the minimum size are discussed in the *Implementing a Slot Limit* issue paper.

Increase in Minimum Size Limit

An increase in the minimum size limits is not recommended for the commercial fishery. In 2017, 80% of the fish harvested in the commercial fishery were less than 18 inches TL (Figure 4.1.11 in the *Achieving Sustainable Harvest* issue paper). Increasing the minimum size limit would increase the volume of releases from this fishery. In addition, continued increase in the minimum size limit would place increased harvest on the largest fish in the stock, which would disproportionately be females. For the commercial fishery, an increase in the minimum size limit would result in additional dead discards, particularly in the gill-net fishery that has a discard mortality rate of 23% (Lee et al. 2018).

Public comment for increasing the minimum size limit in the recreational fishery has been received numerous times over the years, with an increase to 18-inches most often mentioned. For the recreational fishery, increasing the minimum size limit would increase the volume of releases from this fishery, many of which may be mortalities and would decrease angler success. In 2017, 71% of the southern flounder harvested (by weight, pounds) by the recreational fishery were under 18-inches TL (Figure 4.6.2 in the *Implementing a Slot Limit* issue paper). If the recreational minimum size limit were to be set at 18-inches TL, an additional 28,000 pounds of dead discards would be created based on 2017 data with a total harvest savings of approximately 283,352 pounds over the year. To determine what impact changing the minimum size limit to 18-inches TL would have on the TAL, seasonal calculations were re-evaluated. Several seasons were identified, in addition to the season currently established (Aug. 16 to Sept. 30) in Amendment 2, that would meet the overall harvest target reduction of 142,206 pounds (Table 4.1.A1). Although an increase in the minimum size limit has the potential to increase the length of a season, there is increased error around these estimates. Additionally, as the stock rebuilds, the seasons identified may not continue to meet the target harvest reduction due to increased angler success (Figure 4.1.A1).

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.1.A1. Season and total harvest for an 18-inch TL minimum size limit based on 2017 data.

Season	Total Harvest (pounds)
No Closure	167,774
Aug 16--Sep 30	47,401
Aug 1--Sep 30	49,149
Jul 16--Sep 30	64,576
Jul 1--Sep 30	91,376
Aug 1--Oct 15	52,914
Aug 16--Oct 15	51,167
Jul 1--Aug 31	47,493
Jul 1--Sep 15	66,396
Sep 1--Oct 31	58,760
Sep 1--Nov 15	68,808

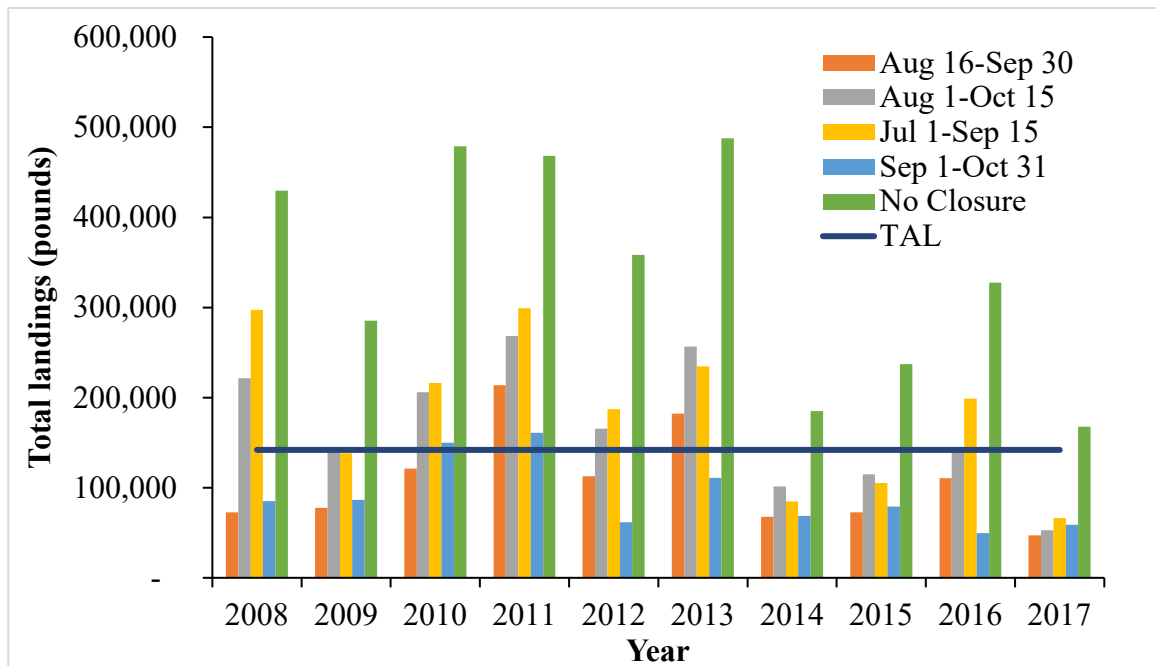


Figure 4.1.A1. Total hook-and-line harvest for seasonal options based on data for 18-inch minimum size limit from 2008–2017. Years 2010, 2011, and 2013 represent years of above average harvest. TAL of 142,206 pounds is represented by the blue solid line.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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COMMERCIAL GEAR LIMITATIONS

Current gear configurations, including 6.0 ISM for large-mesh gill nets, 5 and ¾ ISM escape panels in pound nets combined with a 15-inch TL minimum size limit for flounder, have reduced the volume of discards observed. Although the only fishery for which discards can currently be estimated is the large mesh gill-net fishery, anecdotal evidence supports limited discards in the pound net fishery. Due to the apparent effectiveness of the current gear configurations and the current minimum size limit, additional changes to gear are not recommended at this time; however, if size limits are considered for the estuarine flounder fishery, changes to gear configurations may be warranted.

DEVELOPMENT OF FISHING DAYS (WEEKEND/WEEKDAYS/HOLIDAYS) FOR THE RECREATIONAL FISHERY

The adoption of Southern Flounder Amendment 2 by the NCMFC mandated a 72% reduction in pounds for both the commercial and recreational sectors beginning in 2020 to achieve sustainability of the stock within 10 years. To achieve this reduction within the recreational fishery, MRIP data from 2008–2017 were analyzed to determine appropriate bag limits that operate in concurrence with seasonal closures. A reduction in pounds necessitated incorporation of the discard mortality estimates across specific bag and season combinations. The harvest of southern flounder exhibits a distinct seasonality and the bulk of the harvest occurs during the summer months. To achieve an acceptable reduction in harvest, seasonal scenarios focused on reducing harvest during the summer months. This analysis demonstrated that the only scenario in which the recreational TAL was not exceeded was through a four-fish bag limit on southern flounder within a season spanning Aug. 16 through Sept. 30. At the request of the NCMFC, the division explored the possibility of protracting the recreational season through combinations of weekday and weekend day types. Additional input from the Southern Flounder Advisory Committee recommended a weekday specific season during the summer months with an allowance for weekend only fishing during the fall.

MRIP catch rate estimates were obtained through a variety of weightings reflective of angler avidity including location, day type (weekend vs. weekday), and time of day. MRIP produces catch estimates by applying the weighted catch rates to estimates of effort obtained through the Fishing Effort Survey (see *Description of the Fisheries* section). Importantly, the MRIP definition of day type includes Friday as a weekend day type due to angler avidity aligning more closely with observations from Saturday and Sunday. As such, it is disproportionately weighted with expanded catch rate estimates reflecting this increased avidity. Thus, it is of particular note that Friday is included as a weekend day type when data are deconstructed for analysis. Initial analyses sought to achieve targeted reductions for particular day types as a proportion of day type specific contributions. Specifically, a weekend target of 76,000 pounds and a weekday target of 46,000 pounds would achieve the overall target reduction of 142,206 pounds. This analysis demonstrated that when individual day types were given equal consideration regarding targeted reductions, there was no deviation from initial reduction projections using the combined data set; however, when individual day types were considered within the context of the recreational hook-and-line TAL (142,206 lb), it is possible to achieve a variety of scenarios that extend the season for over three months and still achieve desired reductions but with increased error around the produced estimates.

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The scenario that most closely approaches the harvest allowance includes a summer season from July 16 through Sept. 30 that permits harvest only during MRIP defined weekdays (Monday, Tuesday, Wednesday, and Thursday). This weekday season will provide a projected harvest of 92,354 pounds. A subsequent season consisting of MRIP defined weekend days (Friday, Saturday, Sunday) will begin on Oct. 15 and last until Nov. 30. This fall weekend season will provide a projected harvest of 27,803 pounds. The combined harvest of 121,666 pounds will fall below the TAL of 142,206 pounds (Table 4.1.A2; Figure 4.1.A2).

Alternate management scenarios incorporate species-specific harvest (i.e., summer, southern, Gulf) and are further evaluated in the *Increased Recreational Access* issue paper. When constituent flounder species are given consideration in establishing bag limits, there is potential to craft additional seasons that further extend the seasonal harvest of flounder. Verifying the recreational angling community’s ability to differentiate among North Carolina’s three flounder species will be requisite before single species management options can be explored.

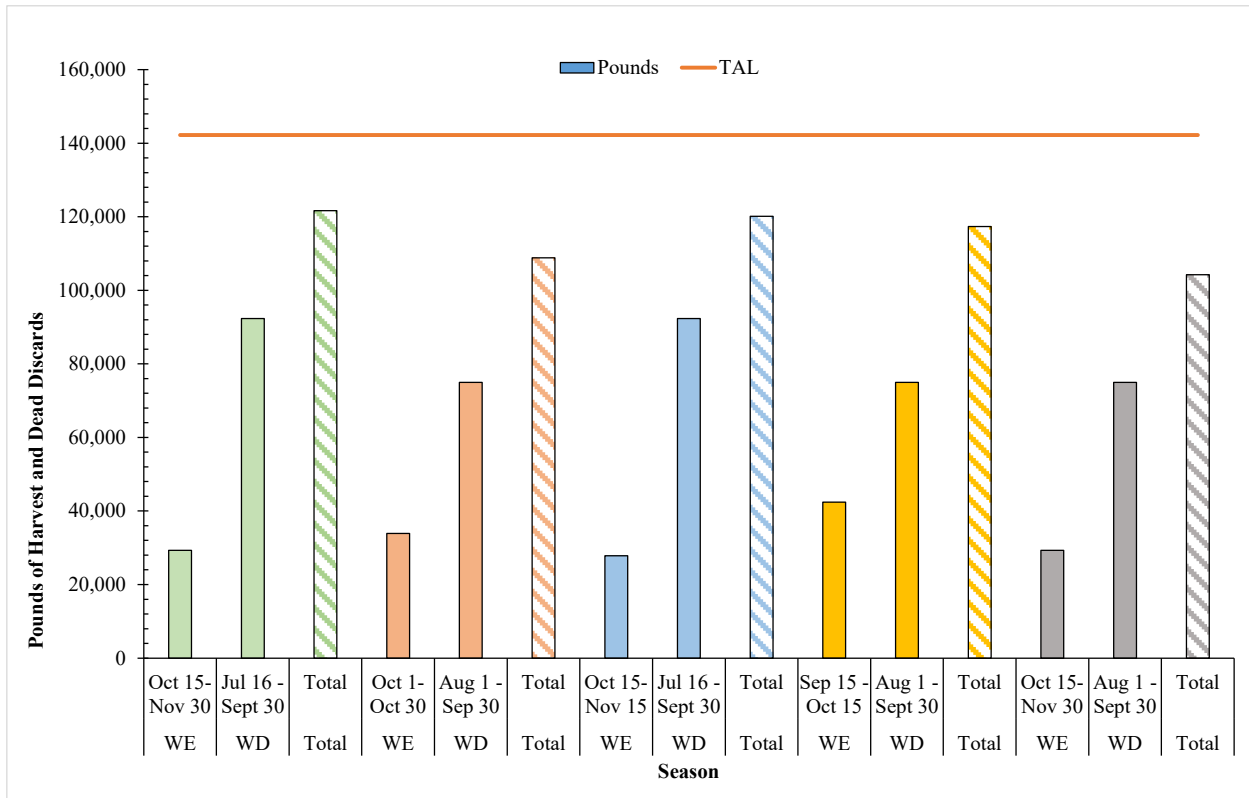


Figure 4.1.A2. Southern flounder harvest projections from seasons using day-type specific combinations. (Note: WD = Weekdays and WE = Weekends).

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.1.A2. Southern flounder harvest projections from seasons using day-type specific combinations.

Day Type	Season	Pounds
Weekend	Oct 15 –Nov 30	29,313
Weekday	Jul 16–Sept 30	92,354
	Total	121,666
Weekend	Oct 1–Oct 30	33,903
Weekday	Aug 1– - Sep 30	74,953
	Total	108,856
Weekend	Oct 15 –Nov 15	27,803
Weekday	Jul 16–Sept 30	92,354
	Total	120,157
Weekend	Sep 15–Oct 15	42,386
Weekday	Aug 1–Sept 30	74,953
	Total	117,339
Weekend	Oct 15- Nov 30	29,313
Weekday	Aug 1 - Sept 30	74,953
	Total	104,266

The scenarios provided will allow greater access to the resource by providing concessions for for-hire stakeholders who rely heavily on weekday clientele during the summer months while also affording anglers access to the fall flounder fishery. The primary concern with this approach is that under the initial season combining all day types provided anglers with a defined window within which to fish, thus increasing the likelihood of achieving targeted reductions. The extension of a season across multiple months between specific day types increases the opportunity for individuals to alter their behavior to capitalize on the resource, which has the potential to compromise projected reductions. It may be beneficial to consider options with a lower projected harvest to provide a buffer against temporal displacement across a protracted season. This is also suggested as the reductions are based on the terminal year (2017) of the assessment. During periods of higher abundance (e.g., 2013), weekday and weekend estimates vary greatly and are often greater than allowed for the recreational hook-and-line TAL (Figure 4.1.A3).

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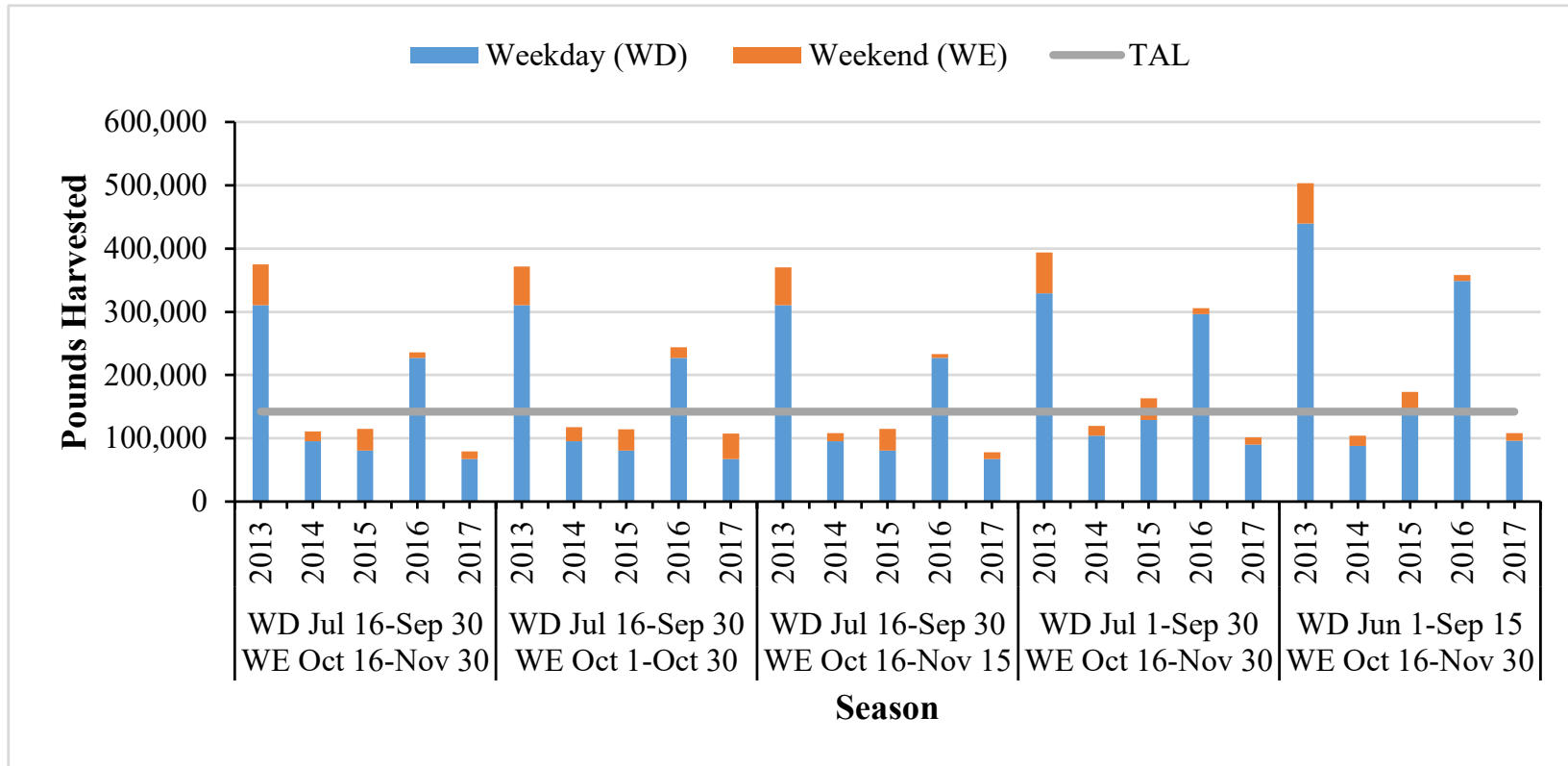


Figure 4.1.A3. Annual variability in harvest of southern flounder (pounds) during identified day type combinations, 2013–2017. (Note: WD = Weekdays and WE = Weekends)

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RECREATIONAL FISHERY VESSEL LIMITS

Potential implementation of vessel limits for all recreational gear were evaluated. The Private/Rental boat mode in MRIP is responsible for the largest portion of the recreational landings of southern flounder. The vessels intercepted by MRIP had an average of two anglers present from 2008 through 2017; however, the number of anglers ranged from one to 11 (Table 4.1.A3). It is the trips where more than two anglers are present that cause concern. In the southern flounder recreational fishery, the use of a trip limit may be useful to maintain the quota allocation for the hook-and-line and gig fisheries. Vessel limits may have a larger impact to recreational southern flounder harvest if bag limits are not reduced from four fish per person per day. Much like reduction in bag limits, effects of vessel limits are not quantifiable at this time as estimates would be based on prior years which will not be reflective of the fishery moving forward. Due to this, implementing trip limits would serve to reduce the chances of exceeding the TAL for the recreational fishery and thus reduce the chances of significant impacts in subsequent seasons due to required accountability measures. As stock abundance increases during the rebuilding period, it is likely angler success will increase as well. If angler success improves, any gains achieved through limited open seasons will be lessened, limiting the actual recovery of the species. Harvest must be constrained using multiple measures in the recreational fisheries while rebuilding occurs; however, if the recreational bag limit is reduced to one fish then the implementation of vessel limits may not be necessary. If reductions in bag limits are not implemented and vessel limits are imposed, the vessel limits themselves may not be adequate to limit harvest as rebuilding occurs. Under the proposed quota system, any overages that occur, even if under vessel limit constraints, will be applied to subsequent years. Data suggest that limiting harvest and thus reducing the chances of exceeding the recreational TAL is best suited with a reduction in bag limit.

Table 4.1.A3. Average, minimum, and maximum number of anglers present on a vessel in the Private/Rental Boat mode for the recreational southern flounder fishery from 2008–2017.

Year	Average	Minimum	Maximum
2008	2	1	8
2009	2	1	9
2010	2	1	11
2011	2	1	10
2012	2	1	6
2013	2	1	7
2014	2	1	6
2015	2	1	6
2016	2	1	5
2017	2	1	6
Total	2	1	11

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APPENDIX 4.2. INCREASED RECREATIONAL ACCESS BY MANAGING SOUTHERN FLOUNDER SEPARATELY FROM OTHER FLOUNDER SPECIES

I. ISSUE

Implement single species or genus level management to increase recreational access to summer and Gulf flounder while maintaining harvest reductions in the southern flounder fishery.

II. ORIGINATION

The adoption of Southern Flounder FMP Amendment 2 by the NCMFC mandated a 72% reduction in pounds starting in 2020 for both the commercial and recreational sectors to achieve sustainability of the stock within 10 years (NCDMF 2019). To achieve this reduction within the recreational fishery, MRIP data from 2008-2017 were analyzed relative to the terminal year (2017) landings to determine appropriate bag-limits that operate in concurrence with seasonal closures. Importantly, Amendment 2 contained acute management measures (seasons) to achieve sustainable harvest and was predicated on the immediate development of Amendment 3 for the purpose of implementing more comprehensive long-term management measures to achieve sustainable harvest.

At the request of the NCMFC and the Southern Flounder FMP Advisory Committee, the division examined alternative management scenarios that incorporate species-specific harvest of flounder (i.e., summer, southern, Gulf). When constituent flounder species are given consideration, the potential exists to develop additional scenarios that further extend the seasonal harvest of flounder species.

III. BACKGROUND

Southern flounder, or flounder species in general (*Paralichthys* spp.), are one of the most targeted recreational species in North Carolina. Southern flounder are primarily landed by recreational fishermen using hook and line. Additional harvest, albeit to a lesser extent, is accomplished with gigs and recreational use of commercial gears (e.g., anchored large-mesh gill nets). Between 2008 and 2017, North Carolina's total recreational removals (in pounds) were approximately 19% of the total coast-wide southern flounder removals (North Carolina to the east coast of Florida; NCDMF 2019). The recreational flounder fishery in North Carolina accounted for 28% of the state's total removals (26% in landings and an additional 2% of dead discards) in 2017 (the terminal year of the assessment; NCDMF 2019). Additionally, between 2008 and 2017 southern flounder contributed 73% of total flounder landings with summer contributing 22% and Gulf contributing 5%. For additional information on landings see the *Description of the Fisheries* section and *Achieving Sustainable Harvest* issue paper.

In North Carolina, the recreational flounder fishery is managed as an aggregate consisting of three main species of flounder (southern, summer, and Gulf). Thus, a closure on the southern flounder recreational fishery means the harvest of the other flounder species is prohibited. This is particularly relevant for the closure of the recreational ocean fishery and is acknowledged as an unintended consequence of this aggregate management. Based on MRIP data, most flounder harvest across all species occurs in estuarine waters (Figure 4.2.1). Of the flounder landed in state territorial seas and the EEZ (referred to as "ocean" from this point in the document forward), approximately 50% of the ocean recreational harvest are species other than southern

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flounder. Specifically, summer flounder are more frequently encountered in the ocean fishery relative to southern flounder. Gulf flounder represents less than 6% of total flounder harvest and is predominately harvested in ocean waters (Figure 4.2.1). Pending species-specific management, recreational access to summer and Gulf flounder will not be possible when the southern flounder season is closed.

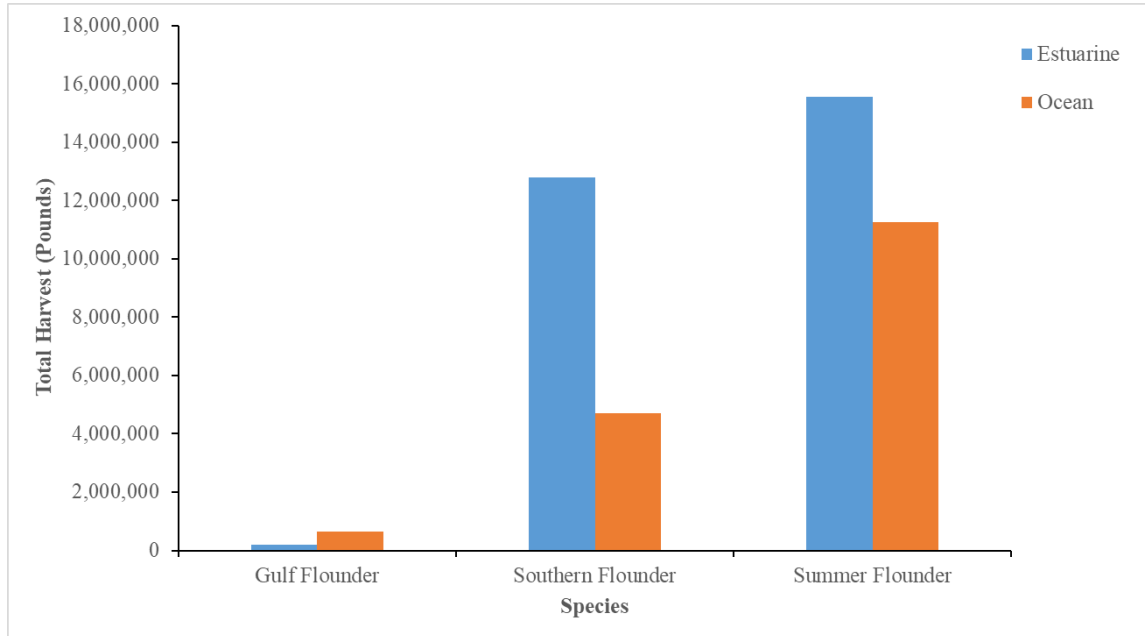


Figure 4.2.1. Pounds of harvest by flounder species from the ocean and estuarine waters, 1981–2019.

This issue paper examines the application of single-species management within a seasonal framework. The deconstruction of flounder species into discrete management units will provide an opportunity for stakeholders to have continued access to summer and Gulf flounder while simultaneously maintaining the required reduction for southern flounder as defined in Amendment 2.

Educational outreach is key to this issue as species identification lays the groundwork for successful implementation and long-term viability of managing flounder by species or aggregations. The division has developed a [Flounder Identification Guide](#) that is available through the “Hot Topics” page of the NCDEQ website. This guide describes the main characteristics (presence of ocellated or non-ocellated spots, gill rakers, and fin ray counts) to identify the three main flounder species in North Carolina waters and serves as a reference to educate anglers.

The absence of ocellated spots in southern flounder relative to Gulf and summer flounder is a defining characteristic that can be used as the primary metric to differentiate among flounder species. Because the primary characteristic for identification (i.e., ocellated spots) is shared between summer and Gulf flounder, it may be possible to aggregate summer and Gulf flounder into a single ocellated flounder category.

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In North Carolina, the management of flounder species has undergone several regulatory iterations to promote the sustainability of the stock. The first implementation of a minimum size limit occurred in 1979 at 11 inches TL for both estuarine and ocean waters. In 2005, the first bag limit was implemented for estuarine waters at eight fish. Subsequent minimum size limits have been implemented through the original North Carolina Southern Flounder FMP (NCDMF 2005), Amendment 1 (NCDMF 2013), Supplement A to Amendment 1 (NCDMF 2017), and revisions to the joint Atlantic States Marine Fisheries Commission (ASMFC) and Mid-Atlantic Fishery Management Council Summer Flounder, Scup, and Black Sea Bass FMP (ASMFC 2017; MAFMC 2019). Despite changes in regulations through time, the overall trend for southern flounder harvest has declined. This decline was underscored by the coast-wide stock assessment. As such, the acceptance of Amendment 2 to the Southern Flounder FMP mandated a 72% reduction in pounds beginning in 2020 to promote the recovery of the stock within 10 years. This reduction could best be accomplished through a 45-day southern flounder recreational season spanning Aug. 16 through Sept. 30 as discussed in the *Achieving Sustainable Harvest* issue paper.

IV. AUTHORITY

North Carolina General Statutes

G.S. 113-134 RULES

G.S. 113-182 REGULATION OF FISHING AND FISHERIES

G.S. 113-182.1 FISHERY MANAGEMENT PLANS

G.S. 113-221.1 PROCLAMATIONS; EMERGENCY REVIEW

G.S. 143B-289.52 MARINE FISHERIES COMMISSION – POWERS AND DUTIES

North Carolina Marine Fisheries Commission Rules

15A NCAC 03H .0103 PROCLAMATIONS, GENERAL

15A NCAC 03I .0120 POSSESSION OR TRANSPORTATION LIMITS THROUGH STATE WATERS; SALE OF NATIVE SPECIES

15A NCAC 03M .0503 FLOUNDER

15A NCAC 03M .0512 COMPLIANCE WITH FISHERY MANAGEMENT PLANS

V. DISCUSSION

MRIP data from 2008 through 2017 were analyzed to determine seasons that would allow harvest of ocellated flounder and not jeopardize rebuilding of the southern flounder stock. Seasons for additional access to ocellated flounder have been identified, in addition to the Aug. 16 to Sept. 30 season for southern flounder. Seasons identified will be selected so as not to exceed the total allowable landings for the recreational fishery for southern flounder while minimizing the potential of additional discards to not exceed the total removals. See the *Achieving Sustainable Harvest* issue paper for further explanation.

Importantly, increases in minimum size limits for flounder species have caused an inversion of harvest between summer and southern flounder, such that the latter has accounted for most flounder harvest since 2001 (Figure 14 in the *Description of the Fishery* section). The ASMFC has implemented state and/or regional level conservation equivalencies for the management of summer flounder since 2001 (ASMFC 2017). The 2017 summer flounder landings were 33.2% lower than the 10-year average and 57.7% lower than the 20-year average. The ASMFC must be

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notified of any changes to the summer flounder fishery in North Carolina state waters; however, approval of changes by the ASMFC is not required if the changes are expected to be more restrictive than the management measures already approved by the ASMFC. Changes to the summer flounder fishery in EEZ waters off North Carolina may be impacted by the Mid-Atlantic Fishery Management Council and National Marine Fisheries Service (NMFS). Until conservation equivalencies are approved by NMFS, coast-wide measures for summer flounder in the EEZ include a four-fish possession limit, a 19-inch TL minimum size limit, and an open season of May 15–Sept. 15 (MAFMC 2019). These measures serve as a default each year until annual conservation equivalencies are approved by the NMFS, which allow state regulations to be applied to EEZ waters. The impacts to the proposed ocellated flounder fishery in the early season are that these conservation equivalencies are not usually approved until May or June, which is after this proposed season. The timing of NMFS approving conservation equivalency management measures in EEZ waters would potentially limit the ocellated flounder season to state territorial waters only. These federal regulations impact the North Carolina fishery differently as state management of flounder is collective and not by individual species.

Discussed below is the option that meets the required reductions for southern flounder and increases access to the summer and Gulf flounder fisheries. Some seasons are more conservative than others, which may be more prudent to select until factors such as correct species identification and increased discards can be evaluated as they relate to the recovery of southern flounder. Any southern flounder harvest during the additional season will need to be accounted for in the recreational fishery quota so the required reductions are not compromised. In addition, flounder harvest will only be allowed in the ocean when the southern flounder season is closed and only with hook-and-line; no gigging will be allowed as anglers cannot correctly identify species prior to harvest. All explored seasons presented assume that all anglers correctly identify all southern flounder and release them.

As stated above, flounder fishing will be limited to the ocean during the ocellated season and is allowed by the transportation limits rule, 15A NCAC 03I .0120. This rule allows summer and Gulf flounder to be transported during the open ocellated season through closed waters, provided anglers do not stop and fish in estuarine waters with flounder on board.

The division recommendation in the achieving sustainable harvest issue paper is that southern flounder harvest be constrained to the season selected in Amendment 2; this is a 45-day season spanning Aug. 16 through Sept. 30 with a one-fish bag limit. The most conservative alternative option (besides status quo) is allowing stakeholders access to ocellated stocks from March 1 through April 15 from ocean waters only with a one-fish bag limit and also a one-fish bag limit during the southern flounder season. This satisfies the target southern flounder reduction while allowing an estimated harvest of an additional 1,025 pounds of ocellated flounder (Table 4.2.1). Though the additional estimated harvest of ocellated flounder during this time is low, this does not account for potential changes in angler behavior wherein additional ocellated landings may occur within this short season. The March 1 through April 15 season also minimizes potential southern flounder harvest compared to other potential seasons. This additional season has the potential to increase the harvest of southern flounder by an estimated 1,267 pounds or approximately 1.0% of the annual harvest allocation.

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Table 4.2.1. Estimated ocean ocellated flounder landings and anticipated southern flounder landings under various options for the hook-and-line fishery.

Ocean Only				Ocean and Estuarine				
Ocellated Flounder Season	Bag Limit Ocellated Season	Estimated Ocellated Flounder Landings	Southern Flounder Landings Early Season	Southern Flounder Season	Bag Limit Southern Flounder Season	Southern Flounder Landings Late Season	Total Southern Flounder Landing	Total Allowable Southern Flounder Landings
None	0	0	0	Aug 16 – Sep 30	1	118,128	118,128	142,206
Mar 1– Apr 15	1	1,025	1,267	Aug 16 – Sep 30	1	118,128	119,395	142,206
Apr 1– June 30	1	23,116	50,159	Aug 16 – Sep 30	1	118,128	168,287	142,206
Apr 1– Sep 30	1	56,009	143,330	Aug 16 – Sep 30	1	74,860	218,190	142,206

Note: Recreational gig fishery would not be allowed to operate during the ocellated season.

Note: None of the southern flounder seasons would allow harvest of more than one southern flounder in the aggregate.

Importantly, as the southern flounder stock recovers there will be increased access to the resource. Analysis of MRIP data during the development of Amendment 2 reveals that recreational anglers rarely achieved the four-fish bag limit and catch rates are typically one fish. From approximately 17,000 in-person angler intercepts conducted in 2017 only one angler achieved the four-fish bag limit and only 2% of trips harvested more than one fish. To buffer against increased harvest compromising targeted reductions it will be beneficial to constrain the bag limit to one fish in any flounder season. For additional discussion on bag limits and angler success see the *Achieving Sustainable Harvest* issue paper.

Additional analysis of ocellated flounder seasons provide examples of the potential for excessive southern flounder harvest during additional seasons relative to a year-round ocellated season. These included a three-month ocellated season from April 1 through June 30 and a six-month ocellated season from April 1 through Sept 30, with a one-fish bag limit with harvest allowed in ocean waters. These truncated seasons provide a means to further reduce incidental harvest of non-ocellated (southern) flounder while allowing an estimated 23,116 and 56,009 pounds of ocellated harvest respectively (Table 4.2.1). Conversely, the potential southern flounder harvest during these truncated seasons will negatively impact management actions necessary to constrain harvest below the TAL. These longer (three- and six-month) ocellated seasons are expected to have impacts on the southern flounder fishery by 50,159–68,470 additional pounds of southern flounder harvest if anglers misidentify southern flounder (Table 4.2.1; Figure 4.2.2). These estimates are the least conservative but provide contrast to show the potential problems when attempting to allow additional ocellated harvest. The potential magnitude of southern flounder harvest precludes these additional seasons from being developed as options.

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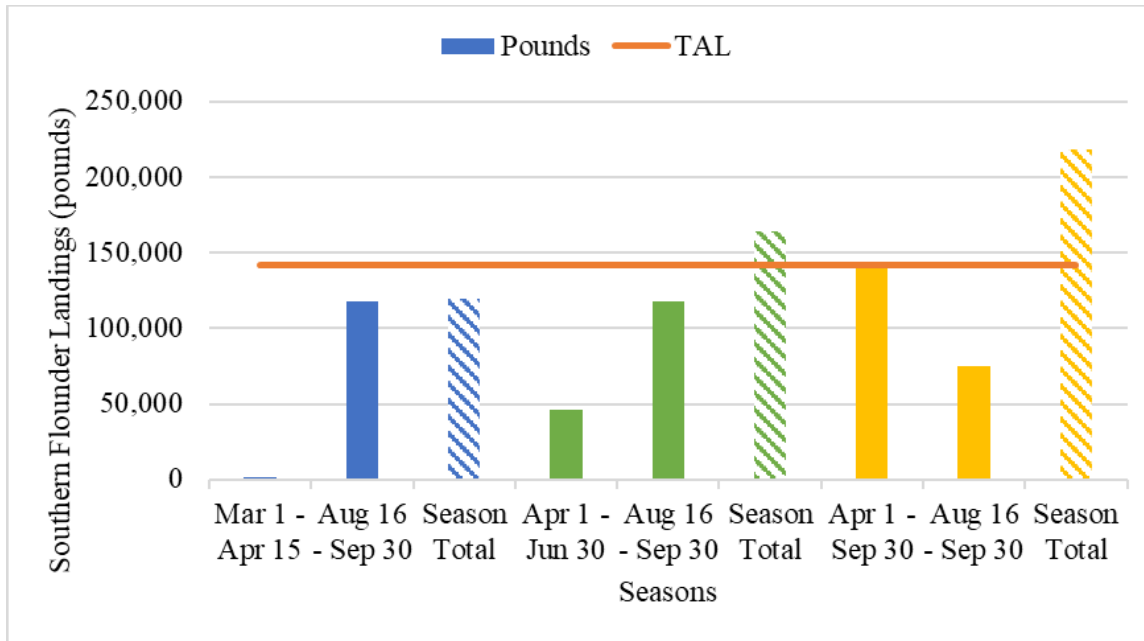


Figure 4.2.2. Southern flounder landings (in pounds) for seasons in reference to total allowable landings (TAL). All scenarios are based on a one-fish bag limit.

The most important caveat of single-species management is the evaluation of the recreational angler's ability to distinguish among North Carolina's constituent flounder species. The CAP is currently developing a mobile phone application to empirically investigate the recreational angler's ability to correctly identify flounder. The results of this investigation will be necessary before any implementation of single-species management. Analysis of potential ocellated flounder seasons assumed that accurate species identification does not occur to show the worst-case scenario projected. If anglers adapt and learn identification of flounder species, impacts presented will be lower and subsequently the southern flounder season during the fall may not be as impacted.

Allowing increased access to the recreational fishery through species-specific management by allowing the division to implement seasons through the adaptive management framework would be the most risk averse approach while still allowing harvest of other flounder species. It allows access to summer and Gulf flounder during a trial six-week season during March 1 through April 15 for the hook-and-line fishery in ocean waters only. Using gigs to harvest flounder may not be allowed during the ocellated flounder season as identifying flounder to the species level prior to harvest is necessary.

Anticipated harvest of southern flounder during the ocellated season will be accounted for through MRIP sampling. Though southern flounder are not allowed to be harvested during this time, if angler identification is not accurate, landings of southern flounder have the potential to be higher than currently estimated. If the preliminary estimates of southern flounder harvest are higher in the early season than anticipated, the fall fishery will be shortened. The total volume of southern flounder harvest from both seasons will comprise the estimates of harvest to compare to the annual quota. Any overages will be deducted from the subsequent year's quota and the

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seasons will be adjusted as necessary. This change in seasons to account for southern flounder harvest is necessary to maintain required reductions in the recreational southern flounder fishery.

Allowing harvest of summer and Gulf flounder when the southern flounder season is closed increases the possibility that southern flounder will be harvested to a greater extent than allowed under the sustainable harvest requirements. The potential for increased harvest may negate reductions achieved through the southern flounder season and limit rebuilding of the stock. Development of adaptive management measures to manage increased access to summer and Gulf flounder can be found in the *Adaptive Management* issue paper.

VI. PROPOSED MANAGEMENT OPTIONS

(+ potential positive impact of action)

(- potential negative impact of action)

Option 1: Status quo, do not allow species-specific management to increase access to the recreational fishery

- + Maintains stringent management measure to ensure best chance of rebuilding
- Does not allow for access to more abundant summer and Gulf flounder stocks

Option 2: One-fish ocellated bag limit from March 1 through April 15 in ocean waters only and one-fish bag limit consisting of any species of flounder during the southern flounder season

- + Allows for harvest of summer and Gulf flounder outside of identified southern flounder season
- + Complements recommended sustainable harvest bag limit
- + Minimizes potential impacts of misidentification by limiting seasons
- + Harvest of all southern flounder accounted for to meet required reductions
- +/- Ocean harvest only during early season
- Increased chance of southern flounder harvest due to species misidentification concerns
- Unequal access among recreational fishing gears during the early season
- Potential impacts to fall season due to excess southern flounder harvest in the early season

VII. RECOMMENDATION

NCDMF Initial Recommendation

The NCDMF initial recommendation is to allow a one-fish ocellated bag limit in an early season from March 1 – April 15 and a one-fish flounder bag limit during the fall season from Aug. 16 – Sept. 30, with the understanding that the fall season may be truncated due to excessive southern flounder harvest during the early season (Option 2).

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VIII. LITERATURE CITED

- ASMFC (Atlantic States Marine Fisheries Commission). 2017. Addendum XXVIII to the summer flounder, scup, and black sea bass fishery management plan: summer flounder recreational management in 2017. Arlington, VA. 13 p.
- ASMFC. 2018. Draft Addendum XXXI to the summer flounder, scup, and black sea bass fishery management plan for public comment. Arlington, VA. 36 p.
- MAFMC (Mid-Atlantic Fisheries Management Council). 2019. Framework adjustment 14 to the summer flounder, scup, and black sea bass fishery management plan. Dover, DE. 161 p.
- NCDMF (North Carolina Division of Marine Fisheries). 2005. North Carolina southern flounder (*Paralichthys lethostigma*) fishery management plan. North Carolina Division of Marine Fisheries, Morehead City, NC. 260 p.
- NCDMF. 2013. North Carolina southern flounder (*Paralichthys lethostigma*) fishery management plan: Amendment 1. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC. 380 p.
- NCDMF. 2017. North Carolina southern flounder (*Paralichthys lethostigma*) fishery management plan: Supplement A to Amendment 1. North Carolina Division of Marine Fisheries, Morehead City, NC. 83 p.
- NCDMF. 2019. North Carolina southern flounder (*Paralichthys lethostigma*) fishery management plan: Amendment 2. North Carolina Department of Environmental Quality, Division of Marine Fisheries, Morehead City, NC. 62 p.

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APPENDIX 4.3. INLET CORRIDORS AS A MANAGEMENT TOOL TO INCREASE SOUTHERN FLOUNDER ESCAPEMENT

I. ISSUE

Consider the development of inlet corridors to provide additional protection to mature female southern flounder during their escapement or migration out of coastal inlets to oceanic spawning areas.

II. ORIGINATION

The feasibility of establishing inlet corridors as a management tool is being explored based on comments by the Southern Flounder Advisory Committee at their October 2019 meeting and comments provided during the public scoping period.

III. BACKGROUND

Southern flounder is an estuarine-dependent species, spending most of their early life history as juveniles and sub-adults in the estuary before exiting the estuary at maturity and migrating to the ocean to spawn offshore (see the *Description of the Stock* section). It is during these fall estuarine migrations southern flounder are most vulnerable to capture. Inlets, such as those common to North Carolina's estuaries, create a natural bottleneck that southern flounder must navigate to escape the final area of internal fishing pressure before entering the ocean to migrate offshore. The implementation of inlet corridors has been suggested as a possible management tool that, in theory, could alleviate fishing mortality on migrating southern flounder during this presumed period of increased vulnerability. This issue paper will explore available data and possible strategies regarding the use of inlet corridors for southern flounder management. The questions to be explored are as follows:

- 1) Do data exist that provide insight into which coastal inlets (i.e., corridors) are critical to southern flounder spawning migrations? Is there an inlet-specific seasonality to the migrations through these inlets to the ocean?
- 2) Do data indicate inlets are truly acting as a bottleneck where elevated fishing mortality is occurring due to increased vulnerability to capture?
- 3) What are the potential gear interactions that may occur in coastal inlets and what potential restrictions should be considered for these gears? What will be the impact to other fisheries (species) that are pursued by these same gears?
- 4) Can any savings from inlet corridors be quantified or do the data indicate this will be a non-quantifiable precautionary measure?

IV. AUTHORITY

North Carolina General Statutes

G.S. 113-134 RULES

G.S. 113-182 REGULATION OF FISHING AND FISHERIES

G.S. 113-182.1 FISHERY MANAGEMENT PLANS

G.S. 143B-289.52 MARINE FISHERIES COMMISSION – POWERS AND DUTIES

North Carolina Marine Fisheries Commission Rules

15A NCAC 03H .0103 PROCLAMATIONS, GENERAL

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15A NCAC 03M .0503 FLOUNDER

V. DISCUSSION

- 1) Do data exist that provide insight into which coastal inlets (i.e., corridors) are critical to southern flounder spawning migrations? Is there an inlet-specific seasonality to the migrations through these inlets to the ocean?

Removals due to harvest and discards of southern flounder, regardless of sector, are comprised primarily of juvenile southern flounder residing in the estuary (Flowers et al. 2019a). Southern flounder tend to remain within the estuaries until the onset of maturity. As fish of both sexes begin to mature (approximately age-2), they undergo a fall migration. Eventually, mature southern flounder will traverse through one of several coastal inlets into oceanic waters where spawning occurs.

Current understanding of southern flounder movements and maturity is based on multiple studies that include tagging, otolith microchemistry, and maturity data along with commercial and recreational catch information. Movement of juveniles within the estuary has been shown to be limited and often somewhat localized (Scharf et al. 2015). Data indicate southern flounder overwinter as juveniles in the estuary (Monaghan 1996; Taylor et al. 2008; Craig et al. 2015). Southern flounder tend to reside in the estuary until age 2 or the onset of maturity (Rulifson et al. 2009), at which point migration offshore occurs from September through November of primarily age-2 and older fish (Monaghan and Watterson 2001; Loeffler 2018). Movement begins in a southerly direction within the Albemarle and Pamlico sound estuarine systems, with fish eventually exiting the estuaries through coastal inlets (Craig et al. 2015). After fish migrate into the ocean, fish tend to continue moving in a southerly direction. Fish leaving North Carolina estuaries in the fall have been recaptured in all states south of North Carolina [i.e., South Carolina, Georgia, and Florida; Monaghan 1992; NCDMF, unpublished data]. Craig et al. (2015) found all southern flounder recaptures that made large scale movements in the fall (>50 km) were recaptured in systems south of the original tagging location.

The timing of emigration through inlet corridors has been explored using acoustic telemetry methods (Scharf et al. 2015; Scheffel et al. 2020). These studies used acoustic tags to investigate seasonal movement patterns and determine the rate and seasonality of movements from the estuary to the ocean (emigration) in New River, North Carolina. In this system, southern flounder emigration peaked between October and November (Figure 4.3.1) and emigration patterns were similar across years (Scheffel et al. 2020). This period also corresponds to the seasonal peak in statewide landings seen in the commercial fishery each year with increased movement and landings occurring in the upper estuary during September and transitioning to the lower estuary into October and November. Existing data from conventional tagging and commercial landings indicate this general window of time (October through November) is likely the primary period of emigration for southern flounder, not just in New River, but throughout coastal North Carolina.

Current data do not allow any determination of which inlet(s) are most critical or most commonly used for southern flounder emigration. Tagging data do indicate, however, that

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Oregon Inlet is less frequently used than the numerous inlets to the south (NCDMF, unpublished data). As a result, inlets from Cape Hatteras southward are likely to be most critical for emigration by southern flounder, which is supported by available tagging data and the aforementioned studies. The timing of emigration is likely more defined and quantified than the specific inlets being used.

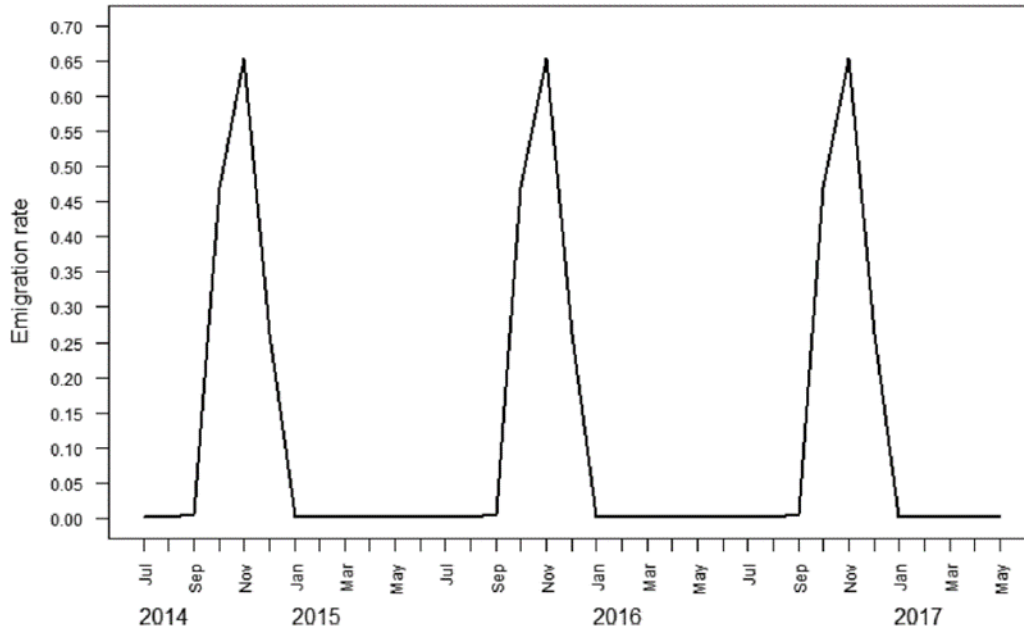


Figure 4.3.1. Estimates of instantaneous Emigration (E) for the New River estuary produced by a telemetry model. Annual E assumed to be equal across years. (Source: Scheffel et al. 2020)

- 2) Do data indicate inlets are truly acting as a bottleneck where elevated fishing mortality is occurring due to increased vulnerability to capture?

It is unknown if, and to what extent, southern flounder exploitation may be increased based on their emigration in the fall through coastal inlets. Harvest data specific to these locations would provide a good indicator to gauge whether coastal inlets serve as a bottleneck allowing for elevated exploitation. Unfortunately, landings data for neither commercial nor recreational sectors can be pared down to include only harvest or releases from inlets. Activities in and around coastal inlets include a variety of means used to capture southern flounder. Recreational fishing for flounder species is very popular in coastal inlets. It occurs over many months, particularly from summer through early fall; however, flounder harvested include not just southern flounder, but also summer and Gulf flounder. Giggling, by both the recreational and commercial sectors, occurs in and around coastal inlets with fish targeted from summer through fall. While these more active and mobile gears effectively capture flounder in coastal inlets, the high energy habitat in many coastal inlets can be a limiting factor to the use of passive gears such as gill nets and pound nets. That is not to say these gears are not used near coastal inlets, but the available areas suitable for fishing these gears in these high energy areas is limited. Tagging data specific to coastal inlets may offer another indicator to gauge whether coastal inlets are areas of increased exploitation for southern flounder. During a telemetry study conducted by

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Scharf et al. (2015) in New River, the inlet corridors were monitored for any acoustically tagged southern flounder emigrating from the estuarine system. In the study, it was noted that southern flounder exhibited two distinct behaviors. One behavior was described as resident behavior where southern flounder were more sedentary with only limited movement within the estuary. This behavior occurred over a protracted time period. The second was a more sudden behavior where there was a brief but more extensive movement representing the onset of the spawning migration in the fall. This shift in behavior resulted in southern flounder leaving the system within a matter of days (Figure 4.3.2). This increased movement meant less time was spent by fish in the inlet corridor. Peak movement occurred between Oct. 19 and Nov. 16, when 85% of the emigrations occurred. Tagged fish harvested in this study occurred primarily within the estuary and movement through the inlet occurred over just a short time period.

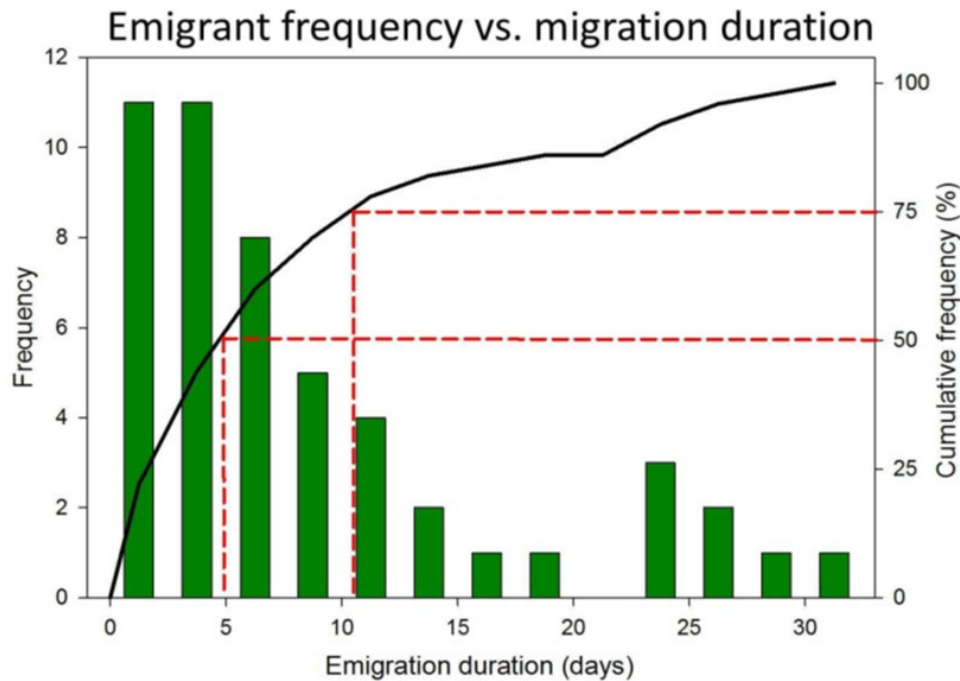


Figure 4.3.2. The number of days from the initiation of migratory behavior until southern flounder emigrated out of the New River estuary. The cumulative frequency distribution (solid black line) indicated that 50% of emigrants left the system within five days after initiation of migration behavior (bottom dashed red line), while 75% of emigrants exited within about 10 days of first showing emigration behavior (top dashed red line). (Source: Scharf et al. 2015)

A broader look at statewide tagging data provides more insight into whether coastal inlets act as a bottleneck leading to increased harvest of southern flounder. Data were examined for external tags applied to southern flounder by the NCDMF from 2014 through 2019 (NCDMF, unpublished data). These flounder were tagged over a wide range of areas and across all months (Figure 4.3.3). Movements of southern flounder documented in this study are consistent with those described by Scharf et al. (2015). During this period, 299 recaptures have occurred for southern flounder where time at large has been at least 10 days (Figure 4.3.4). Of these recaptures, 270 (90%) were recaptured within the estuary, 25 (8%) were captured in the inlet corridor, and four (<2%) were captured from the ocean. Inlet recaptures occurred from multiple

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gears and across sectors, with most taken by hook-and-line (n=10) followed by both recreational giggers (n=6) and commercial giggers (n=6). Inlet corridors were defined by placing two-mile perimeters around larger inlets (Oregon Inlet, Hatteras Inlet, Ocracoke Inlet and Barden Inlet) and one-mile or half mile perimeters around smaller southern inlets (Figure 4.3.4).

Available tagging data indicate coastal inlets do not appear to be acting as a bottleneck serving as an area of increased exploitation of southern flounder. The primary source of fishing mortality on this species is occurring within the estuarine system.

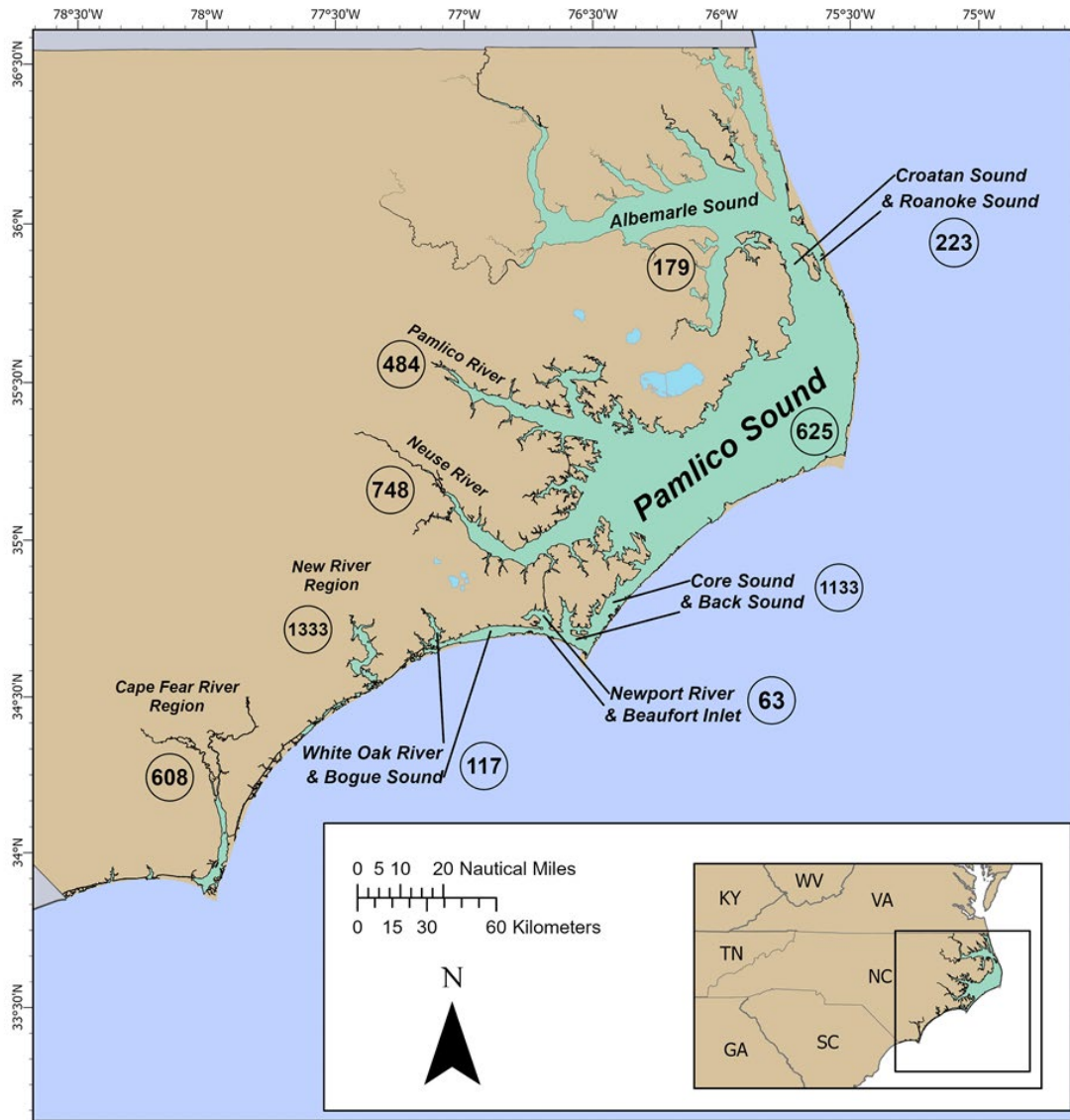


Figure 4.3.3. Tagging locations and number of southern flounder tagged (in circles by waterbody) in North Carolina estuarine waters from 2014 through 2019.

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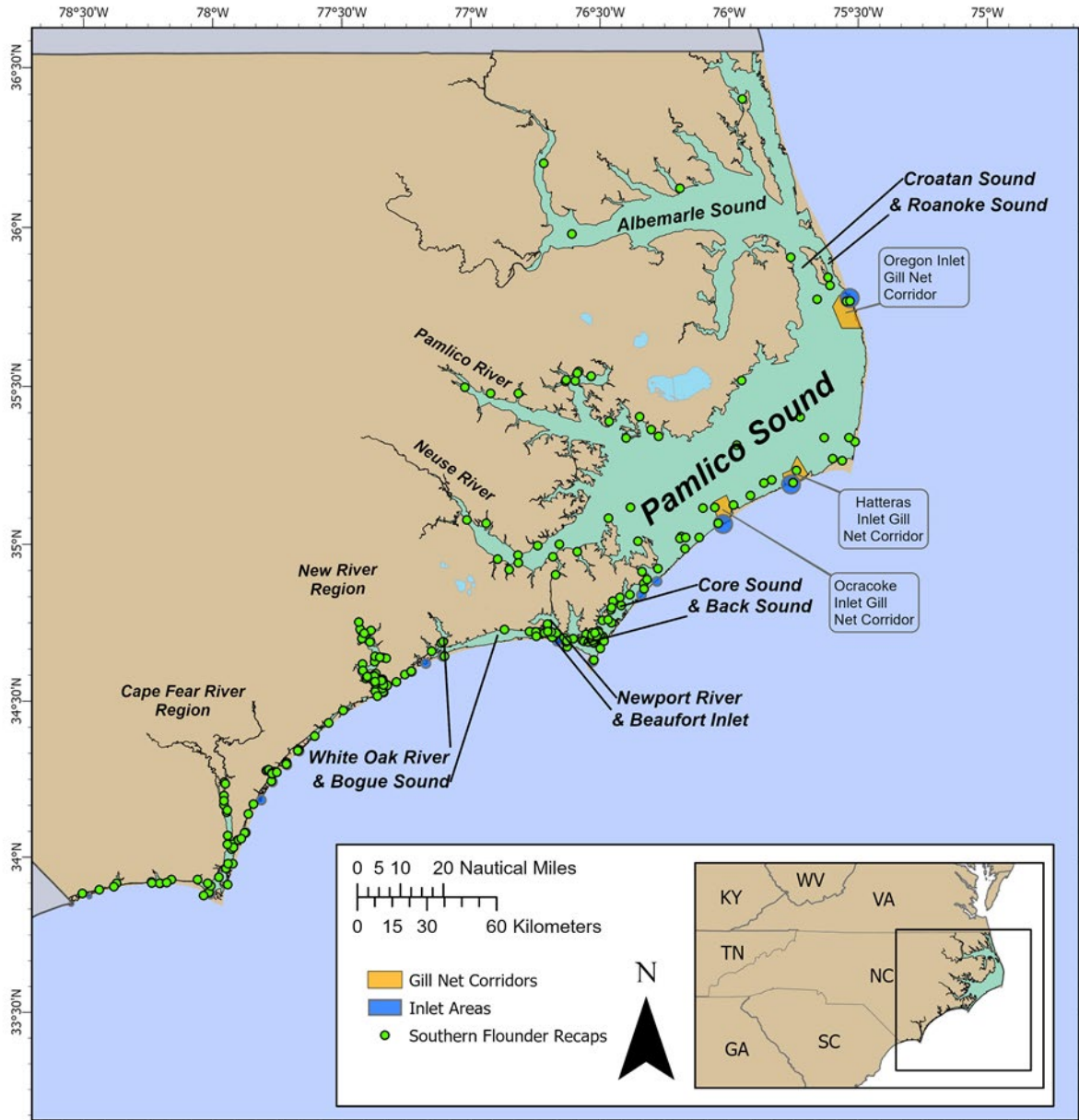


Figure 4.3.4. Recapture locations of southern flounder tagged in North Carolina estuarine waters from 2014 to 2019.

- 3) What are the potential gear interactions that may occur in coastal inlets and what potential restrictions should be considered for these gears? What will be the impact to other fisheries (species) that are pursued by these same gears?

The southern flounder stock is subject to fishing mortality from the recreational and commercial sectors for much of the year and across a wide range of habitats from the upper estuaries to the inlets and oceans. Recreational harvest typically peaks in the summer months, while commercial harvest peaks in the fall. A likely reason for this contrast is that recreational anglers are mobile and typically fish their gear in an active fashion that is not dependent on fish movement to

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capture fish. The commercial sector, however, relies primarily on passive gear (gill nets and pound nets). These passive gears by nature require southern flounder (or any fish species) to move in order to be captured. For this reason, the fall commercial fishery is directly linked to, and largely dependent on, the fall migration of southern flounder. It is during this fall migration period of September through November that harvest peaks for these gears (NCDMF Trip Ticket Program). Scharf et al. (2015) observed some evidence for southern flounder movements and the rate of emigration coinciding with the passage of cold fronts in the fall. This is consistent with observed increases in catches reported by pound netters in other parts of the state after these types of fall weather events.

Recreational hook-and-line trips occurring in coastal inlets capture a diverse set of species. Anglers fishing with gear typically used to capture southern flounder will commonly encounter other species, and southern flounder will also be encountered when targeting other species. Summer flounder, Gulf flounder, red drum, spotted seatrout, bluefish, and many other species are captured using similar tactics in coastal inlets. Closing inlet corridors to recreational fishing would be far reaching in its impact to these fisheries.

Gigging around coastal inlets is a commercial and recreational endeavor. Unlike hook-and-line fishing, gigging can be more selective as many fish species are typically identified before they are gigged while some are not. For example, southern flounder, there is the added issue of their similarity in appearance to summer and Gulf flounder, which occur in these same areas. For this reason, it is not likely that gigging for flounder species would be feasible in inlet corridors if the intention of the regulation was to protect southern flounder.

Stationary gears such as flounder pound nets and gill nets have traditionally been fished in areas adjacent to but not within inlets. All current flounder pound net sets are located from Core Sound and north to the Albemarle and Currituck sounds. As previously mentioned, flounder pound nets are somewhat limited in the immediate vicinity of coastal inlets. Flounder pound nets do, however, occur with regularity in areas adjacent to inlets as shallower habitat and lower energy conditions allow. These locations are productive fishing areas for southern flounder during the fall migration. Similarly, gill nets have traditionally been fished around coastal inlets, although much of the habitat in the high energy portion of the inlet is not conducive to setting anchored gill nets. It should be noted corridors already exist that limit large-mesh gill nets, crab pots, and trawling in the vicinity of inlets. The large-mesh gill-net closures exist in some inlet corridors because of restrictions maintained through the ITP under Section 10(a)(1)(B) of the ESA of 1973 (Public Law 93-205) to “minimize, monitor, and mitigate” sea turtle interactions in the commercial anchored gill-net fisheries. Inlet corridors to protect sea turtle ingress and egress through coastal inlets exist for Oregon Inlet, Hatteras Inlet, and Ocracoke Inlet (Figure 4.3.4). These inlet closures are in effect from Sept. 1 through Dec. 31, which is inclusive of the period of the spawning migration for southern flounder. Additionally, the area around Barden Inlet has also been closed to large mesh anchored gill nets during the last two years (2018 and 2019). This closure was due to excessive interactions with green sea turtles (*Chelonia mydas*) in 2017, but it is not explicitly required by the ITP.

- 4) How will any savings from inlet corridors be quantified or do the data indicate this will be a non-quantifiable precautionary measure?

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Implementing inlet corridors for southern flounder cannot be quantified in terms of reductions in catch or harvest. No data sources exist to estimate what proportion of the catch comes from these specific areas. Based on available results from tagging studies, it does not appear that inlets serve as areas of increased exploitation (NCDMF, unpublished data). Telemetry studies indicate southern flounder may limit their travel time in inlets, specifically during their fall migration period (Scharf et al. 2015). Recapture data from traditional tags support this finding and show that most of the catch and exploitation on this species is occurring within the estuary and not in the inlet or ocean (NCDMF, unpublished data). Based on these findings, it is unlikely that inlet corridors would limit exploitation rates without more quantifiable and effective management measures across the fisheries.

While inlet corridors do not offer a viable management alternative that provides a quantifiable measure to rebuild southern flounder stocks, inlet corridors do provide an important transition habitat for this species, linking the estuarine nursery habitat with the offshore spawning habitat. For further information on habitat use and the importance of habitat by life stage for this species see the *Description of the Stock* and the *Ecosystem and Fishery Impacts* sections. Additionally, a comprehensive review of habitats important to southern flounder is further described in the CHPP (NCDEQ 2016).

In summary, inlet corridors, while providing an essential function in the life history of southern flounder, present specific challenges when considered as a management tool to reduce harvest. Specific inlets critical to southern flounder migration are not fully understood and additional research is currently underway to investigate southern flounder migration patterns and spawning locations. With respect to impacts on other fisheries, inlet corridor closures by season, area, or gear would have negative impacts on commercial and recreational fisheries for other species captured in these locations. Any potential harvest reductions resulting from inlet corridors would be unquantifiable. Further, available data do not suggest inlets currently serve as a bottleneck resulting in increased harvest. In terms of the overfished status, the most prudent approach would be to remove the incentive to overharvest southern flounder through more quantifiable measures such as quota management or seasonal closures. Seasonal closures could effectively act in the same manner as inlet corridors if the closed seasons correspond to periods of emigration related to spawning. Likewise, quota management would set harvest levels to end overfishing and rebuild depleted stocks. Finally, evaluation of inlet corridors may be best approached during the next revision of the CHPP. A thorough evaluation of inlet corridors for the protection of migrating or spawning species may be more applicable on a broad scale and not at the individual species level.

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VI. PROPOSED MANAGEMENT OPTIONS

(+ potential positive impact of action)

(- potential negative impact of action)

Option 1: Status quo, do not establish inlet corridors for southern flounder during spawning migrations.

- + No negative impact on current fishing practices (commercial and recreational)
- + Inlet corridors do not appear to result in increased fishing pressure for southern flounder
- Corridors would afford additional, albeit unquantifiable protection for stock
- Corridors would indirectly provide additional protection for other species

Option 2: Implement inlet corridors during the southern flounder spawning migration for North Carolina coastal inlets.

- + Additional protection for southern flounder
 - + Additional indirect impact and protection of other species
 - Unquantifiable, would not contribute toward needed harvest reductions
 - Loss of harvest opportunities for other species in these areas due to removal of gears that interact with southern flounder
 - May simply shift fishing pressure to areas adjacent to inlet corridors
- Contribution in magnitude of southern flounder and exact timing of migration by inlet is unknown

2A. Implement inlet corridors affecting all gears in the selected areas

2B. Implement inlet corridors affecting only specific gears in the selected areas

VII. RECOMMENDATION

NCDMF Initial Recommendation

The NCDMF initial recommendation is to not establish inlet corridors for southern flounder during spawning migrations and is based on available data and potential impacts to other fisheries (Option 1).

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APPENDIX 4.4. ADAPTIVE MANAGEMENT STRATEGY FOR THE NORTH CAROLINA SOUTHERN FLOUNDER FISHERY

I. ISSUE

Implement an adaptive management strategy for the North Carolina southern flounder fishery.

II. ORIGINATION

North Carolina Division of Marine Fisheries (NCDMF)

III. BACKGROUND

Adaptive management combines management and monitoring with the aim of updating knowledge and improving decision making over time. Adaptive management uses a learning process to improve management outcomes (Holling 1978). The challenge with using adaptive management is to find a balance between gaining knowledge to improve management and achieving the best outcome based on current knowledge (Allan and Stankey 2009). As more is learned about a fishery, adaptive management provides flexibility to incorporate new data and information to accommodate alternative and/or additional actions. In the context of North Carolina FMPs, adaptive management is an optional management framework that allows for specific management changes to be implemented between FMP reviews under specified conditions to accomplish the goal and objectives of the plan. A FMP that uses adaptive management as a tool needs to identify specifically:

- The circumstances under which adaptive management changes may be made (when);
- The types of measures that may be changed (what);
- The schedule for implementation of changes (effective date); and
- The procedural steps necessary to effect a change (how).

The more clearly defined “when,” “what” and “how” for adaptive management, the fewer unintended consequences there will be and the more certainty there is for the regulated public and managers.

Amendment 3 to the Southern Flounder FMP establishes management strategies including an adaptive management strategy for the North Carolina southern flounder fishery based on the peer-reviewed and approved stock assessment for the South Atlantic southern flounder stock (Flowers et al. 2019). The stock assessment established biological reference points necessary for managing the southern flounder stock within sustainable harvest.

A reduction of 72% of total removals (in pounds of fish) is projected to end overfishing within two years to achieve sustainable harvest and rebuild the southern flounder spawning stock to the target within 10 years of the date of adoption of Amendment 2 with at least a 50% probability of success; this timeline does not restart with Amendment 3. This level of reduction is projected to bring spawning stock abundance to the target value of 12 million pounds of mature females.

Adoption of the adaptive management framework for Amendment 3 in conjunction with the other management strategies in the plan provides the best likelihood of success in achieving sustainable harvest in the southern flounder fishery while maximizing flexibility for fishermen in harvesting flounder. The Southern Flounder FMP Amendment 3 defines and documents the scope of management measures the Fisheries Director may implement within the bounds of

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Amendment 3. The record of specific actions is in the form of the issued flounder proclamations each year.

IV. AUTHORITY

North Carolina General Statutes

G.S. 113-134. RULES.

G.S. 113-182. REGULATION OF FISHING AND FISHERIES.

G.S. 113-182.1. FISHERY MANAGEMENT PLANS.

G.S. 113-221.1. PROCLAMATIONS; EMERGENCY REVIEW.

G.S. 143B-289.52. MARINE FISHERIES COMMISSION – POWERS AND DUTIES.

North Carolina Marine Fisheries Commission Rules

15A NCAC 03H .0103 PROCLAMATIONS, GENERAL

15A NCAC 03M .0503 FLOUNDER

15A NCAC 03M .0512 COMPLIANCE WITH FISHERY MANAGEMENT PLANS

V. DISCUSSION

Adoption of management measures presented in the *Achieving Sustainable Harvest, Increased Recreational Access, Implementing a Slot Limit, and Phasing Out Large-Mesh Gill Net* issue papers will determine the adaptive management measures needed for Amendment 3. Adaptive management gives the Fisheries Director flexibility under specified conditions to manage the southern flounder fishery. Flexible management measures could include adjusting opening dates for gears and areas or sectors, implementing trip limits in the commercial sector for certain gears, or altering areas where the fishery can occur. This strategy allows changes to the framework of Amendment 3 and the specific management measures implemented each year may vary as the stock responds to selected measures. For example, if the recreational fishery sector exceeds its TAL for a given year, the Fisheries Director could cancel the early ocellated season or implement a complete closure for the recreational fishery. If a complete closure is not warranted, the Fisheries Director may choose to shorten the selected seasons or reduce the daily bag limit to reduce the chances of exceeding the TAL in subsequent years.

As long-term sustainable harvest strategies are implemented, participants in the commercial and recreational fisheries will likely adapt over time, potentially changing fishing behavior. As fisheries adapt to the new harvest levels, it will be crucial to provide flexibility to the Fisheries Director to close the seasons based on specified conditions, like the potential to exceed the TAL. This is within proclamation authority to adjust certain management measures for success in achieving sustainable harvest. Thorough discussion of each of the management actions presented below can be found in the *Achieving Sustainable Harvest, Increased Recreational Access, Implementing a Slot Limit, and Phasing out Large-Mesh Gill Net* issue papers.

Amendment 3 proposes modifying the commercial seasons to maintain a quota with allocations based on gear and area; modifying the recreational season with quota allocations to the hook-and-line and gig fisheries; implementing and altering recreational bag limits; and implementing commercial trip limits and recreational vessel limits. Upon adoption of Amendment 3, management strategies approved in Amendment 3, including adaptive management, will be implemented through use of proclamation authority allowing the Fisheries Director to:

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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- Determine opening dates for commercial seasons based on measures selected through the *Achieving Sustainable Harvest* issue paper.
- Close the commercial fishery based on quota monitoring data to maintain harvest levels at or below the TAL, including closure when a majority of harvest has occurred (typically about 80% of the quota allocation, but it can be less or more).
- Develop and implement commercial trip limits to maximize the harvest and minimize the risk of exceeding the quota during the open season.
- Select recreational season dates for the hook-and-line and gig fisheries.
- Implement and alter bag limits for the recreational fishery.
- Implement and alter vessel limits for the recreational fishery.
- Change the recreational southern flounder season based on harvest of southern flounder that occurs during the ocellated season.
- Cancel the early recreational ocellated season if it is necessary to prevent exceeding the TAL for the recreational southern flounder fishery.
- Apply accountability measures for both the commercial and recreational fisheries.

To inform the decision to exercise and implement this authority, the Fisheries Director would use available information including information on gear and area combinations and quota available for harvest for each management area as described in the *Achieving Sustainable Harvest* issue paper. The Fisheries Director would use the results from quota monitoring to determine when closures of the commercial fishery would occur. If the Fisheries Director decides there is sufficient quota remaining, the Fisheries Director may approve additional harvest periods using trip limits to constrain the harvest.

Selection of recreational season dates would be informed by the volume of quota allocation available for a year after any quota overages the prior year have been taken into account. The selected seasons must conform to the required reductions outlined in the *Achieving Sustainable Harvest* issue paper. The recreational seasons selected may be impacted if a separate non-southern flounder season is adopted as part of Amendment 3. Additional information on the potential impacts described below can be found in the *Increased Recreational Access* issue paper.

Quota overages in a year will need to be deducted from commercial or recreational allocations for subsequent years. Any overage adjustments would be completed prior to the identification of season dates for the subsequent year.

Development of trips limits could be based on annual or interannual harvest levels and the amount of quota allocation remaining for a specific gear/area combination. Trip limits can also vary among gear/area combinations due to the number of participants in the fishery or available landings. Trip limits would need to be identified on an annual basis and would only be implemented if sufficient quota remains to be caught and if continued harvest, with trip limits in place, does not increase the risk of exceeding the quota allocation. Determination of whether or not sufficient quota remains for a re-opening is solely within the discretion of the Fisheries Director.

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The bag limit for flounder is currently set at four fish by Amendment 2; however, a bag limit of two or more fish increases the likelihood that the recreational sector will exceed its TAL due to increased angler success as the fishery rebuilds. The ability to implement and subsequently alter bag limits would allow the Fisheries Director to constrain the recreational fishery if an initial bag limit greater than one fish through Amendment 3 allows for unsustainable removals.

Currently, there are no vessel limit requirements in the North Carolina southern flounder recreational fishery. Vessel limits may be useful in constraining the harvest of southern flounder in the recreational fishery as the fishery rebuilds. Vessel limits may be more important if the recreational fishery bag limit is set at two fish or greater in order to avoid exceeding the TAL. This is especially important as the stock rebuilds and angler success increases. If the bag limit is reduced to one fish per person per day, the usefulness of a vessel limit is likely reduced. Additional information on vessel limits can be found in the *Achieving Sustainable Harvest* issue paper.

Development of the *Increased Recreational Access* issue paper outlines a strategy for a seasonal approach for additional harvest of ocellated species of flounder outside of the southern flounder recreational season. If the Fisheries Director determines that the allowed ocellated season is preventing a sustainable recreational southern flounder fishery due to excessive landings, the Fisheries Director may cancel subsequent ocellated seasons to maintain required reductions necessary to rebuild the southern flounder stock. In addition, the ASMFC must be notified of any changes to the summer flounder fishery in North Carolina state waters; however, approval of changes by the ASMFC is not required if the changes are expected to be more restrictive than the management measures already approved by the ASMFC. Changes to the summer flounder fishery in EEZ waters off North Carolina may be impacted by the MAFMC and NOAA Fisheries. Due to the ASMFC, MAFMC, and NOAA Fisheries requirements, the Fisheries Director's ability to adaptively manage the ocellated seasons may be impacted.

Future increases in quota would likely not occur until the southern flounder spawning stock biomass is recovered and this cannot be determined until completion of an updated stock assessment. If a stock assessment determines that an increase in quota is possible due to stock rebuilding, the resulting increase can be allocated to the sectors. Revisions to allocations can occur, most commonly to account for changes among sectors or stock status. Changes among sectors include scenarios where one group consistently has excess allocation remaining, or where one group consistently exceeds its allocation. Under each scenario TAL can be re-allocated to another sector based on management preferences. This can be achieved through future amendments.

Adoption of the adaptive management framework for Amendment 3 in conjunction with the other management strategies in the plan provides the best likelihood of success in achieving sustainable harvest in the southern flounder fishery while maximizing flexibility for fishermen in harvesting flounder. Not adopting an adaptive management framework for Amendment 3 would result in the division not having the flexibility to alter management measures to maintain sustainable harvest in the southern flounder fishery.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Upon adoption of this adaptive management strategy, any additional changes in management strategies beyond those outlined must be undertaken through the amendment or supplement process. These adaptive management strategies and measures will be evaluated for success by completing an updated stock assessment prior to the next comprehensive review of the N.C. Southern Flounder FMP.

VI. PROPOSED MANAGEMENT OPTIONS

- (+ potential positive impact of action)
- (- potential negative impact of action)

Option 1: Adopt the adaptive management framework based on the peer-reviewed and approved stock assessment.

- + Management is based on biological reference points for stock rebuilding.
- + Provides for the protection and future sustainability of the southern flounder stock
- + Provides for the greatest amount of flexibility while maintaining total allowable landings
- +/- Provides potential for additional access to other flounder stocks while maintaining total allowable landings of southern flounder
- Potential uncertainty in selected seasons
- Impacts may be greater for some gear or areas more than others

Option 2: Do not adopt the adaptive management framework.

- Difficult to maintain TAL
- Does not allow for flexibility in management strategies
- Lack of flexibility jeopardizes stock rebuilding to meet statutory requirements

VII. RECOMMENDATION

NCDMF Initial Recommendation

The NCDMF initial recommendation is to implement adaptive management for the southern flounder fishery (Option 1).

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APPENDIX 4.5. RECREATIONAL AND COMMERCIAL SECTOR ALLOCATION IN THE NORTH CAROLINA SOUTHERN FLOUNDER FISHERY

I. ISSUE

Provide the NCMFC with analysis that shows various commercial and recreational allocation percentages.

II. ORIGINATION

At the November 2020 NCMFC business meeting, the NCMFC passed a motion to consider commercial and recreational allocations in the Southern Flounder FMP Amendment 3 of 70/30, 65/35, 60/30 with 10% allotment for gigging, 60/40, and 50/50.

III. BACKGROUND

The NOAA defines allocation as a direct and deliberate distribution of the opportunity to participate in a fishery among identifiable, discrete user groups or individuals (Blackhart 2005). In fisheries managed by the South Atlantic and Gulf of Mexico fishery management councils, the share a sector gets is typically based on historical harvest amounts. Revisions to allocations do occur, most commonly to account for changes among sectors or stock status. Changes among sectors includes scenarios where one group consistently has excess allocation remaining, which can be re-allocated to another sector based on management preferences. Changes to stock status also impact reallocation; if the stock rebuilds and harvest levels can be increased, quota would be increased to allow for more harvest. Authority to make changes to allocations lies with the commission or body charged with making management decisions. For the purpose of this paper the term “sector” will be used to differentiate between the commercial and recreational components of the southern flounder fisheries.

At its November 2020 business meeting, the NCMFC asked the division to review several allocation scenarios for Amendment 3 to the N.C. Southern Flounder FMP. The sector allocation selected by the NCMFC will provide the basis for implementing quota management in the southern flounder fishery. Selection of allocations is informed by data provided by the division, in this case historical landings. The commission can also rely on economic, social, and behavioral aspects of each sector that may influence allocation decisions.

The historically based allocation of 73% commercial 27% recreational (Table 4.5.1) in Amendment 2 is based on historical harvest for each sector from 2017. As with the 73/27 historically based allocation, the commercial and recreational sectors include gear sub-allocations based on historical harvest. In the initial draft of Amendment 3 discussed with the FMP advisory committee, the recommendation for the commercial sector is for separate mobile gear (all gears except pound nets) and pound net categories (approximately 50/50 sub-allocations) and for the recreational sector to have separate hook-and-line and gig gears (89/11 sub-allocation). Different allocation scenarios will significantly change available harvest in a sector, so the commission will need to consider ramifications to the gear sub-allocations and whether those fisheries remain realistically viable to prosecute. The available landings for a specific fishery may be too low to invest further in the expense of the gear, if sub-allocations are not changed.

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Much like regional councils, the NCMFC and N.C. Wildlife Resources Commission have historically allocated quotas to fishing sectors based on historical harvest. In some fisheries, like the Albemarle Sound and Roanoke River Management Areas striped bass fishery, the quota was ultimately revised so a 50/50 parity was achieved between the commercial and recreational sectors. In 1991, the initial striped bass quota was allocated 62.5/37.5 based on historical landings. After seven years of rebuilding at this initial allocation, the stock’s SSB was declared recovered, allowing for an increase in quota. In 1998, the quota was increased by 94,340 pounds, of which 29% was allocated to the commercial sector and the remaining 71% was allocated to the recreational sector. This increase brought the quota allocation to a 50/50 parity.

Table 4.5.1. Allocation options for the North Carolina southern flounder fishery that maintain overall landings reduction of 72%.

**This denotes a 10% allocation for gigs that was further divided out to each sector based on historical allocation (73/27).*

NCMFC Options (% Allocation)	Total Allowable Landings (TAL) in Pounds				Change in TAL
	Commercial		Recreational		
	TAL	% Reduction	TAL	% Reduction	Pounds
Historical Harvest	390,493	72	141,859	72	0
70/30	372,646	73	159,706	68	+/- 17,847
65/35	346,029	75	186,323	63	+/- 44,464
*60/30/10	358,459	74	173,893	66	+/- 32,034
60/40	319,411	77	212,941	58	+/- 71,082
50/50	266,176	81	266,176	47	+/- 124,317

IV. AUTHORITY

North Carolina General Statutes

G.S. 113-134 RULES

G.S. 113-182 REGULATIONS OF FISHING AND FISHERIES

G.S. 113-182.1 FISHERY MANAGEMENT PLANS

G.S. 143B-289.52 MARINE FISHERIES COMMISSION – POWERS AND DUTIES

V. DISCUSSION

Initial analyses of southern flounder quota allocations followed the convention of using historical landings from a previous year or years. To provide information for the NCMFC motion, commercial and recreational data were analyzed based on 2017 harvest data, the terminal year of the stock assessment. Table 4.5.1 shows the allocation options as requested by the NCMFC.

Shifting allocation between sectors is within the authority of the NCMFC (G.S. 113-134, 113-182, 113-182.1, and 143B-289.52). Changes to sector allocation may have negative and positive impacts to different sub-sectors in the southern flounder fishery. Allocation shifts to the recreational sector would provide additional harvest, possibly allowing for longer seasonal access if the daily bag limit is lowered. If the bag limit is not lowered, gains from increased

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allocation may help to provide a buffer against potential overages from increased angler success (see the *Achieving Sustainable Harvest* issue paper).

The commercial sector TAL would be lowered by the same amount of the recreational gains. As noted earlier, it is also prudent to consider the gear sub-allocations within the sectors (Table 4.5.2) as allocation shifts may have consequences that impact one gear category more than another. Reductions in the commercial allocation may have negative impacts on the commercial fishery as a lower allocation will result in a reduced harvest period.

The *Description of the Fisheries* section contains additional information that provides background details on landings, effort, and economic data for the commercial and recreational fisheries. Tables 4 and 5 in the *Description of the Fisheries* section provides commercial southern flounder landings by year and gear and the number of trips, average pounds per trip, and the number of participants by year and gear.

Table 4.5.2. Sub-allocations for the commercial and recreational sectors for the NCMFC options based on the 2017 harvest.

*This denotes a 10% allocation for gigs that was further divided out to each sector based on

NCMFC Option	Commercial		Recreational	
	Mobile Gear	Pound Net	Hook-and-Line	Gig
Historical Allocation	195,105	195,388	126,315	15,544
70/30	186,188	186,458	142,206	17,500
65/35	172,889	173,140	165,907	20,416
*60/30/10	180,228	178,231	159,706	14,187
60/40	159,590	159,821	189,608	23,333
50/50	132,992	133,184	237,010	29,166

historical allocation (73/27).

Table 4.5.3 shows the annual variation in harvest for the recreational hook-and-line fishery and what the following years' TAL consequences might have been. In Table 4.5.3, landings during the identified season are displayed on a yearly basis to provide examples of overages that could occur while trying to meet the TAL necessary for rebuilding based on historical allocations. If more fish are available because of a good year class both sectors would likely see increases in harvest. For the recreational sector, where daily reporting is not available, the larger the bag limit the greater the risk of exceeding the landings.

Tables 4.5.4 and 4.5.5 demonstrate the effects to the recreational sector between the historical allocation (73/27) and a 60/40 allocation. For each table, annual landings data (2008 through 2017) were prorated to an Aug. 16–Sept. 30 season under different bag limits (one fish, two fish, three fish, four fish). Estimated landed pounds were then compared to a 73/27 allocation (Table 4.5.4) and a 60/40 allocation (Table 4.5.5) to determine whether or not the TAL would be exceeded for each bag limit option based on the percent of the allocated harvested. Finally, the percent of the allocated harvested for each year was used to calculate the subsequent year

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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allocation for each bag limit option. Any overages that occur in one year will be deducted in subsequent years, possibly resulting in no recreational fishery for a year or more. It should be noted that for the recreational sector, where daily reporting is not realistic, the larger bag limits increase the risk of exceeding the TAL. When compared to each other, Tables 4.5.4 and 4.5.5 also show that with more allocation provided to the recreational fishery and a lower bag limit, the lower the chance of the recreational fishery of exceeding their TAL.

Table 4.5.3. Recreational hook-and-line landings of southern flounder Aug. 16–Sept. 30 at the four-fish bag limit for current season and years compared to the status quo allocation (73/27 does not include discards). Highlighted cells indicate overages in TAL the previous year resulting in closures the following year.

Year	Pounds Landed	% Overage	Subsequent Year Allocation
2008	106,493	-15.7	126,315
2009	204,422	61.8	48,209
2010	260,665	*106.4	0
2011	348,203	*175.7	0
2012	213,170	68.8	39,461
2013	396,543	^213.9	0
2014	133,016	5.3	119,615
2015	142,540	12.8	110,091
2016	172,348	36.4	80,283
2017	108,420	-14.2	126,315

* Denotes a scenario where the recreational hook-and-line fishery would not have quota in subsequent year resulting in a one-year closure due to overages.

^ Denotes a scenario where the recreational hook-and-line fishery would not have a quota in two subsequent years resulting in a two- year closure due to overages.

Future increases in total quota would not occur until the southern flounder SSB is recovered and this cannot be determined until an updated stock assessment is completed. Additionally, changes in allocation may alter the rebuilding schedule. Projections for rebuilding use a model that estimates changes in SSB by looking at the rate of removals according to the size classes that each sector harvests. Allocation changes would impact the overall size range of fish removed from the population and could therefore impact model projections.

All of the proposed reallocation scenarios increase recreational quota while lowering the commercial quota, there is the expectation that similar economic effects will follow. Specifically, as the overall commercial allocation is reduced, the total value of the commercial southern flounder industry will decrease, while the value of the recreational southern flounder fishery may be mitigated to some extent due to increased angler expenditures to target this species (Table 4.5.6; *Description of the Fisheries* section Tables 8 and 10); however, economic losses and gains are unpredictable.

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Decreasing the commercial allocation may result in a proportional decrease in value. It is possible, per-pound southern flounder prices may rise with reduced supply, counteracting the losses from reduced quota; however, if commercial quota reductions were large enough, the southern flounder fishery could see reduced participation, creating even larger socio-economic losses. The magnitude of these economic changes within each sector is unknown and unquantifiable.

Allocation deliberations should take into consideration the limited southern flounder TAL. Reallocation between sectors at this time could have unintended social and economic consequences that are most noticeable at the finer level of specific fisheries within each sector. It may be more prudent to allocate future quota increases towards one sector over the other as SSB expands. This can be achieved in future amendments with methodic increases until the preferred allocation is achieved.

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Table 4.5.4. Example of predicted harvest of southern flounder for a recreational hook-and-line season and compared to a 73/27 allocation and then applied to subsequent years to show future harvest during an Aug. 16–Sept. 30 season. Highlighted cells indicate bag limits that exceed the TAL for the indicated year: the darker the shade the higher the overage.

Season	Year	Harvest of Southern Flounder (pounds)				Percent of Allocation Harvested based on 73/27 allocation				Subsequent Year Allocation (pounds)			
		4-Fish Bag	3-Fish Bag	2-Fish Bag	1-Fish Bag	4-Fish Bag	3-Fish Bag	2-Fish Bag	1-Fish Bag	4-Fish Bag	3-Fish Bag	2-Fish Bag	1-Fish Bag
Aug 16 - Sep 30	2008	106,492	106,492	106,492	91,066	84	84	84	72	126,315	126,315	126,315	126,315
Aug 16 - Sep 30	2009	204,486	187,897	160,774	126,395	162	149	127	100	48,144	64,733	91,856	126,235
Aug 16 - Sep 30	2010	260,612	246,868	218,187	166,911	206	195	173	132	-	5,762	34,443	85,719
Aug 16 - Sep 30	2011	349,421	326,406	310,900	247,169	277	258	246	196	-	-	-	5,461
Aug 16 - Sep 30	2012	213,292	198,612	184,701	145,504	169	157	146	115	39,338	54,018	67,929	107,126
Aug 16 - Sep 30	2013	396,801	313,050	278,762	210,948	314	248	221	167	-	-	-	41,682
Aug 16 - Sep 30	2014	132,458	132,458	127,395	114,937	105	105	101	91	120,172	120,172	125,235	126,315
Aug 16 - Sep 30	2015	142,881	137,615	129,351	90,711	113	109	102	72	109,749	115,015	123,279	126,315
Aug 16 - Sep 30	2016	168,236	168,236	165,769	156,700	133	133	131	124	84,394	84,394	86,861	95,930
Aug 16 - Sep 30	2017	114,667	114,667	110,461	97,184	91	91	87	77	126,315	126,315	126,315	126,315

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Table 4.5.5. Example of predicted harvest of southern flounder for a recreational hook-and-line season and compared a 60/40 allocation and then applied to subsequent years to show future harvest during an Aug. 16–Sept. 30 season. Highlighted cells indicate bag limits that exceed the TAL for the indicated year.

Season	Year	Harvest of Southern Flounder (pounds)				Percent of Allocation Harvested based on 60/40 allocation				Subsequent Year Allocation (pounds)			
		4-Fish Bag	3-Fish Bag	2-Fish Bag	1-Fish Bag	4-Fish Bag	3-Fish Bag	2-Fish Bag	1-Fish Bag	4-Fish Bag	3-Fish Bag	2-Fish Bag	1-Fish Bag
Aug 16 - Sep 30	2008	106,492	106,492	106,492	91,066	56	56	56	48	189,608	189,608	189,608	189,608
Aug 16 - Sep 30	2009	204,486	187,897	160,774	126,395	108	99	85	67	174,730	189,608	189,608	189,608
Aug 16 - Sep 30	2010	260,612	246,868	218,187	166,911	137	130	115	88	118,604	132,348	161,029	189,608
Aug 16 - Sep 30	2011	349,421	326,406	310,900	247,169	184	172	164	130	29,795	52,810	68,316	132,047
Aug 16 - Sep 30	2012	213,292	198,612	184,701	145,504	112	105	97	77	165,924	180,604	189,608	189,608
Aug 16 - Sep 30	2013	396,801	313,050	278,762	210,948	209	165	147	111		66,166	100,454	168,268
Aug 16 - Sep 30	2014	132,458	132,458	127,395	114,937	70	70	67	61	189,608	189,608	189,608	189,608
Aug 16 - Sep 30	2015	142,881	137,615	129,351	90,711	75	73	68	48	189,608	189,608	189,608	189,608
Aug 16 - Sep 30	2016	168,236	168,236	165,769	156,700	89	89	87	83	189,608	189,608	189,608	189,608
Aug 16 - Sep 30	2017	114,667	114,667	110,461	97,184	60	60	58	51	189,608	189,608	189,608	189,608

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Table 4.5.6. Ex-vessel value of the commercial southern flounder fishery by year and gear.

Year	Gear				Total
	Gigs	Gill Net	Other	Pound Net	
2008	\$173,360	\$3,798,463	\$132,613	\$1,545,858	\$5,650,295
2009	\$159,031	\$3,160,714	\$116,727	\$1,173,459	\$4,609,932
2010	\$267,482	\$2,067,067	\$66,801	\$1,294,539	\$3,695,889
2011	\$256,846	\$1,397,565	\$34,239	\$1,064,477	\$2,753,128
2012	\$388,313	\$2,343,199	\$126,800	\$1,593,169	\$4,451,482
2013	\$320,380	\$2,742,687	\$114,816	\$2,495,307	\$5,673,190
2014	\$414,206	\$1,884,626	\$53,263	\$2,487,577	\$4,839,672
2015	\$417,189	\$1,235,836	\$38,535	\$2,132,007	\$3,823,567
2016	\$506,533	\$1,442,921	\$42,423	\$1,618,655	\$3,610,533
2017	\$547,308	\$2,220,595	\$32,975	\$2,854,873	\$5,655,751
Total	\$3,450,649	\$22,293,674	\$759,193	\$18,259,922	\$44,763,437

VI. PROPOSED MANAGEMENT OPTIONS

Management Options

(+ potential positive impact of action)

(- potential negative impact of action)

Below are overarching positive (+) and negative (-) impacts for all options. The options are listed after the impacts.

- +/- Allocation not based on biological need.
- +/- Allocation other than status quo not based on historical landings.
- +/- Increasing allocation to the recreational sector provides more fish to harvest but depending on amount may not increase the season dates, season lengths, or bag limits.
- + Increasing allocation to the recreational sector mitigates some of the economic impact of the reductions to the recreational fishery.
- Decreasing allocation to the commercial fishery exacerbates the economic impact of the commercial fishery.
- Increasing allocation to the recreational fishery provides additional harvest to the sector with the least precise estimates.
- Changes in allocation may alter the rebuilding schedule (changing allocation changes the fish available to each sector and their associated selectivity, projections are based on sector specific selectivity).
- Depending on how much allocation is shifted to the recreational sector there may be significant impacts to the commercial seasons.
- May be necessary to adjust allocations within a sector to maintain specific gear-based fisheries.

Option 1. Historical Harvest/ Status quo (73 commercial/27 recreational)

Option 2. 70/30

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Option 3. 65/35

Option 4. 60/30/10, includes a 10 percent allocation for the gig fishery

Option 5. 60/40

Option 6. 50/50

VII. NCMFC SELECTED MANAGEMENT STRATEGY

The NCMFC approved a motion to set the allocation for Amendment 3 at 70% commercial and 30% recreational at the February 26, 2021 business meeting.

Division staff presented its analysis of the above options at the February 2021 business meeting. The NCDMF Acting Director stated on the record at that meeting that the division did not endorse, recommend, or advocate any one of these options including the status quo option and that it was the NCMFC's sole decision to vote on whatever percentage split it choose. Following deliberation, the NCMFC voted 5-4 in favor of selection of sector harvest allocations of 70% commercial and 30% recreational for the upcoming Amendment 3 to the Southern Flounder FMP.

At a March 2021 special meeting the NCMFC revisited the allocation discussion. As a result, the NCMFC approved a motion (5-4) to amend the previously adopted southern flounder allocation to adjust the allocation to 70/30 in 2021 and 2022 to 60% commercial and 40% recreational in 2023 and achieve a 50/50 parity in allocation in 2024.

VIII. LITERATURE CITED

Blackhart, K., D.G. Stanton, and A.M. Shimada. 2005. NOAA Fisheries Glossary, U.S. Dept. of Commerce, NOAA Tech. Memo. F/SPO-69, 61 p.

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APPENDIX 4.6. IMPLEMENTING A SLOT LIMIT IN THE SOUTHERN FLOUNDER FISHERY

I. ISSUE

Examine the impacts of changing size limits by implementing a harvest size slot limit in the southern flounder fishery.

II. ORIGINATION

This issue originated from a request brought forth by the North Carolina Marine Fisheries Commission.

III. BACKGROUND

Managing fisheries using size regulations to constrain harvest is common practice, but there is often a trade-off between conservation (i.e., spawning stock biomass) and fishery objectives (i.e., maximizing sustainable yield or harvest numbers; Gwinn et al. 2015; Ayllon et al. 2018, 2019). Often minimum size limits are used but can negatively impact a stock by truncating the age and size structure if effort is high (Moreau and Matthais 2018). Slot limits, particularly in freshwater recreational fisheries, are becoming more popular as they have the ability to protect juveniles and spawning adults (Gwinn et al. 2015) and can help maintain a more mature age structure when compared to minimum size limit regulations (Ayllon et al. 2019). However, if overfished stocks are to be recovered, management actions must first focus on reducing both fishing effort and hooking/bycatch mortality. Once these rates are under control, slot limit regulations could lead to improved sustainability (Ayllon et al. 2018).

Slot limits are not appropriate for all species, but should be considered if the population in question has the following characteristics (Baker et al. 1993; Brousseau and Armstrong 1987):

- good natural reproduction,
- slow growth, especially of young fish,
- relatively high natural mortality of young fish, and
- high angling effort.

Additionally, the upper limit of a slot limit should provide meaningful harvest protection for the species in question (Oliver et al. 2021). If discard mortality and non-compliance for a species are high, then slot limits become less effective as a management tool (Ayllon et al. 2019). Based on the criteria defined by Baker et al. (1993) for slot limits, southern flounder may not be an appropriate candidate as the current fishing mortality is above the threshold reference point, the spawner-recruit relationship is unknown, and juvenile flounder are fast growing (Flowers et al. 2019).

Slot limits may be useful to constrain harvest after fishing effort and mortality are reduced and the stock rebuilds. Benefits for the development of a slot limit for southern flounder revolve around increasing harvest of males, protection of large mature females, and the idea that releasing all larger southern flounder would speed up recovery through increased egg production. Southern flounder are sexually dimorphic, with females reaching larger sizes than males. Males

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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over 20 inches TL have not been recorded and few males are over 17 inches TL (Figure 4.6.1). While a 50:50 ratio is assumed for southern flounder smaller than 5-inches TL, the female proportion increases for fish 5.5-inches TL or greater and becomes more pronounced at 12-inches TL. Therefore, a slot limit does not guarantee a higher harvest of males. Water temperatures have been shown to influence the sex ratios of southern flounder where higher or lower temperatures can result in a higher proportion of males to females (Luckenbach et al. 2003, 2009; Honeycutt et al. 2019; Montalvo et al. 2012) indicating there may be more males available for harvest. It is unknown what impact annual changes in environmental factors have on the recovery of southern flounder, even if all fish over a certain size are released. For more information on environmental influence on sex ratios, see the *Ecosystem and Fishery Impacts* section.

Most, if not all, fish released over a potential slot limit would be female (Figure 4.6.1). However, the length at which half of female southern flounder are mature is 16-inches TL (Midway and Scharf 2012; Flowers et al. 2019). Division data indicates all females over 19 inches TL are likely mature (NCDMF, unpublished data). While there are no fecundity data currently available from wild individuals to indicate whether larger fish produce more offspring, fecundity generally increases with female body size. In a hatchery setting, southern flounder are capable of producing up to 18 million eggs with an average hatching rate of 15% (Watanabe et al. 2001). These estimates should be viewed with caution because the laboratory experiments were conducted under ideal conditions.

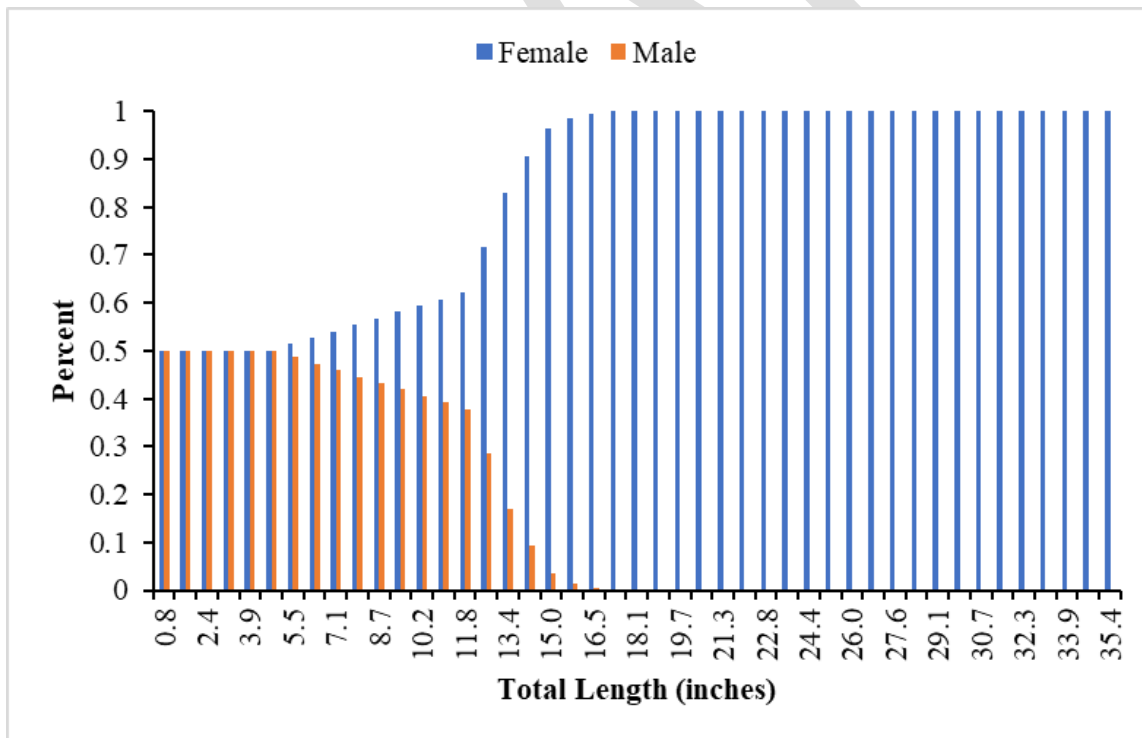


Figure 4.6.1. Sex ratios of southern flounder relative to total length.

In 2017, approximately 10% of the total commercial and recreational harvest were fish greater than 20 inches TL (Figures 4.6.2 and 4.6.3). In 2020, catches of fish larger than 20 inches TL

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increased for both sectors. It is expected that larger fish will continue to show up in the catches due to the limited seasons occurring in the fall which allow for a longer period of growth prior to being harvested. The current stock shows a truncated age and size structure (Flowers et al. 2019), meaning larger fish are not necessarily older fish. The maximum age observed in both fisheries has decreased over the last decade, and the majority of fishing pressure for both sectors is focused on one or two age classes of fish where most fish harvested are age-2 (NCDMF 2021). Both the age and length structure of the population are expected to improve as the stock recovers. Along with the poor age structure of the stock, it is unknown if the few fish over age-3 have spawned multiple times. It should be noted that while the additional escapement of larger fish may benefit the stock, any fish discarded outside of the slot have an associated post-release mortality, adding to the dead discards.

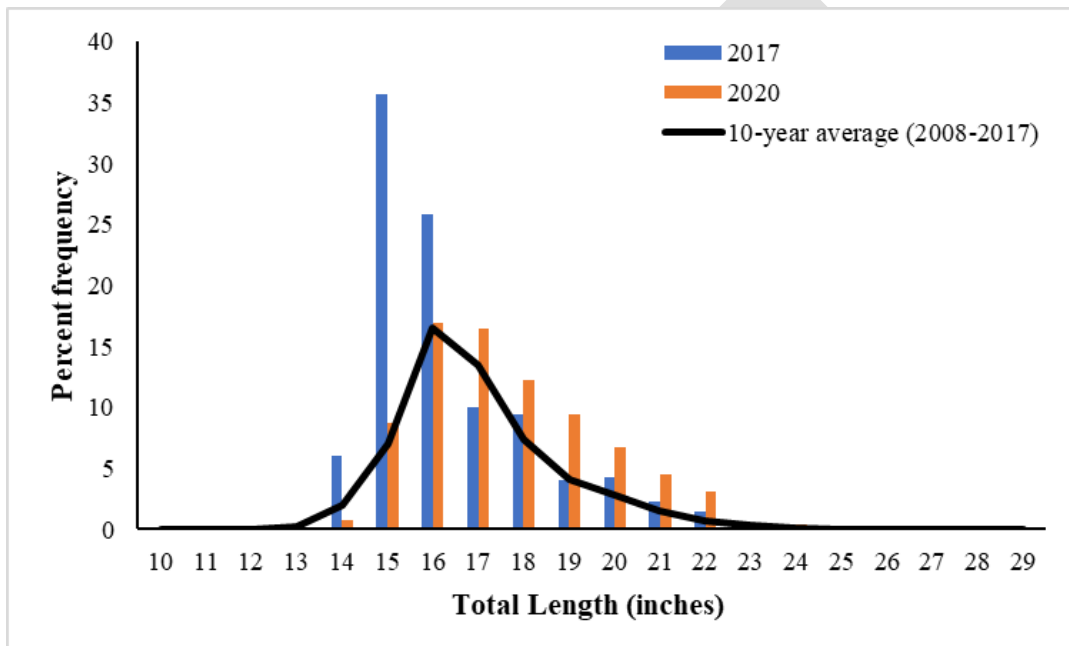


Figure 4.6.2. Percent frequency (by pound per inch) of commercial southern flounder harvest by total length, 2017 and 2020. The 10-year average (2008-2017) is also included for reference. (Source: North Carolina Trip Ticket Program and NCDMF fish house sampling biological data)

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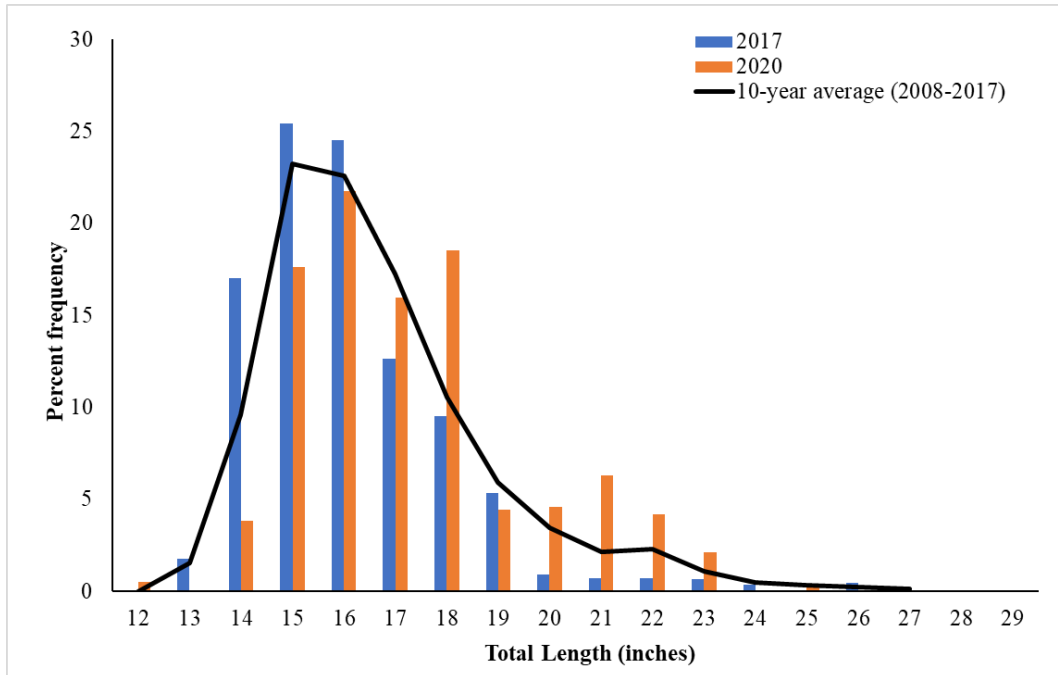


Figure 4.6.3. Percent frequency (by pound per inch) of recreational southern flounder harvest by length, 2017 and 2020. The 10-year average (2008-2017) is also included for reference. (Source: Marine Recreational Information Program)

In North Carolina, the management of flounder species has undergone several regulatory changes to promote the sustainability of the stock. The first implementation of a minimum size limit occurred in 1979 at 11 inches TL for both estuarine and ocean waters. Subsequent minimum size limits have been implemented through the original North Carolina Southern Flounder FMP (NCDMF 2005), Amendment 1 (NCDMF 2013), Supplement A to Amendment 1 (NCDMF 2017), and revisions to the joint Atlantic States Marine Fisheries Commission (ASMFC) and Mid-Atlantic Fishery Management Council Summer Flounder, Scup, and Black Sea Bass FMP (ASMFC 2018; MAFMC 2019). The use of a slot limit, as a potential management tool for curtailing harvest in the southern flounder fishery, has not been explored in previous management plans. A slot limit could be implemented for the recreational and/or commercial fisheries. At this time, the focus of this issue paper will be the potential implementation of a slot limit for the recreational hook-and-line fishery only as requested by the NCMFC.

IV. AUTHORITY

North Carolina General Statutes

G.S. 113-134 RULES

G.S. 113-182 REGULATION OF FISHING AND FISHERIES

G.S. 113-182.1 FISHERY MANAGEMENT PLANS

G.S. 113-221.1 PROCLAMATIONS; EMERGENCY REVIEW

G.S. 143B-289.52 MARINE FISHERIES COMMISSION – POWERS AND DUTIES

North Carolina Marine Fisheries Commission Rules

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15A NCAC 03H .0103 PROCLAMATIONS, GENERAL

15A NCAC 03M .0503 FLOUNDER

15A NCAC 03M .0512 COMPLIANCE WITH FISHERY MANAGEMENT PLANS

V. DISCUSSION

The population level effects of implementing a slot limit for the recreational southern flounder hook-and-line fishery in North Carolina is non-quantifiable as developing projections based on a slot limit cannot be calculated on an individual state basis. The 2019 stock assessment does not include a spatial component; as a result, all size limit changes would be relative to the entire stock of southern flounder. There are multiple minimum size limits in place across the unit stock, which have ranged in recent years from 12- to 16-inches TL. The analyses of implementing a slot limit are based solely on North Carolina harvest estimates and may or may not be representative of the coast-wide stock and it would not be possible to attribute the implementation of a slot limit as the cause of changes to stock size.

Slot limits of 15 to 16 inches (1 inch), 15 to 17 inches (2 inch), 15 to 18 inches (3 inch), and 15 to 19 inches (4 inch) TL were explored for the recreational hook-and-line fishery. For ease of enforcement and education, these slot limits include fish at but not greater than the maximum length. For example, the 15- to 16-inch TL slot is only one inch as it includes fish from 15 inches up to and no greater than 16 inches TL. Most harvest for both sectors is less than 20 inches TL thus, implementing a slot limit may act as a buffer to prevent overages to the TAL. The implementation of a slot limit will not extend the season or increase the TAL (Table 4.6.1). In fact, to account for the additional dead discards the TAL would need to be reduced, resulting in fewer harvest opportunities so not to exceed the TAC. Releasing larger fish may help in the recovery of the stock but at this time the effects cannot be quantified. It is also likely that more larger fish are emigrating to the ocean since implementation of the harvest reductions through seasonal closures implemented in Amendment 2.

Estimates in recreational harvest can only be analyzed at the season and bag level for the hook-and-line fishery as length data are not available from the gig survey. The identified slot limits are very narrow and may be imperceptible to fishermen using gigs. Therefore, it is not realistic for the recreational gig fishery to operate under a slot limit as gigs have an assumed 100% mortality associated with capture. Due to the anticipated increase in dead discards that would occur outside of the slot limit, gigs become detrimental to re-building unless a non-lethal gig-like gear was implemented. The gig fishery could continue to operate under the current minimum size limit. However, this creates a greater potential for enforcement issues and non-compliance.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.6.1. Pounds of southern flounder harvest (no discards) at a four-fish and one-fish bag limit, 2013. This year represents a year of high harvest and what could happen as the stock rebuilds. For reference, the NCMFC allocations are 142,206 lb (30% recreational allocation), 189,608 lb (40%), and 237,010 lb (50%).

Season	Landings (lb)- Slot Limit							
	15 to 16 inches		15 to 17 inches		15 to 18 inches		15 to 19 inches	
	4-Fish Bag Limit	1-Fish Bag Limit	4-Fish Bag Limit	1-Fish Bag Limit	4-Fish Bag Limit	1-Fish Bag Limit	4-Fish Bag Limit	1-Fish Bag Limit
No closure	266,659	218,399	380,114	280,432	544,443	396,391	638,143	439,743
Apr 16–Jun 30	29,669	26,707	47,222	42,164	95,532	69,216	141,213	94,341
May 1–Jun 30	29,669	26,707	40,159	35,101	88,469	62,153	134,149	87,277
Jun 1–Jul 15	24,130	24,130	41,736	38,370	96,656	72,344	145,238	99,257
Aug 1–Sep 30	170,542	127,984	226,416	147,034	313,735	208,979	347,159	218,135
Aug 16–Sep 30	156,752	114,193	204,120	128,528	284,590	184,428	316,724	193,202
July 16–Sep. 30	178,324	135,232	234,197	154,282	323,470	217,495	359,504	229,262
July 1 -Sep.30	189,893	146,801	252,883	171,698	522,892	242,022	389,586	256,474
June 16–Sep. 15	161,353	131,993	222,932	162,920	354,683	257,242	437,354	293,976
Aug 16-Oct 15	159,344	116,785	209,928	133,809	295,774	195,085	330,095	206,047
Aug-16-Oct 30	183,686	138,921	253,082	164,360	344,925	231,068	385,245	243,618

The MRIP survey design for the hook-and-line fishery includes length data with an associated sampling weight equivalent to the sampling weight applied to generate the expanded harvest estimates. Therefore, slot limit analyses can be compared to estimates produced in reference to the TAL but not the TAC. Importantly, the contribution of generated discards can be substantial. For example, analysis of MRIP size data demonstrates that the only slot limit scenario with landings below the TAL during the 2020 6-week season was 15 to 16 inches TL (Table 4.6.2). Generated dead discards for those fish greater than the upper bound for this slot limit are 24,604 pounds. Estimates of existing dead discards average 41,331 pounds between 2008 and 2017. The additional generated dead discards would increase this average creating the need to reduce the TAL to offset the increase in discards. Additionally, changes in bag limits substantially decrease reliability of estimates. For example, in 2017 only 29 southern flounder were observed between Aug. 16 and Sept. 30. A one fish bag limit analysis during this season excludes 41% of the observations. This is further compounded by a skewed age structure where 89% of observed southern flounder were 19 inches TL or less. For these reasons, estimates produced for slot limits are not a reliable indicator of the effect a slot may have on recreational harvest.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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Table 4.6.2. Pounds of southern flounder harvested by the recreational hook-and-line fishery during the 2020 season, by slot limit option. The no slot example shows the harvest under the current 15-inch TL minimum size limit. The TAL in 2020 was 126,315 pounds.

Season	Slot Limit (in)	Harvest (lb)
Aug. 16 - Sept. 30	No slot	362,119
Aug. 16 - Sept. 30	15-16	88,743
Aug. 16 - Sept. 30	15-17	140,448
Aug. 16 - Sept. 30	15-18	218,009
Aug. 16 - Sept. 30	15-19	238,565

There are several data limitations hindering the evaluation of slot limits including fecundity at age, effect of seasons on the size of fish harvested, and distribution of flounder as they emigrate into the ocean. Additionally, species level biological data are currently unavailable for unobserved discarded flounder. North Carolina's three constituent flounder species are notoriously difficult to differentiate. This ambiguity presents a unique challenge for fisheries management in that discard information provided by the recreational angling community may be inadvertently errant. To properly consider the discard estimates of these species produced by the APAIS conducted in North Carolina, the number of fish discarded and reported at the genus species level must be evaluated. Only a very small percentage of the angling community are perceived to have the ability to identify flounder to the species level. Thus, samplers are instructed to record all reported flounder discards at the left-eyed flounder genus level. To partition the unobserved catch to the species level, a ratio of southern, summer, and Gulf flounder is first determined from the observed catch. The ratio of catch is applied to the estimated unobserved catch to produce estimates of discards for each species. It is unlikely that the relative contribution of each species within the harvested catch is identical with that of discarded catch. Specifically, the assumption that discarded individuals share the same spatiotemporal distribution as those harvested has not been validated. This concern is underscored by demonstrated ontogenetic differences in habitat use and migratory patterns for these congener species (Walsh et al. 1999; Dorval et al. 2005). The ability to accurately identify discarded flounder to the species level is critical to characterize unobserved dead discards. If these data limitations can be addressed, it will be possible to more accurately quantify the use of implementing a slot limit.

While these analyses have data limitations, they do illustrate potential annual variation. Figures 4.6.4-4.6.7 illustrate the effect a slot limit may have on the recreational fishery relative to the allocation changes passed by the NCMFC in March 2021. As the stock rebuilds the potential recreational seasons identified in the *Achieving Sustainable Harvest* issue paper may fail to meet the target harvest reduction due to increased angler success (Figures 4.6.4-4.6.7). In 2020, angler success increased relative to the last five years, particularly for anglers catching only one fish. Catch rates, indicative of success, almost doubled between 2019 and 2020. Therefore, decreasing the bag limit, even if a slot limit is implemented, is necessary to constrain harvest and prevent massive overages. For further discussion on the effects of increased angler success and bag limits, see the *Achieving Sustainable Harvest* issue paper.

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Moreau and Matthias (2018) found narrow slot limits for certain freshwater species can be used to prevent overharvest when bag limits are left unchanged. However, in this study if the bag limit was reduced to one fish, the slot limit range could potentially be expanded allowing for the harvest of larger fish. This would be more appropriate as the stock rebounds and the length and age structure expands. Any slot limit will potentially increase the discarded fish which is problematic for species such as southern flounder which have high post-release mortality (9%) and discard to catch ratios (nine released for every fish kept; Moreau and Matthias 2018). Slot limits generally result in lower harvest and more discards by weight, and therefore higher and more frequent overages would occur compared to a minimum size limit (Wiedenmann et al. 2013). As older, larger fish become more abundant, the volume of removals due to discard mortality and non-compliant harvest is expected to increase (Kasper et al. 2020).

The discards of larger, heavier fish will increase the poundage of dead discards. This increase could be especially problematic for the recreational fishery due to the volume of releases each year. It is assumed that most fish discarded in the recreational fishery are discarded because they are below the minimum size limit and therefore weigh less than half a pound. By discarding fish above the slot limit the overall weight of dead discards would increase, potentially to greater than five pounds per fish. Thus, increasing the likelihood of not just exceeding the TAL each year but the TAC as well.

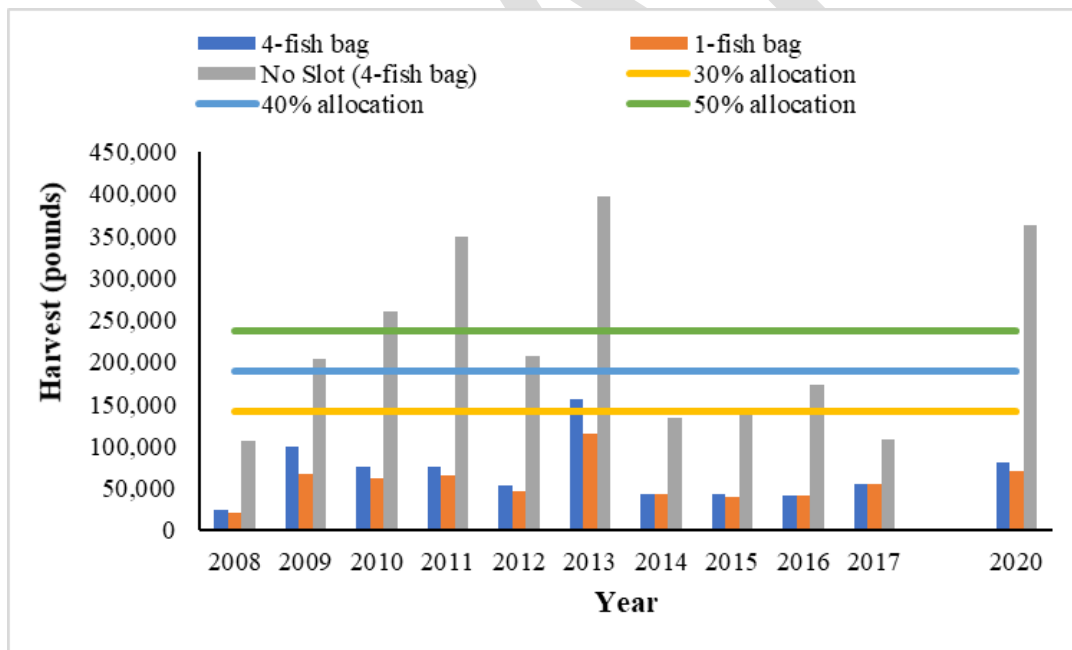


Figure 4.6.4. Total hook-and-line harvest during Aug. 16–Sept.30 at a four-fish and one-fish bag limit and a 15–16-inch slot based on data from 2008 to 2017 and 2020. The years 2010, 2011, and 2013 represent years of above average harvest; 2020 represents the first full year under seasonal management through Amendment 2. NCMFC allocations are presented for reference.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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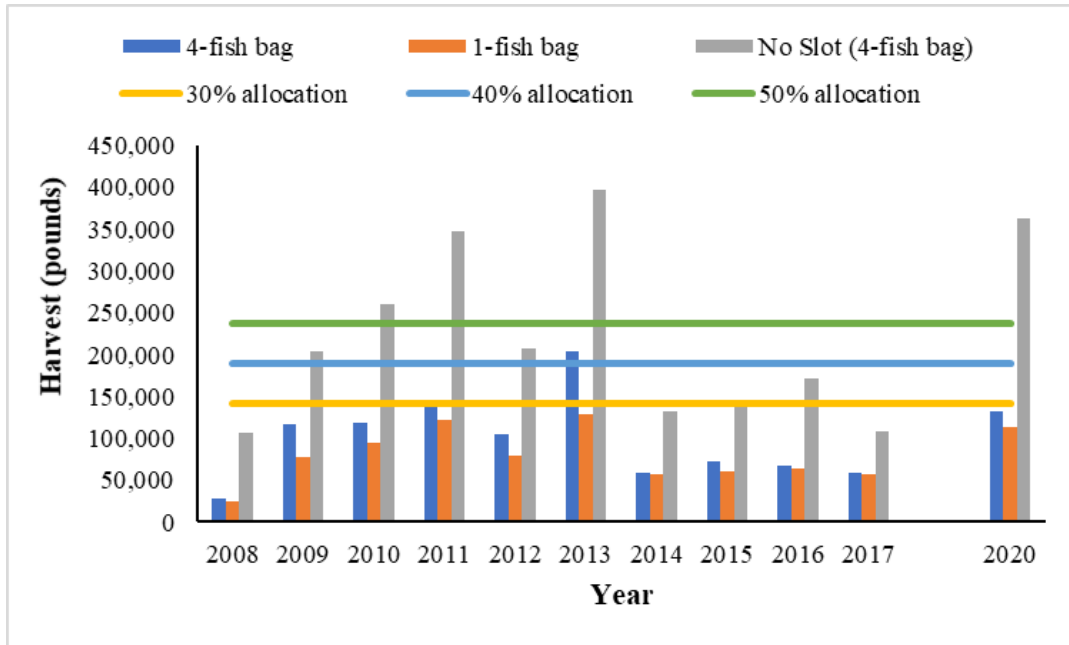


Figure 4.6.5. Total hook-and-line harvest during Aug. 16–Sept.30 at a four-fish and one-fish bag limit and a 15–17-inch TL slot based on data from 2008 to 2017 and 2020. The years 2010, 2011, and 2013 represent years of above average harvest; 2020 represents the first full year under seasonal management through Amendment 2. NCMFC allocations are presented for reference.

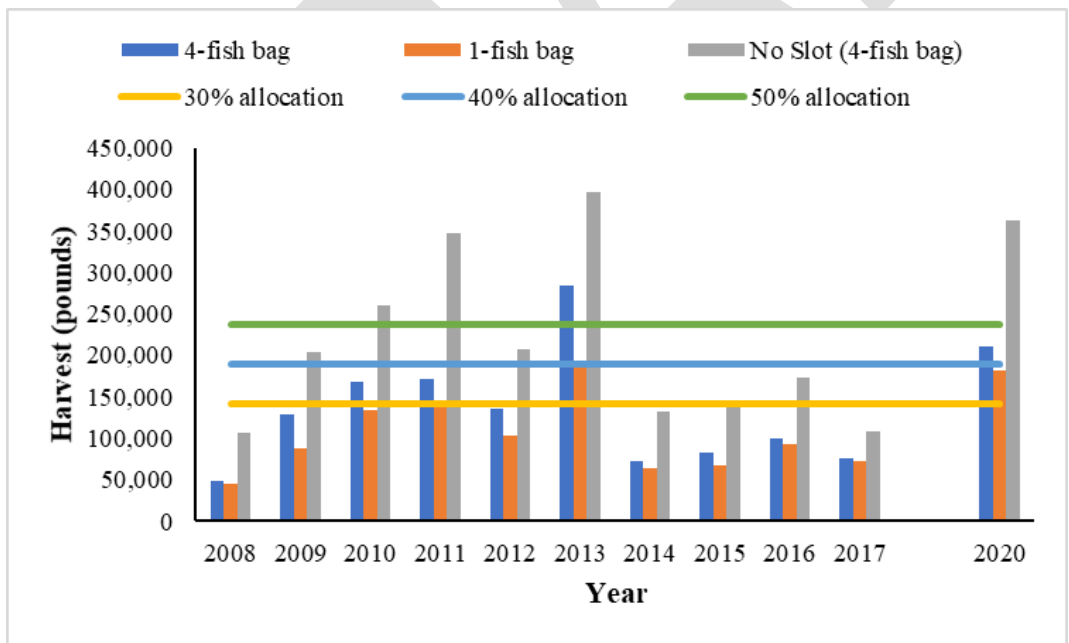


Figure 4.6.6. Total hook-and-line harvest during Aug. 16–Sept.30 at a four-fish and one-fish bag limit and a 15–18-inch TL slot based on data from 2008 to 2017 and 2020. The years 2010, 2011, and 2013 represent years of above average harvest; 2020 represents the first full year under seasonal management through Amendment 2. NCMFC allocations are presented for reference.

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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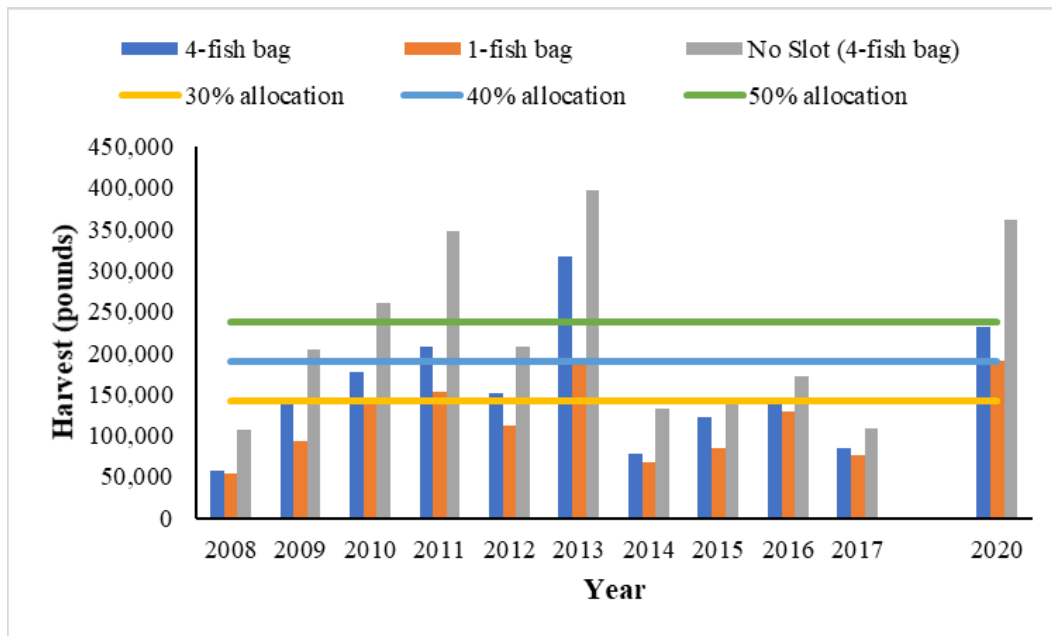


Figure 4.6.7. Total hook-and-line harvest during Aug. 16–Sept.30 at a four-fish and one-fish bag limit and a 15–19-inch TL slot based on data from 2008 to 2017 and 2020. The years 2010, 2011, and 2013 represent years of above average harvest; 2020 represents the first full year under seasonal management through Amendment 2. NCMFC allocations are presented for reference.

Previous analysis of summer flounder slot limits showed an increase in harvest of smaller fish, while only reducing some harvest on the larger fish. This increased fishing mortality rates and resulted in only marginal benefits (Wong 2009). Non-compliance and high-grading within the slot were concerns with the implementation of a slot limit. As such, it was recommended that narrow slot ranges be avoided due to issues related to angler satisfaction, non-compliance, and enforcement. Importantly, the use of slot limits for a flounder species was not recommended until rebuilding goals and data needs for the species were met (Wong 2009; ASMFC 2018).

As the stock rebuilds, any benefit of a buffer may disappear as more fish become available within the slot. Though slot limits are normally associated with the recreational sector, slot limits may be implemented in both sectors since there are differences in fishing seasons. Any savings may be lost if larger fish are released by the recreational sector only to be available for harvest in the commercial fishery (as is currently being discussed). This is also true within the recreational sector if gigs are not held to the same slot. Finally, it is also an important consideration for the recreational fishery if there is an early and late season; fish may grow into or out of the slot between those seasons to an unknown effect.

Though size limits could not be changed under Amendment 2, the 2020 season offers an opportunity to see how the implementation of a slot limit may have affected landings under seasonal management. Of the options presented in this issue paper, only the narrowest slot limit may have possibly prevented the recreational hook-and-line fishery from exceeding their TAL

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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(126,315 pounds) in 2020 (Table 4.6.2). The other options presented would have minimized the overages when compared to no slot limit.

Selection of Slot Limits with a Minimum Size Limit Lower than 15 Inches

Decreasing the minimum size limit could potentially increase harvest on males while decreasing pressure on larger females. However, it cannot be guaranteed that more males will be harvested. Depending on the minimum slot size, males could account for 10% to 40% of the fish available for harvest (Figure 4.6.1). In the summer flounder headboat fishery, Morson et al. (2017) found that lowering the minimum size for a slot limit below the current minimum size regulations could potentially meet management goals while distributing harvest over both sexes for summer flounder. However, the slot limits that did not increase fishing mortality were all narrow (2-4 inches), contained the current minimum size within the slot limit, and were not applicable to all areas and habitats.

Even at previous minimum size limits, southern flounder landings were still dominated by female fish (NCDMF, unpublished data). It is thought that males move offshore at a smaller size than females and do not return to the estuary after spawning (Stokes 1977), potentially decreasing the efficacy of a lower minimum size. While it is understood that harvest of larger females could be detrimental to the recovery of the stock, many female fish less than 16 inches TL are not mature, and harvest of these fish can also negatively impact recovery. It is not possible to determine the sex of southern flounder prior to harvest and therefore, immature females would still be harvested.

Slot limits with a minimum length smaller than the current minimum length would increase the harvest of small fish. Because the southern flounder population is dominated by young fish (Flowers et al. 2019), this could significantly increase the overall number of fish harvested due to their greater availability. This increase in harvest would increase the fishing mortality rate.

In contrast, a reduction in the minimum size limit when implementing a slot limit may allow increased harvest on summer flounder. Summer flounder caught in North Carolina are typically smaller than southern flounder. As recreational size limits have increased through regulatory changes over the years, the ratio of harvest between summer and southern flounder has changed (Figure 14 in the *Description of Fisheries* section).

The recreational size limit for flounder has been 15 inches TL since 2011 and multiple size limit changes have occurred over the time series making it difficult to determine any effect lowering the size limit would have. Any calculations performed would introduce a high level of imprecision and be based on data that may not be representative of the current fishery. There are numerous concerns with decreasing the minimum size limit for the recreational sector. These concerns revolve around the large volume of recreational discards of fish that are currently under the 15-inch TL minimum size limit (approximately 1.9 million fish in 2017). Lowering the minimum size limit would potentially turn these discards into harvest. Increasing the harvest from the recreational fishery would not meet the projected reductions necessary for rebuilding, and under adaptive management would lead to shortened or closed seasons. Data are not available on the size of discards so it is unclear how harvest would change if the minimum size

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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for a slot was dropped to 12- or 13-inches TL. When the size limits were lower (1989-2007), these smaller fish accounted for 30-40% of the recreational harvest.

The slot limit options proposed have a minimum size of 15 inches TL. This is because MRIP staff do not see discarded flounder and therefore do not collect any associated biological data. Data on the species composition and length of discarded flounder is not available. This overwhelming data limitation prohibits calculating the potential impact of lowering the size limit or implementing a slot limit with a lower bound below the current size limit. The division's License and Statistics section has developed a smartphone application (Catch U Later!) to collect information on discarded flounder to help identify not only species composition of discards but length frequency as well. Data from this app will be available over the next several years. As these data are collected, determining the impact of lowering the size limit will be possible.

The following are additional positive (+) and negative (-) impacts on lowering the minimum size limit below 15 inches TL.

- + Would reduce the harvest of larger females
- + May increase the harvest of males
- Cannot evaluate sustainable harvest of slot limits with a reduced minimum size limit
- Would likely increase the number of fish harvested
- Smaller minimum size limit would expose smaller fish to harvest, including smaller females
- No guarantee that harvest of males will increase
- Would not prevent dead discards of larger fish
- The larger fish that are released and die will contribute to increasing the average weight of dead discards reducing the available weight for harvest
- The combination of increased harvest of small fish and increased dead discard weight of larger fish is likely to lead to overages in the fishery
- Would impact summer flounder harvest and require ASMFC/MAFMC approval

Additional Management Considerations

It should be noted that while the NCMFC may choose a preferred slot limit as a management option, the NCDMF would need approval from ASMFC to implement any changes to the current minimum size limit. The ASMFC has implemented state and/or regional level conservation equivalencies for the management of summer flounder since 2001 (ASMFC 2017). Conservation equivalency management measures are reviewed annually and based on the coast-wide summer flounder recreational harvest limit and overages when they occur. The ASMFC must be notified of any changes to the summer flounder fishery in North Carolina state waters; however, approval of changes by the ASMFC is not required if the changes are expected to be more restrictive than the management measures already approved by the ASMFC. Conservation equivalencies may not be approved by ASMFC until the February following Amendment 3 implementation. Therefore, slot limits, if approved by the NCMFC and the ASMFC, would not be implemented until the 2023 fishing year at the earliest. If ASMFC does not approve slot limits as part of North Carolina's conservation equivalency for summer flounder, the state could be found out of compliance through the Summer Flounder, Scup, and Black Sea Bass FMP. These interjurisdictional regulations impact the North Carolina fishery as state management of flounder

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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is collective and not by individual species. Further, management regulations through ASMFC continue to increase the summer flounder minimum size limit, indicating approval of a lower minimum size might not occur. If the NCMFC were to implement a slot limit with a lower minimum size without ASMFC approval, North Carolina could be found out of compliance leading to a closure of the fishery.

Changes to the summer flounder fishery in EEZ waters off North Carolina may be impacted by the Mid-Atlantic Fishery Management Council and National Marine Fisheries Service (NMFS). Until conservation equivalencies are approved by NMFS (which usually occurs in May or June), coast-wide measures for summer flounder in the EEZ include a four-fish possession limit, a 19-inch TL minimum size limit, and an open season of May 15–Sept. 15 (MAFMC 2019). These measures serve as a default each year until annual conservation equivalencies are approved by the NMFS, which allow state regulations to be applied to EEZ waters.

VI. PROPOSED MANAGEMENT OPTIONS

Management Options

- (+ potential positive impact of action)
- (- potential negative impact of action)

Below are overarching positive (+) and negative (-) impacts for all options, specific impacts from an option may be found below that option.

Option 1. Status quo, Do not implement a slot limit and maintain the 15-inch TL current minimum size limit.

- + Maintains current regulations and allows anglers to harvest citation size flounder
- + Meets compliance requirements for summer flounder through the joint ASMFC/MAFMC plans
- + Doesn't create regulatory disparity between the recreational hook-and-line and gig fisheries
- + Meets sustainability if harvest is below the TAL
- + Escapement of mature fish is occurring through the 72% reduction
- Would not reduce the harvest of larger, more fecund females
- Does not provide additional protections to the stock

Option 2. Implement a slot limit for the recreational hook-and-line fishery.

The following positive and negative impacts apply to all of option 2.

- + May help to constrain harvest and prevent overages if used in conjunction with the TAL and seasons for the recreational hook-and-line fishery
- + Meets sustainability if harvest is below the TAL
- +/- Potentially allows for additional escapement of the larger, more fecund females
- Requires approval from ASMFC/MAFMC for conservation equivalency, which may not be approved

AMENDMENT 3 DRAFT 2 - SUBJECT TO CHANGE

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- Larger fish protected by the slot limit in the recreational fishery may be harvested by the commercial fishery later in the year
- Fish discarded outside of the slot have an associated mortality and dead discards would increase
- May increase the number of fish harvested to meet the same TAL
- Would increase overall weight of dead discards and could potentially lead to exceeding TAC and not meeting the needed overall reduction
- May disproportionately impact gig and RCGL gill-net fisheries if applied to all recreational gear, not just the hook-and-line fishery
- Greater potential for noncompliance and high grading
- Does not allow anglers to harvest citation size flounder

2A. Implement a 15 to 16 Inch (1 inch) TL Slot Limit.

2B. Implement a 15 to 17 Inch (2 inch) TL Slot Limit.

2C. Implement a 15 to 18 Inch (3 inch) TL Slot Limit.

2D. Implement a 15 to 19 Inch (4 inch) TL Slot Limit.

VII. RECOMMENDATIONS

*NCDMF Initial Recommendation**

The NCDMF initial recommendation is to not implement a slot limit at this time (Option 1). Slot limits can be an important tool for management, and the division supports considering them as the age and size structures of the population expands. Additionally, the division is working to collect information on the size structure of the discarded southern flounder to inform future management decisions.

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APPENDIX 4.7. PHASING OUT ANCHORED LARGE-MESH GILL NETS IN THE NORTH CAROLINA SOUTHERN FLOUNDER FISHERY

I. ISSUE

Explore the impacts of phasing out anchored large-mesh gill nets from the North Carolina southern flounder fishery by the end of the current Incidental Take Permit (ITP) year.

II. ORIGINATION

This issue originated from a request brought forth by the North Carolina Marine Fisheries Commission NCMFC.

III. BACKGROUND

At their March 2021 NCMFC special business meeting, the NCMFC requested the division explore the impacts of phasing out anchored large-mesh gill nets from the southern flounder fishery by the end of the current ITP. The current North Carolina ITP for the authorized incidental take of threatened and endangered sea turtles expires August 31, 2023, and the ITP authorizing incidental takes of threatened and endangered Atlantic sturgeon expires July 17, 2024 (NMFS 2013, 2014). The division is drafting an application for a new ITP to authorize incidental takes of sea turtles and Atlantic sturgeon for 10 years after the sea turtle ITP expires in 2023. If an option included in this issue paper is approved by the NCMFC, the use of anchored large-mesh gill nets could be phased out by the end of the current sea turtle ITP in August 2023. Due to the timing of the southern flounder season, 2022 may be the final year of the North Carolina southern flounder large-mesh gill net fishery if these measures are adopted by the NCMFC.

Early commercial fishermen tended to use pound nets, seines, gill nets, and spears (gigs) to harvest southern flounder in North Carolina (Chestnut and Davis 1975). Throughout the 1970s - early 1990s, pound net gear ranked highest in the total landings of southern flounder. During the mid-1990s, gill net landings surpassed those of pound nets. Gill nets continued to maintain the highest ranking in landings until 2014, when pound nets once again moved into the top position. The third highest ranking gear for southern flounder is gigs. From 2008 to 2017, on average 53% of southern flounder landings have been from gill nets, 38% from pound nets, and 7% from gigs (Table 4 in the *Description of the Fishery* section, Figure 4.7.1). Landings from other gears accounted for, on average, 2% of the total landings and included crab and peeler pots, crab and shrimp trawls, rod and reel, fyke nets, and haul seines. Due in part to increased regulatory measures, landings from gill nets have declined from 68% to near 40% during this time frame.

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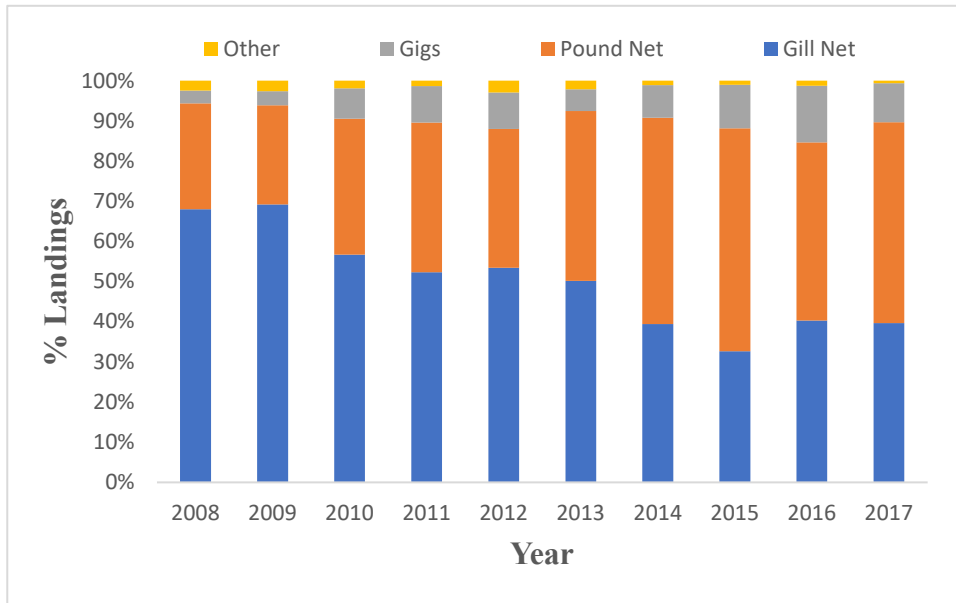


Figure 4.7.1. Percent of annual southern flounder commercial landings by gear type, 2008-2017.

Phasing out a single gear in the southern flounder fishery does not impact sustainable harvest of the southern flounder stock if a quota management system is implemented. Harvest by all gears can be allowed if the total harvest level does not exceed the TAL and dead discards and harvest combined do not exceed the TAC. Phasing out anchored large-mesh gill nets would allow the sub allocation for that gear to be applied to the remaining gears in the commercial fishery. This would result in additional TAL for pound nets and/or mobile gears, but the dead discards of southern flounder occurring through other large-mesh gill net fisheries (i.e., shad, catfish) would be applied to the TAC.

North Carolina additionally allows the recreational use of commercial gears. RCGL holders may use large and small mesh gill nets as well as shrimp trawls and crab pots to harvest species including southern flounder. Between 2002 and 2008, large-mesh gill nets comprised 74% of southern flounder harvested using RCGL gears, with small mesh gill nets (21%), crab pots (4.0%), and shrimp trawls (1%) constituting the remainder among RCGL gears. The number of flounder species harvested between 2002 and 2008 ranged from 18,414 to 53,785 fish annually (Figure 4.7.2).

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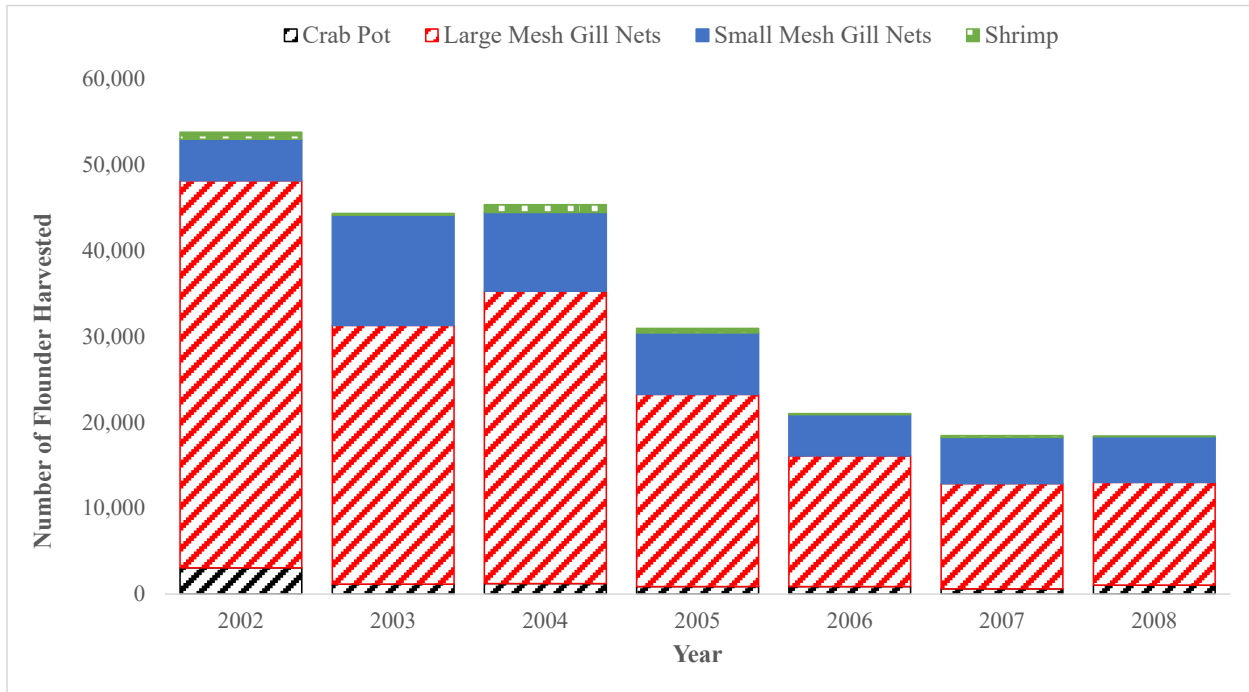


Figure 4.7.2. Number of flounder *species* harvested by RCGL gear type, 2002-2008.

Estimates of RCGL harvest have not been available since 2008 and thus impacts are not quantifiable. If phasing out of the large-mesh gill net commercial fishery is not approved, the use of RCGL gill nets to harvest southern flounder may still be disallowed through Amendment 3 under sustainable harvest. For more information on RCGL and southern flounder see the *Description of the Fisheries* section and the *Achieving Sustainable Harvest* issue paper.

IV. AUTHORITY

North Carolina General Statutes

G.S. 113-134 RULES

G.S. 113-173 RECREATIONAL COMMERCIAL GEAR LICENSE

G.S. 113-182 REGULATION OF FISHING AND FISHERIES

G.S. 113-182.1 FISHERY MANAGEMENT PLANS

G.S. 143B-289.52 MARINE FISHERIES COMMISSION – POWERS AND DUTIES

North Carolina Marine Fisheries Commission Rules

15A NCAC 03H .0103 PROCLAMATIONS, GENERAL

15A NCAC 03M .0503 FLOUNDER

15A NCAC 03O. 0302 AUTHORIZED GEAR

V. DISCUSSION

At the March 2021 special meeting, the NCMFC requested that the division evaluate the potential to phase out the use of large-mesh gill nets in the southern flounder fishery by the end of the current ITP during development of Amendment 3. The possible elimination of specific gears (i.e., anchored large-mesh gill nets) for harvesting southern flounder for either the

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commercial or recreational fishery is statutorily granted to the NCMFC by G.S. 143B-289.52. The division provides the best available data for a fishery (gear) to meet the mandate for producing a sustainable harvest of the southern flounder stock and to evaluate impacts to habitat.

Large-mesh gill nets are regulated by NCDMF through proclamation authority provided by the NCMFC to the Fisheries Director. Phasing out large-mesh gill nets in the southern flounder fishery would be accomplished using this authority by prohibiting the use of large-mesh gill nets for harvesting southern flounder. This would impact RCGL holders as well since large-mesh gill nets would not be an allowable gear to harvest southern flounder. Regulations involving the RCGL are found in G.S. 113-173 and NCMFC Rule 15A NCAC 03O.0302 that authorize certain commercial fishing gear for recreational use. A rule change(s) by the NCMFC is required to completely prevent a specific gear from being used across all fisheries in the state by commercial and RCGL license holders. Additional information on the RCGL can be found in the *Description of the Fisheries* section and the *Achieving Sustainable Harvest* issue paper.

Southern Flounder Large-Mesh Gill Net Fishery

During 2008-2017, an annual average of 808 participants (range: 591- 992) reported southern flounder landings from gill nets. These participants landed southern flounder from 14,643 trips on average from 2008-2017, though not all trips that landed southern flounder were targeting them (Figure 4.7.3). The number of trips landings southern flounder has declined from a high of 23,691 trips in 2009 to a low of 8,422 trips in 2016 (Table 5 in the *Description of the Fishery* section).

In order to characterize common species caught in the southern flounder gill net fishery, a targeted southern flounder trip reported to the NCTTP was defined as any large-mesh gill net trip where southern flounder represented the most abundant species (by weight). This definition accounted for greater than 93% of all southern flounder landings from large-mesh gill nets from 2013 to 2017. Generally, trips targeting southern flounder increased through the summer and peak in the fall (September and October) coinciding with the migration of southern flounder from the estuaries to the ocean prior to spawning as shown in Figure 4.7.3. During the remainder of the year, southern flounder were harvested in gill nets as part of other directed fisheries but were most commonly taken as part of a mixed finfish fishery. From 2013 to 2017, 73% of the large-mesh gill net trips landed southern flounder and 54% met the definition of a targeted trip for southern flounder. From June through October, greater than 75% of all trips made were targeted flounder trips. Only during December (closed season) and January through April, were directed southern flounder trips not the dominate trip type in the large-mesh gill net fishery. Trips during these months tend to be dominated by catches of catfishes, striped bass, and American shad, among other species.

Both finfish and shellfish species may be caught as bycatch in gill net trips targeting southern flounder. This bycatch may be retained or discarded as a result of economic, regulatory, or personal considerations. While southern flounder dominates the catch, the estuarine gill net fishery represents a mixed fishery with multiple species being taken on any given trip. Species include red drum, black drum, catfish species (including invasive blue catfish), sheepshead, spotted seatrout, American and hickory shad, striped bass, bluefish, striped mullet, and an additional 40+ species (Figure 4.7.4). Phasing out anchored large-mesh gill nets would impact

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the harvest of these other species as well. In addition, continuing to set large-mesh gill nets in areas where southern flounder are present could have an impact on rebuilding the stock as the species would be required to be discarded. Southern flounder caught in gill nets have an initial at net mortality associated with entanglement and an approximate 23% post-release mortality (Flowers et al. 2019).

Protected Species and Incidental Take Permits

Since the 1970s, the NCDMF has been proactive in developing ways to minimize impacts to threatened and endangered marine species. The NCDMF works closely with the National Oceanic and Atmospheric Administration (NOAA) Fisheries and other state and federal agencies to develop regulations that minimize impacts to protected species and still allow for economically important fisheries. Of the many federal and state protected species, sea turtles and sturgeon are considered to have the greatest potential to interact with the North Carolina southern flounder fishery. Gill nets may capture protected species as a result of entanglement in the webbing or buoy and anchor lines.

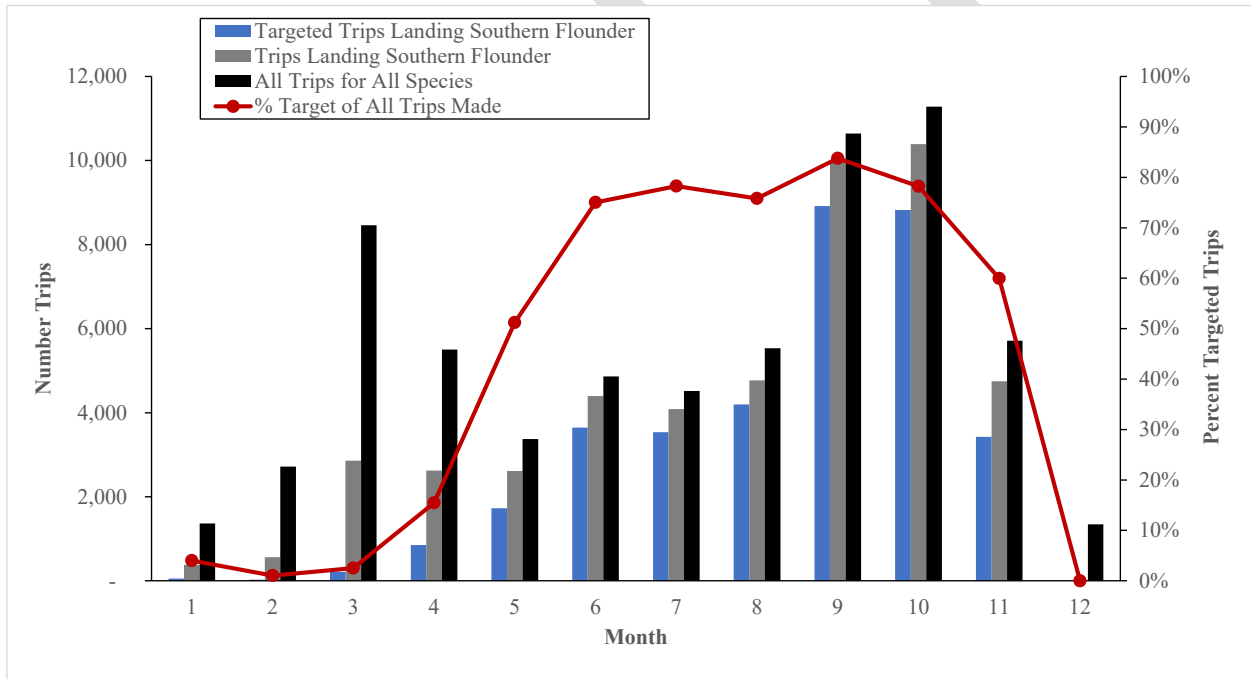


Figure 4.7.3. Total gill net trips compared to gill net trips targeting or landing southern flounder.

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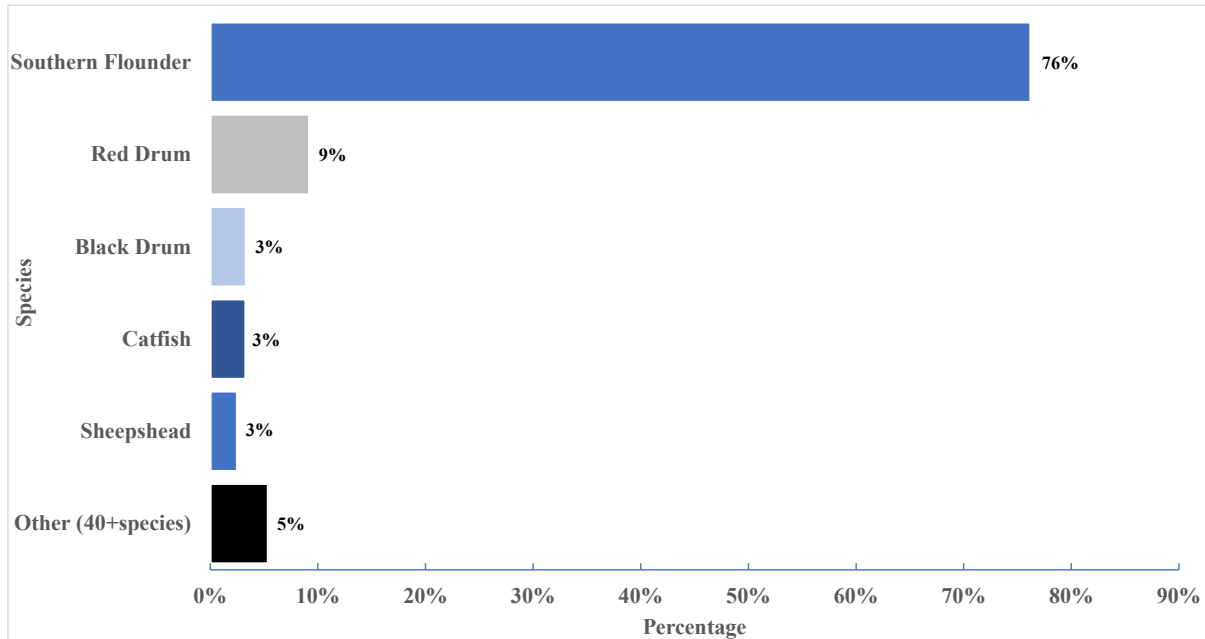


Figure 4.7.4. Top species harvested from anchored large-mesh gill nets where southern flounder are the most abundant species, 2013-2017.

Incidental capture of protected sea turtles and Atlantic sturgeon commonly occurs in the southern flounder gill net fishery. The fishery has undergone various regulations since the early 2000s to monitor and minimize impacts to protected sea turtles. The NCDMF currently allows the estuarine anchored gill net fishery to operate under the authorization from permits (ITP; Section 10(a)(1)(B) of the ESA) granted to the state by NOAA Fisheries for the incidental take of sea turtles and Atlantic sturgeon associated with otherwise lawful commercial gill net fishery in North Carolina inshore state waters (NMFS 2013, 2014). The permits outline authorized levels of annual incidental takes in these fisheries. The state as permit holder must monitor, minimize, and mitigate incidental takes as set forth in the conservation plan provided in the permit. The permits are in effect for a 10-year period: the sea turtle permit was issued in September 2013 and the Atlantic sturgeon permit was issued in July 2014. Since September 2014 (2015 license year), the division has been issuing estuarine gill net permits to any commercial fisherman or RCGL holder who wants to fish anchored gill nets (<https://files.nc.gov/ncdeq/Marine-Fisheries/fisheries-management-proclamations/2014/M-24-2014-EGNP.pdf>). During 2016-2021, an average of 2,619 permits were issued annually (Table 3 in the *Description of the Fishery* section). These permits provide the division with the number of participants who may choose to participate in the gill net fishery using large-mesh or small-mesh gill nets. Not all commercial license holders who obtain an estuarine gill net permit report flounder landings using the gear. For information specific to the North Carolina Incidental Take Permit for sea turtle interactions in the estuarine gill net fishery see: <https://www.federalregister.gov/documents/2013/09/17/2013-22592/endangered-species-file-no-16230>. For specific details related to the Atlantic sturgeon incidental take permit see: <https://www.federalregister.gov/documents/2014/07/28/2014-17645/endangered-species-file-no-18102>.

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Habitat Impacts

Phasing out anchored large-mesh gill nets in the southern flounder fishery would not offer significant habitat protections. Studies on the effect of anchored (or fixed) gill nets on habitat degradation indicate their impact is minor for soft bottom and SAV habitat (Barnette 2001; West et al. 1994; ASMFC 2000).

Economic Impacts

Economic impacts of phasing out the anchored large-mesh gill net fishery for southern flounder would be negative to all commercial license holders who participate in the fishery. The landings could be transferred to the pound net or other mobile gear fisheries, increasing the economic benefits of those gears. The economic impacts may include up to 808 participants on average in the gill net fishery but the participants may choose to enter the gig and or pound net fishery if they do not already participate in them (Table 5 in the *Description of the Fishery* section). This could alter the average ex-vessel dockside value of \$4,476,342 from the southern flounder commercial fishery by moving the gill net values to another gear category where price per pound may be higher on average (Table 8 in the *Description of the Fishery* section). Over the last 10 years, the gill net fishery has accounted for a total of \$22,293,674 of ex-vessel value from the southern flounder fishery (Table 4.5.6 in the *Recreational and Commercial Sector Allocation* issue paper). If large-mesh gill nets are no longer allowed to harvest southern flounder these values may shift to another gear. These effects are a guide as some license holders participate in multiple fisheries.

In terms of evaluating the economic impact of removing all inshore large-mesh gill nets from North Carolina, traditional methods of quantifying this change would not be adequate. Specifically, a change of this magnitude would no longer result in marginal shifts in landings from specific fisheries in the state. Rather, this regulation would likely lead to large-scale behavioral adjustments from a range of stakeholders in the seafood supply chain, causing market shifts, changes in spending and employment, and an overall reorganizing of the state's inshore fisheries. While there would likely be large benefits in certain facets, such as stock health and recreational access, the costs associated with restructuring part of the state's inshore fishing fleet are nearly impossible to predict and go beyond traditional economic impact assessments.

Impacts to the stock due to changes in gill net regulations can be difficult to quantify due to many factors including behavior shifts in the fishery participants. Luczkovich et al. (2021) developed a pair of socio-ecological model scenarios that showed differing impacts based on no additional effort using alternative gears and increasing effort using alternative gears in Core Sound, NC. If effort using alternative gears was not increased, the model predicted increases to the stock size, but if effort using alternative gears did increase the model predicted reductions to the stock size, depending on the behavior changes within the industry (Luczkovich et al. 2021). This study showed a species response to management actions can be contrary to management goals. That is, prohibiting the use of gill nets may alter the behavior of fishermen and make them use alternate gears with higher impacts on the target species or the ecosystem as a whole (Luczkovich et al. 2021).

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VI. PROPOSED MANAGEMENT OPTIONS

Management Options

(+ potential positive impact of action)

(- potential negative impact of action)

Option 1. Phase out anchored large-mesh gill nets from the southern flounder fishery at the end of the current sea turtle ITP.

- + Would allow for increased harvest from other commercial gears
- + Would increase protections of threatened and endangered species
- + May increase the economic impact of the remaining gears
- + May reduce user conflict
- + May reduce costs associated with the large mesh observer program or allow increased coverage for other gears
- +/- Gear elimination not based on sustainable harvest
- +/- Would require adjusting the sub-allocations for the commercial fishery
- +/- Would impact harvest of non-target species
- Would eliminate a historical gear from the southern flounder fishery
- Would impact the largest group by number of trips and participants in the commercial fishery
- Gill nets would still be allowed for other species so discards of southern flounder may still occur
- Would decrease the economic benefit of the commercial gill net fishery
- Some regions may be impacted more than others

Option 2. Status Quo, continue to allow anchored large-mesh gill nets to harvest southern flounder in the North Carolina southern flounder fishery.

- + Continued use of large-mesh gill net fishery to harvest southern flounder
- + Maintain economic impacts of the large-mesh gill net fishery
- + Less impacts to the largest user group in numbers and trips
- +/- Continued harvest of non-target species
- +/- Less impacts to sub-allocations
- Continued impacts to threatened and endangered species
- May not allow for increased harvest of other gears

VII. RECOMMENDATIONS

NCDMF Initial Recommendation

The NCDMF does not have an initial recommendation on this issue paper at this time. The division would like input from the MFC standings advisory committees and the public prior to determining its recommendation.

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VIII. LITERATURE CITED

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- West, T.L., W.C. Ambrose Jr, and G.A. Skilleter. 1994. A review of the effects of fish harvesting practices on the benthos and bycatch: implications and recommendations for North Carolina. US Environmental Protection Agency and NC DEHNR, Raleigh, NC. 107p.

APPENDIX 5. SUGGESTED STATUTORY CHANGES

No statutory changes suggested at this time. This may change based on what the NCMFC approves at final adoption.

Interjurisdictional FMP Amendment 2

Decision Document

Summary

The Interjurisdictional (IJ) Fishery Management Plan (FMP) is the mechanism through which North Carolina adopts by reference FMPs that are approved by the federal South Atlantic and Mid-Atlantic Fishery Management Councils (SAFMC and MAFMC, respectively) or the Atlantic States Marine Fisheries Commission (ASMFC) and that are consistent with N.C. law. Corresponding fishery regulations are implemented in North Carolina to provide compliance or compatibility with approved FMPs and amendments, now and in the future. In November 2021, the North Carolina Marine Fisheries Commission (NCMFC) will have the opportunity to approve the goal and objectives for Amendment 2 to the NC IJ FMP.

Amendment Timing

November 2021	NCMFC votes to approve goal and objectives of FMP
January 2021-November 2021	Division drafts FMP
December 2021	Division holds workshop to further develop draft FMP with Plan Advisory Committee
January 2022	Division Updates draft FMP
February 2022	NCMFC votes to send draft FMP for public and AC review
March 2022	NCMFC Advisory Committees meet to review draft FMP and receive public comment
May 2022	NCMFC Advisory Committees meet to review draft FMP and receive public comment
June 2022 – July 2022	NCDEQ Secretary and Legislative review of draft FMP
August 2022	NCMFC votes on final adoption of FMP
TBD	NCDMF and NCMFC implement management strategies

Background

The IJ FMP is different from other state FMPs as it is the policy framework the state uses to comply with federal Council and ASMFC FMPs. The IJ FMP was first approved in September 2002, amended in 2008, and updated in 2015. The purpose of the FMP is to adopt by reference management measures appropriate for North Carolina contained in ASMFC, SAFMC, and MAFMC FMPs, to reduce duplication of effort and to foster improved communication between fisheries managers. The Fisheries Reform Act requires FMPs to be prepared for all commercially and recreationally significant species or fisheries that comprise North Carolina marine and estuarine resources. For many of these species and fisheries FMPs have already been developed and implemented through the Councils and the ASMFC processes, with North Carolina involvement. The goal of these plans, established under the Magnuson-Stevens Fishery Management and Conservation Act (MSA; federal Council FMPs) and the Atlantic Coastal Fisheries Cooperative Management Act (ACFMA; ASMFC FMPs), are in line with the goals of the FRA to “ensure long-term viability” of these fisheries. The NCMFC role in this process is advisory to the state representatives regarding marine fisheries within the jurisdiction of the ASMFC and federal Councils.

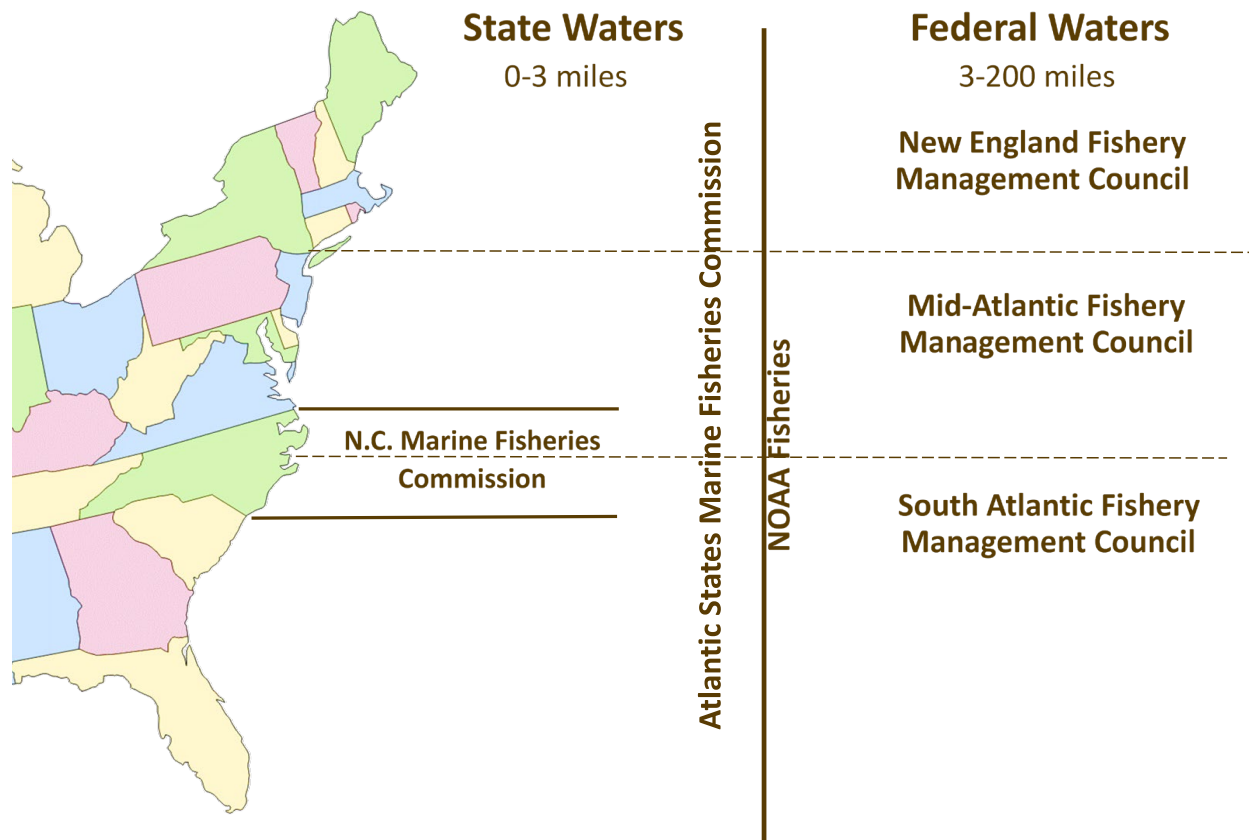


Figure 1. Management authorities of State (0-3 miles) and Federal (3-200 miles) waters of the United States East Coast

Draft Goal and Objectives

The goal of the IJ FMP is to adopt FMPs, consistent with N.C. law, approved by the Councils or ASMFC by reference and implement corresponding fishery regulations in North Carolina to provide compliance or compatibility with approved FMPs and amendments, now and in the future. To achieve this goal, the following objectives shall be met:

- Participate fully, consistent with N.C. law, in all levels (advisory panels, technical committees, stock assessment subcommittees, plan development and review teams, management boards, monitoring committees and other committees) of the ASMFC and Council processes for developing FMPs and amendments through appropriately informed NCDMF staff, NCMFC members, citizen advisors, and the public at large.
- Adopt management measures appropriate for North Carolina coastal waters to implement measures promulgated by the Secretary of Commerce or approved by the ASMFC necessary to implement FMPs, as well as to achieve the sustainable harvest for Council and ASMFC managed species.
- Promote education and public information to help identify the causes and nature of problems in the fish stocks managed by the Councils or ASMFC, their habitat and fisheries, and the rationale for management efforts to solve these problems.
- Develop and implement a management and regulatory process that provides the greatest overall benefit to the State, with respect to food production, recreational opportunities, and the protection of marine ecosystems, and that will produce a sustainable harvest.
- Support research on population ecology and dynamics, socioeconomic impacts, fisheries habitat, and environmental impacts for Council and ASMFC managed species.

Shrimp Fishery Management Plan Amendment 2 *Decision Document*



October 2021



**N.C. Division of Marine Fisheries
3441 Arendell Street
Morehead City, North Carolina 28557**

This Decision Document is a companion document to Amendment 2 to the Shrimp Fishery Management Plan. It provides a brief overview and context for the issue and includes the NCDMF recommendations and key decision points supporting each, as well as summaries of the public and advisory committee input. The document also provides references to the full Amendment document where more detailed information is located. The Shrimp Fishery Management Plan Amendment 2 document is the plan under consideration and is the focus of all NCMFC action.

Summary

In November 2021 the North Carolina Marine Fisheries Commission (NCMFC) will be reviewing public and Advisory Committee input and selecting their preferred management options for Amendment 2 of the Shrimp Fishery Management Plan (FMP).

Amendment 2 was developed to address a motion adopted in August 2018 by the MFC instructing the DMF to shift the review of the Shrimp FMP from 2020 to 2018 and to begin Amendment 2 with a focus on management to further reduce bycatch and provide additional protections for critical habitat. It should be noted that while there are no statutory requirements for this plan regarding the status of the shrimp stocks, status quo will not meet the goal and objectives.

The North Carolina Division of Marine Fisheries (NCDMF) has drafted, and the public and advisory committees have reviewed, four issue papers (See Appendix 2) to address habitat protections, special secondary nursery areas, area restrictions, and effort management. In addition, the DMF prepared a review of shrimp trawl bycatch information to inform the MFC and stakeholders about bycatch impacts and data needs to inform future decisions (See Appendix 1).

Amendment Timing

January 2020	Division holds public scoping period
February 2020	NCMFC approves goal and objectives of FMP
February 2020 – February 2021	Division drafts FMP
March 2021	Division holds workshops to further develop draft FMP with Plan Advisory Committee
March 2021 – May 2021	Division updates draft plan
May 2021	NCMFC votes to send draft FMP for public and AC review
June 2021	NCMFC Advisory Committees meet to review draft FMP and receive public comment
November 2021	NCMFC selects preferred management options
December 2021 – January 2022	NCDEQ Secretary and Legislative review of draft FMP
February 2022	NCMFC votes on final adoption of FMP
TBD	NCDMF and NCMFC implement management strategies

Goal and Objectives

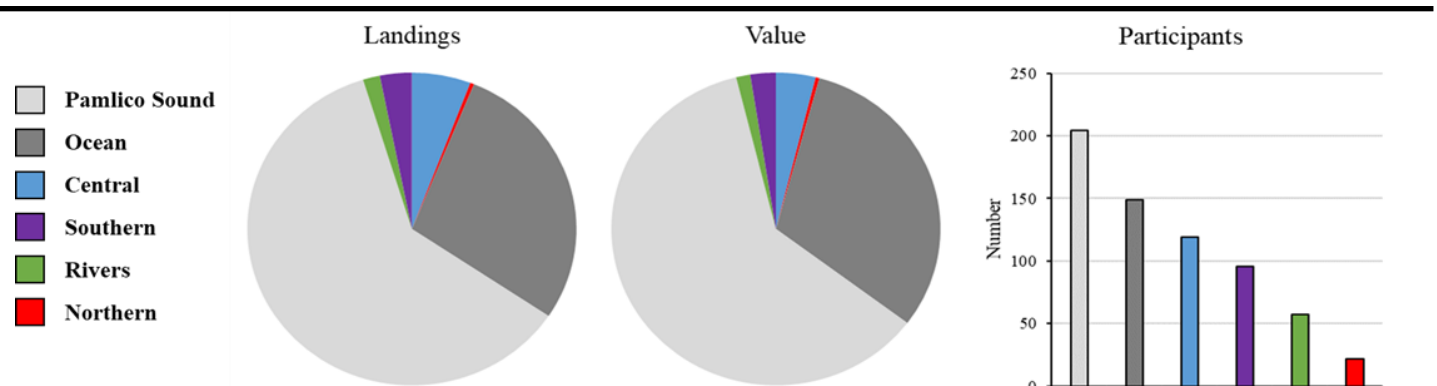
The goal of Amendment 2 to the N.C. Shrimp FMP is to manage the shrimp fishery to provide adequate resource protection, optimize long-term harvest, and minimize ecosystem impacts. The following objectives will be used to achieve this goal.

- Reduce bycatch of non-target species of finfish and crustaceans, as well as protected, threatened, and endangered species.
- Promote the restoration, enhancement, and protection of habitat and environmental quality in a manner consistent with the Coastal Habitat Protection Plan (CHPP).
- Develop a strategy through the CHPP to review current nursery areas and to identify and evaluate potential areas suitable for designation.
- Use biological, environmental, habitat, fishery, social, and economic data needed to effectively monitor and manage the shrimp fishery and its ecosystem impacts (i.e., bycatch, habitat degradation).
- Promote implementation of research and education programs designed to improve stakeholder and the general public's understanding of shrimp trawl bycatch impacts on fish population dynamics.

Background

Shrimp stocks are considered an annual crop. Population size is primarily influenced by environmental conditions and fishing is generally thought to have little influence on population size from year to year. The number of trips landing shrimp annually (effort) fluctuates with shrimp abundance but has gradually declined since 1994. Despite decreasing effort, the shrimp fishery is consistently one of the top two commercial fisheries by value in the state, with a dock side value of over \$22 million in 2019 and 2020 (Figure 7, Page 10) and generating an estimated state-wide sales impact of nearly \$100 million in 2019 including an estimated 1,000 to 2,000 jobs annually (Figure 10, Page 13).

Most commercial shrimp harvest occurs in the Pamlico Sound and surrounding waters (Figure 8 and 9, Page 11). Trawls are the primary gear used to harvest shrimp in North Carolina accounting for over 98% of the commercial harvest each year. Other gears used in the commercial and recreational fisheries include channel nets, shrimp pots, pound nets, and cast nets. Recreational cast nets are currently the only gear allowed for harvesting shrimp in areas closed to the harvest of shrimp by nets.



These figures illustrate the relative contribution of each geographic region to the average state-wide shrimp landings, value and number of participants between 2000—2019. Shrimp Amendment 2 contains breakdowns within each of the regions listed above.

Prior to the 2006 Shrimp FMP, management of the N.C. shrimp fishery focused on optimizing harvest and the economic value of the shrimp fishery. However, since the implementation of Amendment 1 management strategies have focused on protecting critical habitat, reducing bycatch, and addressing user conflict. Of North Carolina's 2.1 million acres of estuary, the second largest estuary in the U.S., approximately 1 million acres (47%) are closed to shrimp trawling. Various gear modifications including BRDs, turtle excluder devices (TEDs), tailbag modifications, area closures and restrictions, and harvest restrictions have been implemented to reduce bycatch and protect critical habitat. In May 2021, the final rulemaking process approved under Shrimp FMP Amendment 1 was completed with rules becoming effective that reclassified ten special secondary nursery areas (SSNAs) as permanent secondary nursery areas (SNAs).

NC Wildlife Federation Petitions for Rulemaking

The North Carolina Wildlife Federation (NCWF) submitted a petition for rulemaking on November 2, 2016, and a modification on January 12, 2017. They put forth seven rules to designate nursery areas, restrict gear and seasonality in the shrimp trawl fishery to reduce bycatch of fish, and establish an eight-inch minimum size limit for spot and a 10-inch minimum size limit for Atlantic croaker. In February 2017, the MFC approved the petitioned rules and began rulemaking. Upon review, the Office of State Budget and Management determined that sufficient state funds are not available to implement the proposed rule changes without undue detriment to the agency's existing activities, and the rules were not adopted. In February 2019, the MFC referred the NCWF Petition for Rulemaking to the Shrimp FMP AC for consideration in developing

Amendment 2 to the FMP. In May 2019 a second Petition for Rulemaking was submitted to the NCMFC by the NCWF. In August 2019, the MFC denied the petition. Once the final decision was made on the second NCWF Petition for Rulemaking, the DMF began the process of developing Amendment 2 of the Shrimp FMP. As tasked by the NCMFC, the goal and objectives of Amendment 2 were developed to address concerns outlined in the NCWF petitions. The Amendment 2 issue papers examine the utility of management strategies contained in the petitions to reduce bycatch and protect critical habitat.

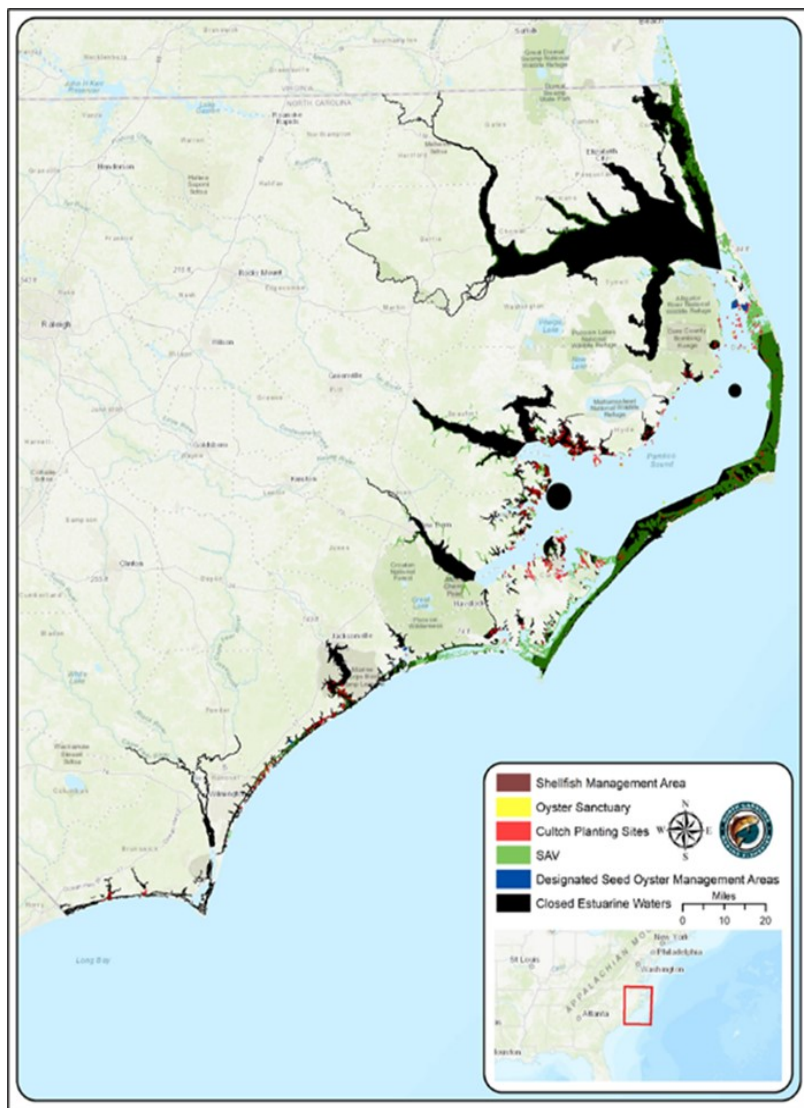
Habitat

North Carolina's estuarine system habitats, such as submerged aquatic vegetation (SAV) and shell bottom, hold tremendous ecological, economic, and social value and warrant management measures ensuring their health. Fishing gears that contact the bottom can have negative effects on habitats. Minimizing and/or avoiding impacts is important for maintaining healthy and productive fish stocks and preserving the ecosystem functions of our coastal estuaries. While habitat protection from shrimp trawling is addressed in the Shrimp FMP, the Coastal Habitat Protection Plan (CHPP) more broadly addresses habitat and water quality issues and solutions.

Existing Habitat Protections

The map to the right shows all current areas closed to shrimp trawling which accounts for approximately 47% of North Carolina's Internal Coastal Waters.

- Nursery Areas
- Trawl Net Prohibited Areas
- Seed Oyster Management Areas
- Oyster Sanctuaries
- Crab Spawning Sanctuaries
- Shrimp Trawl Prohibited Areas
- Albemarle Sound trawl closure

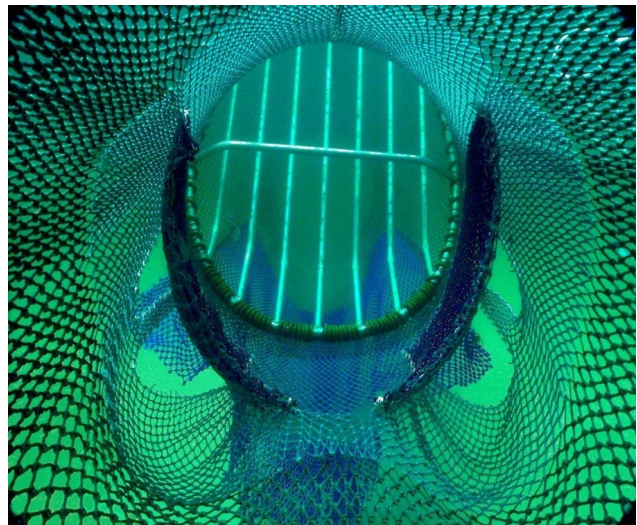


NOTE: In this document area closures refer to closure of an area to trawling or shrimp trawling. Areas would be accessible by all other gears used in the shrimp fishery.

Bycatch

Bycatch is a widely recognized issue in trawl fisheries worldwide (see Appendix 1). The effect of bycatch on impacted species is often debated but generally not well understood. In North Carolina, there is no quantitative measure of the amount of bycatch in the shrimp trawl fishery and obtaining such data is costly and still may not provide the information needed to generate a value. Prior to the implementation of FMPs, North Carolina was the first state to mandate the use of bycatch reduction devices (BRDs) in 1992.

Since Amendment 1, management strategies have focused on protecting critical habitat, reducing bycatch, and addressing user conflict. Of North Carolina's 2.1 million acres of estuary, the second largest estuary in the U.S., approximately 1 million acres (47%) are closed to shrimp trawling. Various gear modifications including BRDs, turtle excluder devices (TEDs), tailbag modifications, area closures and restrictions, and harvest restrictions have been implemented to reduce bycatch and protect critical habitat. In May 2021, the final rulemaking process approved under Shrimp FMP Amendment 1 was completed with rules becoming effective in May of 2021 that reclassified ten special secondary nursery areas (SSNAs) as permanent secondary nursery areas (SNAs) excluding shrimp trawling from those nursery areas.



Examples of Industry Workgroup gear combinations that reduced bycatch by 40 to 57%

Area Restrictions

Area restrictions are an effective management measure to meet sustainability objectives, reduce bycatch, and protect critical habitat. Currently, 1,207,463 acres of estuarine waters in North Carolina are permanently or seasonally closed to trawling. These closures (Table 2.1.1, Pages 72-74) in conjunction with other management measures are effective in reducing bycatch and protecting critical habitat.

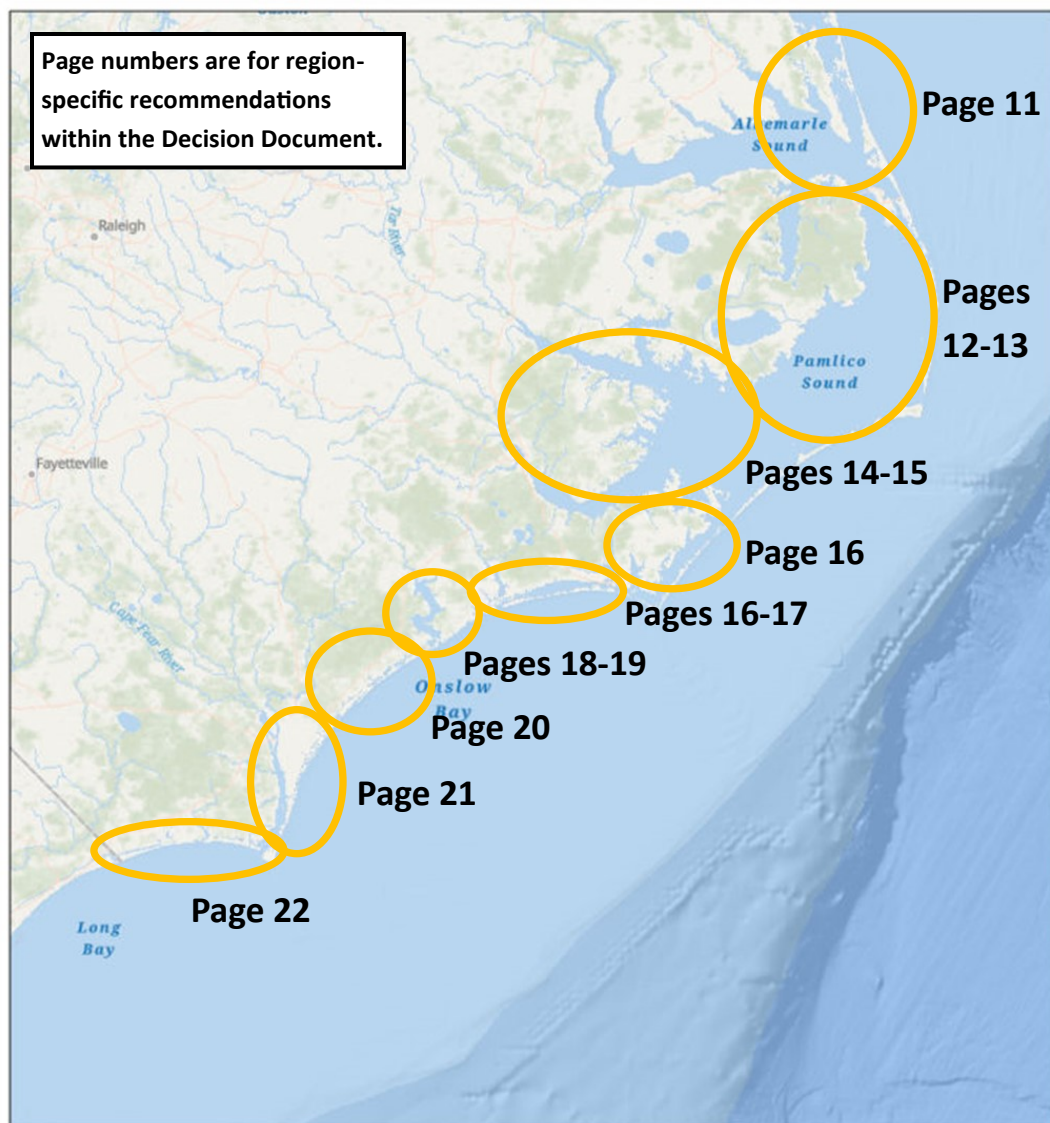
The division is unable to estimate precise economic impacts to the shrimp trawl fishery from area closure options in Amendment 2. Landings, participant, and value data for broad areas are available through the Trip Ticket Program and can be used to generalize potential impacts.

Bycatch reduction impacts on stock status is determined through quantitative stock assessments. The stock assessments or FMPs for Atlantic croaker, spot, weakfish, and southern flounder do not provide specific recommendations for bycatch reductions from shrimp trawls. Due to bycatch species coastwide or regional stock units, it is unknown if bycatch reductions solely in North Carolina will improve a specie's stock status (See Appendix 1, Pages 32-50 and Appendix 2.1, Pages 219-223).



NCDMF Recommended Management Measures

The mission of the NCDMF is to “ensure sustainable marine and estuarine fisheries and habitats for the benefit and health of the people of North Carolina”. In keeping with this mission when making management recommendations the NCDMF reviews the best available science and the potential impacts of various management options to the resource and various user groups based on that science. Because of differing levels of data richness for the issues covered in Amendment 2, NCDMF recommendations were primarily influenced by options with more supporting data and existing research where cumulative impacts are better understood. More comprehensive data for critical habitat and SSNAs is available to inform recommendations than bycatch or effort data. Four of the gear configurations tested by the Industry Workgroup and mandated for use in inside waters where up to 220 ft of combined headrope is allowed reduced bycatch 40 to 57% and their continued use is strongly considered as an effective method of bycatch reduction while allowing access to the shrimp resource. The NCDMF recognizes the need for continued research and enhanced data collection to meet the goal and objectives of the Shrimp FMP and has provided high priority research recommendations needed to better manage the shrimp fishery. **NCDMF recommended management measures that address concerns outlined in NCWF petitions for rulemaking are denoted by an asterisk (*). The page numbers of tables, figures, and text in the issue papers are listed by each recommendation.**



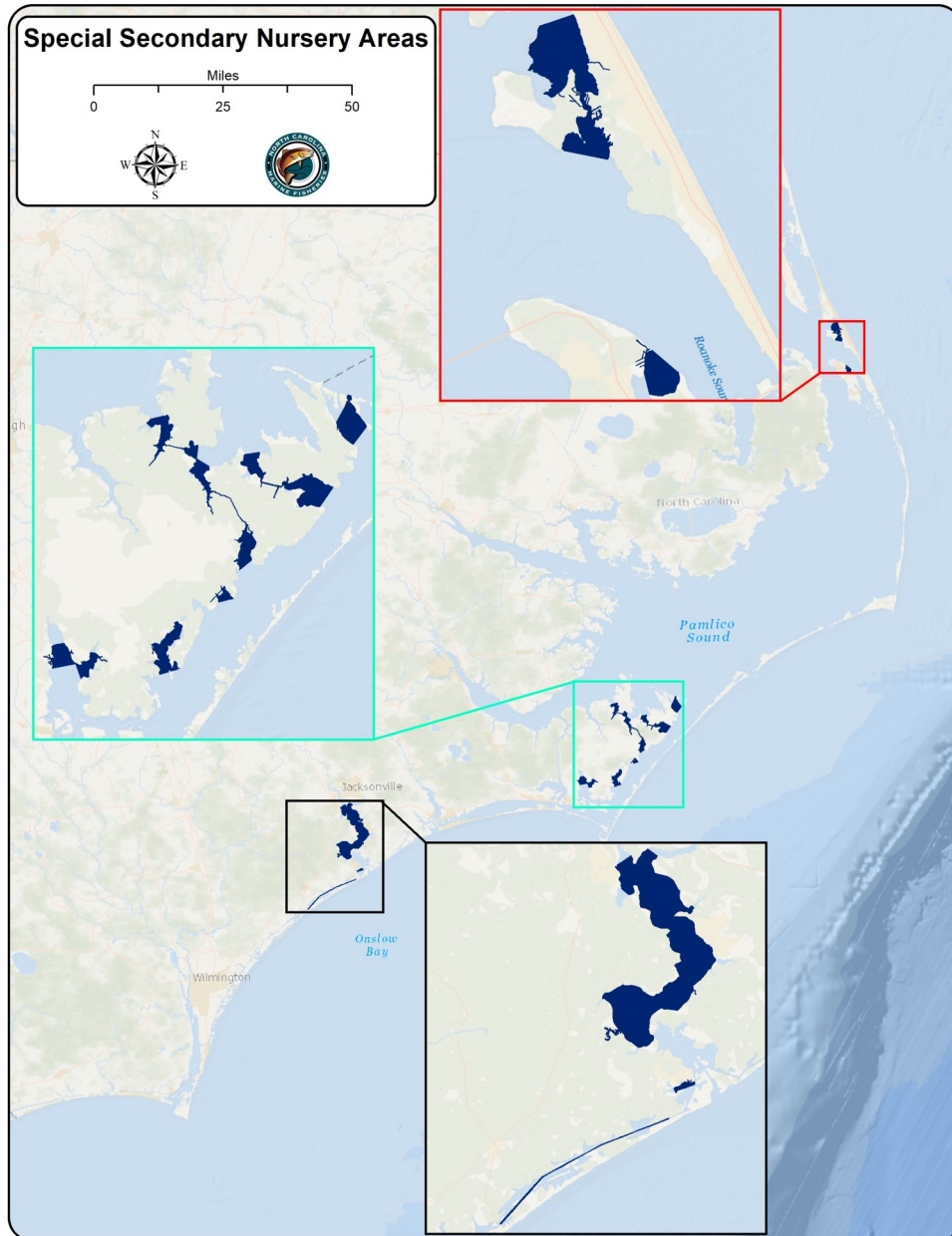
NCDMF Recommended Management Measures

State-wide Recommendations

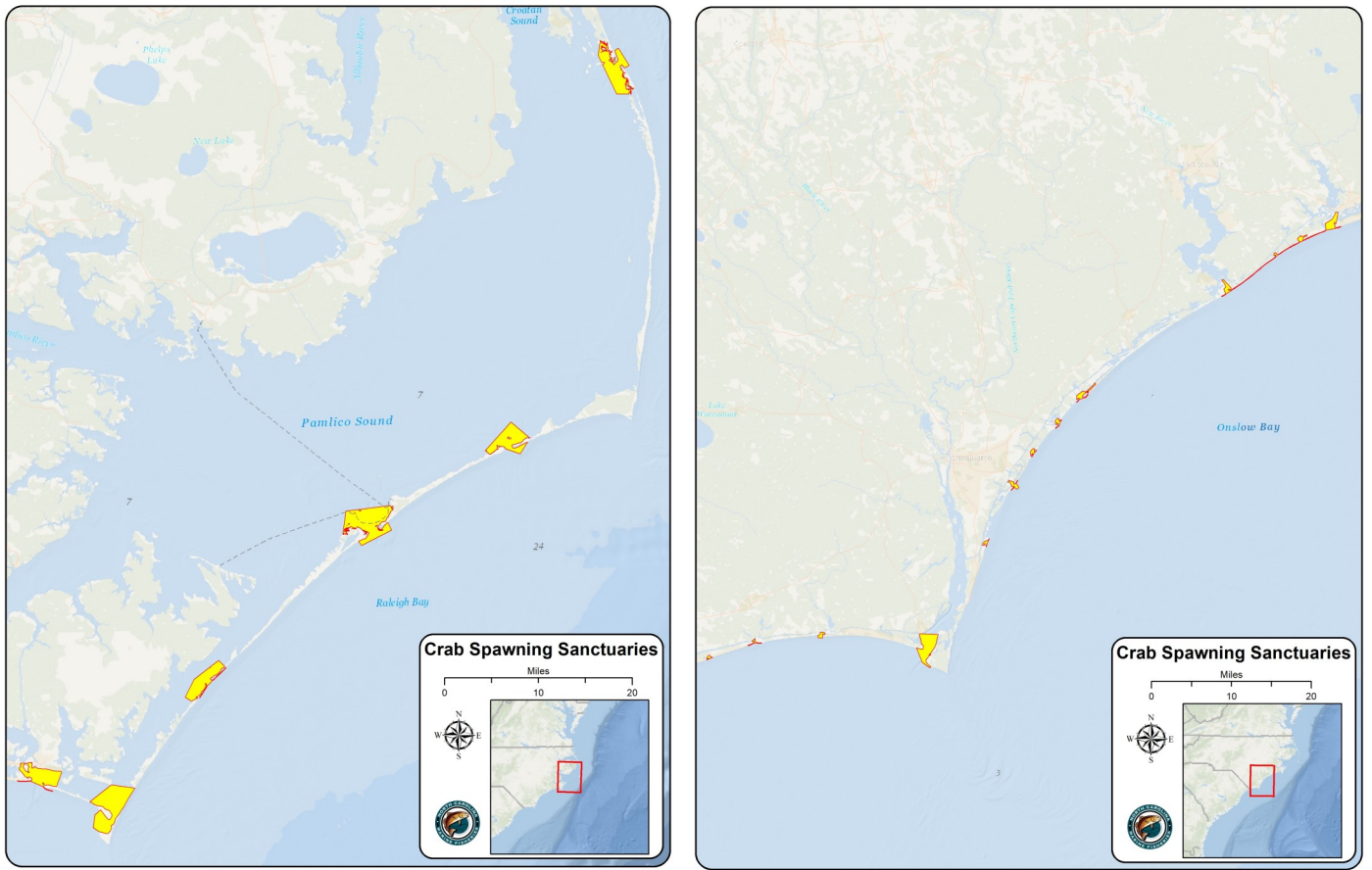
Area Restrictions

- Use targeted closures to protect critical habitat and reduce bycatch (*Appendix 2.1, Page 51; Figures 2.1.1a-g and 2.1.2, Pages 76-83*).*
- Change the designation of all SSNAs to permanent SNAs (*Table 2.2.1, Page 101; Figures 2.2.1-2.2.3, Pages 108-110; Maps 3.1-3.12, Pages 294-305*).*
- Permanently prohibit trawling in all crab spawning sanctuaries (*Table 2.1.1, Page 72; Page 229; Maps 3.1-3.12, Pages 294-305*).

A total of 29,541 acres would close to shrimp trawling in crab spawning sanctuaries and SSNAs if selected as the commission preferred management option. Alternative options considered include status quo (no additional area closures) and complete closure of all internal waters. For all area closures, gear stowaway regulations should be considered for transient vessels.



NCDMF Recommended Management Measures



Decision Rationale - State-Wide Recommendations

- While the goal of bycatch reductions is generally to increase availability of fish to other fisheries, the results and benefits of shrimp trawl bycatch reductions are uncertain given current abundance, stock status, and life history characteristics of most species of concern (e.g., Atlantic croaker, spot, weakfish).
- Targeted area closures implemented with the objective of protecting critical habitats (SAV and shell bottom) and prohibiting trawling in areas where finfish are concentrated will protect vulnerable habitat and reduce bycatch without the severe impacts to the shrimp trawl industry that would occur with complete or large-scale area closures.
- SAV and shell bottom habitats are essential habitat for juvenile finfish and shellfish. Protecting these habitats from shrimp trawls also results in bycatch reduction.
- The negative impacts of trawling over structured habitats, like SAV and shell bottom, are well documented. Soft bottom is the habitat most resilient to trawl damage and disturbance from trawls on soft bottom can be similar to natural disturbances.
- Shifting shrimp trawl effort from critical SAV and shell bottom habitat areas to soft bottom areas is not expected to result in additional habitat degradation.
- Because of current BRD requirements and other effort restrictions, shifting shrimp trawl effort to larger waterbodies where finfish can disperse is not be expected to result in increased bycatch.
- Changing the designation of all SSNAs to permanent SNAs reduces bycatch and protects critical SAV and shell bottom habitat and aligns with the recommendation of the Southern Advisory Committee.
- Changing the designation of SSNAs to permanent SNAs would extend gill net attendance requirements in all waters from May 1 through November 30.
- Permanently prohibiting all trawling in all crab spawning sanctuaries reduces bycatch in important migration corridors and protects critical habitat, particularly in the Oregon Inlet, Barden Inlet, Beaufort Inlet and Bogue Inlet areas.

NCDMF Recommended Management Measures

Effort and Gear Modifications

- **Maintain existing headrope limits for shrimp trawls in Internal Coastal Waters. If needed, implement additional headrope restrictions to resolve user conflicts (*Appendix 2.4, Pages 225, 232; Table A.4.3, Page 311*).***
- **Allow non-trawl net gears to harvest shrimp in areas closed to shrimp trawling (*Appendix 2.4, Pages 225, 228, 237*).**
- **Eliminate the four quarts (heads on) or two and one-half quarts (heads off) recreational creel limit for cast nets only in areas closed to the taking of shrimp (*Appendix 2.4, Pages 228, 236*).**
- **Investigate the feasibility and utility of a long-term shrimp trawl observer program that encompasses all seasons, areas, and gears (*Appendix 1, Pages 35-38, Tables 1.3-1.5*).**
- **Continue collaboration with the commercial stakeholders through the industry workgroup to identify and test gear modifications to continue to reduce bycatch in the shrimp fishery (*Appendix 2.4, Page 220*).**

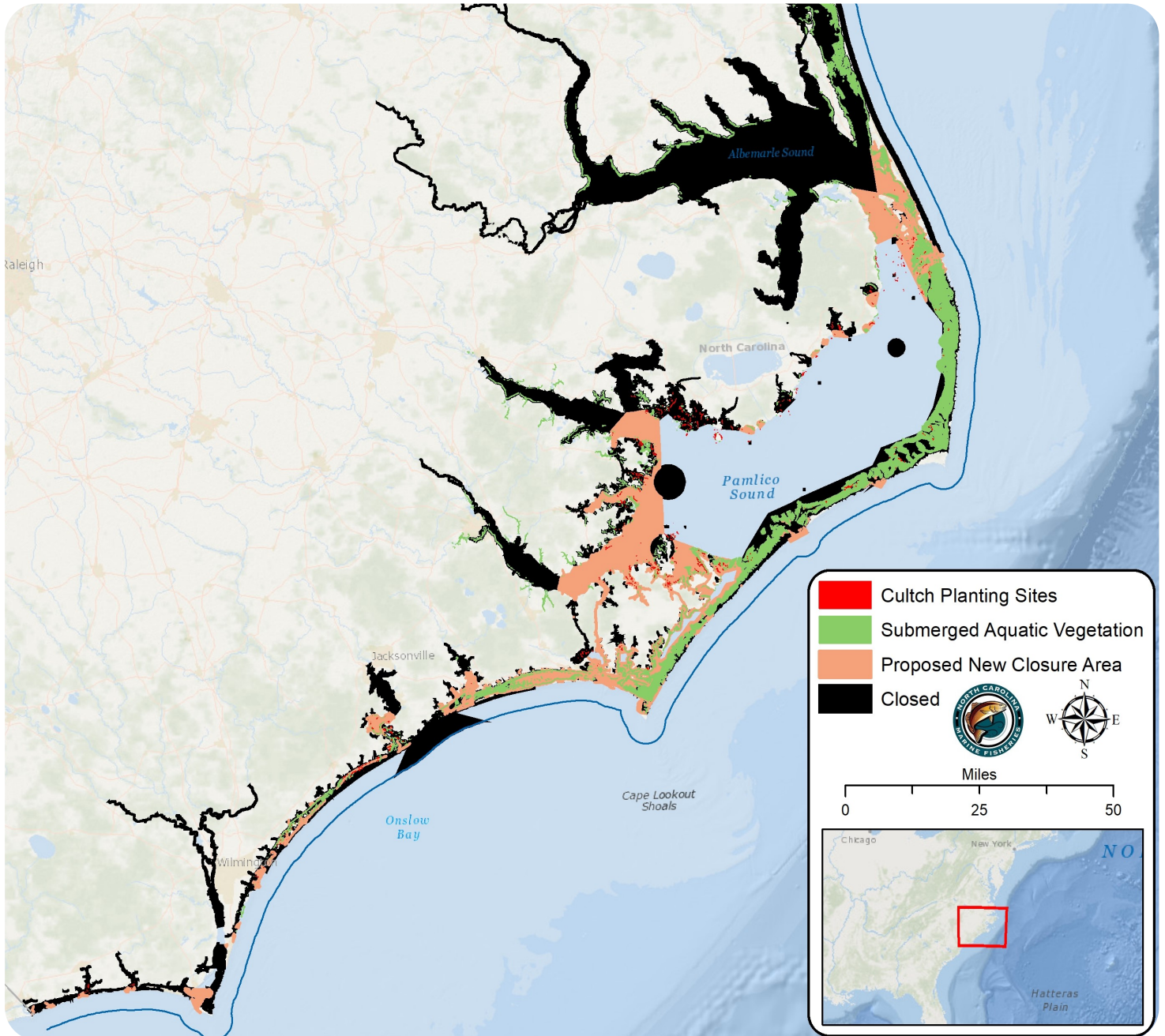
Alternative options considered include status quo (no additional effort restrictions or gear modifications), maximum tow times, daily fishing times, limit number of fishing days, headrope length limits, harvest limits, and limited entry.

Decision Rationale - Effort and Gear Modifications

- Effort and gear restrictions could be implemented statewide or within specific areas as needed.
- Maximum tow times are hard to enforce and are not recommended; however, reducing tow times would likely reduce bycatch mortality.
- Reducing tow times would reduce effort, but effort could be recouped with more tows.
- Commercial trip limits could lead to waste due to the high-volume nature of the fishery and lead to increased operating expenses (i.e., fuel and labor cost associated with frequent trips to port).
- Daily fishing time restrictions (day vs. night) may impact some areas more than others. GLM analysis did not support.
- Mid-week closures would be a burden on fishermen (i.e., more travel, trouble securing crews, etc.).
- Maximum headrope limits should only be used to resolve user conflicts until there is more scientific data to justify it as a management measure to reduce bycatch. Analysis of existing data did not support headrope limits as a means to reduce bycatch.
- Based on input received from the Shrimp AC, reducing maximum headrope limits may not be effective if fishermen increase tow speeds and use deeper bodied nets to offset losses in gear efficiency and may increase bycatch.
- Allowing non-trawl gears in areas closed to shrimp trawling would reduce bycatch and allows additional access to the resource.
- Removing the recreational creel limit in areas closed to shrimp harvest eases enforcement and public confusion. Currently, there are no areas closed to shrimp harvest.
- A long-term shrimp trawl observer program may be the best option to provide consistent estimates of discards in the shrimp trawl fishery and an accurate account of current fleet characteristics. The possibility should be explored further.
- Significant bycatch reductions through gear development and modifications have been achieved through the collaborative efforts with the Industry Workgroup. Continuing this work is recommended as a bycatch reduction strategy.
- Additional testing of gears found to reduce finfish bycatch by 40% should be conducted throughout the state, across all seasons and vessel sizes.

NCDMF Recommended Management Measures Targeted Area Restriction Recommendations

The following map shows the targeted area restrictions recommended by the NCDMF for the entire state. These recommended closures are discussed in detail by geographic regions beginning in the north and moving south in the following pages.



NCDMF Recommended Management Measures

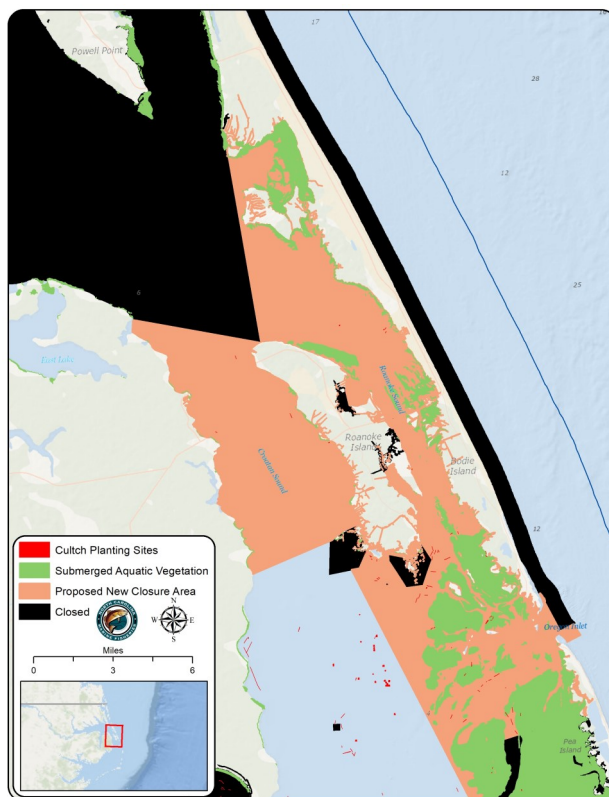
Region-specific Recommendations

Northern Region

The Northern Region includes the Croatan Sound, Roanoke Sound, Pamlico Sound, Pamlico River, Bay River and Neuse River and their tributaries. 228,733 acres would close to shrimp trawling if selected. Alternative options include status quo, complete closure of Croatan and Roanoke sounds, and other partial closures. Full recommendation language is on pages 64 and 146.

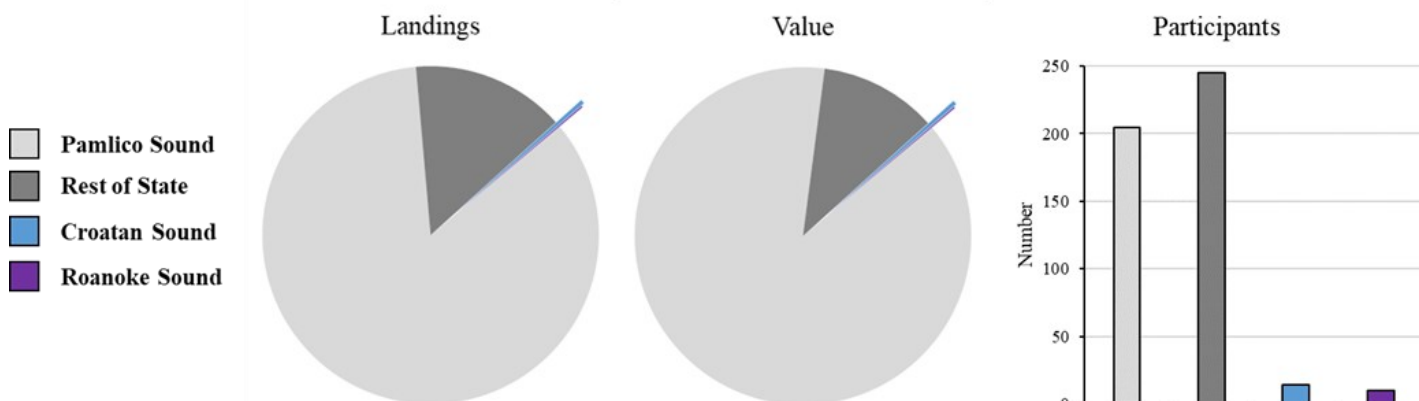
Croatan and Roanoke Sounds

- Prohibit shrimp trawling in Croatan Sound (*Appendix 2.3, Pages 135-136; Figures 2.3.6-2.3.10, Pages 171-175; Map 3.4, Page 297*).
- Prohibit shrimp trawling in Roanoke Sound and Oregon Inlet area (*Appendix 2.3, Pages 135-136, Figures 2.3.6-2.3.10; Pages 171-175; Map 3.4, Page 297*).



Decision Rationale - Croatan and Roanoke Sounds

- Closing the Croatan and Roanoke sounds creates connectivity between existing closed areas in the Albemarle Sound, Pamlico Sound, and the Atlantic Ocean.
- The Croatan and Roanoke sounds are a movement corridor for many species particularly Atlantic croaker, spot, summer flounder and blue crabs between Albemarle Sound, Pamlico Sound, and the ocean. Closing these areas would be expected to reduce bycatch.
- Shell bottom and SAV habitat is abundant in Roanoke Sound and the area around Oregon Inlet. Closing these areas to shrimp trawling prevents disturbance from shrimp trawls and extends the existing closure in place on the western side of the Outer Banks to protect SAV habitat.
- Closing the Croatan and Roanoke sounds will impact the commercial shrimp fishery by reducing access.



Average proportion of commercial landings and value, and number of participants in the North Carolina shrimp fishery in the Croatan and Roanoke sounds compared to Pamlico Sound, and the rest of the state, 2010-2019. The Croatan and Roanoke sounds averaged 30,853 pounds of shrimp landed, \$66,749 of value, and 22 participants from 2010 to 2019.

NCDMF Recommended Management Measures

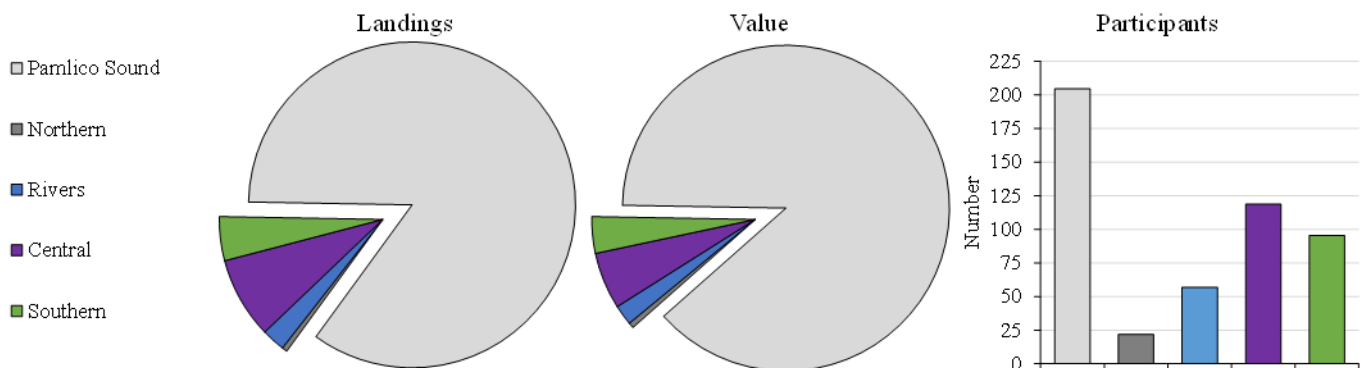
Pamlico Sound and Adjacent Bays

- **Prohibit shrimp trawling in the Parched Corn Bay, Berrys Bay, East Bluff Bay, and West Bluff Bay (Appendix 2.3, Pages 124-127; Figures 2.3.6-2.3.10; Pages 171-175).***
- **Extend existing closures in the mouth of Stumpy Point Bay, Pains Bay, Long Shoal River, Otter Creek ; Hyde County (Appendix 2.3, Page 124-127; Figures 2.3.6-2.3.10; Pages 171-175; Map 3.2, Page 295).***

Alternative options include status quo and larger area closures. Full recommendation language are on page 146.

Decision Rationale - Pamlico Sound and Adjacent Bays

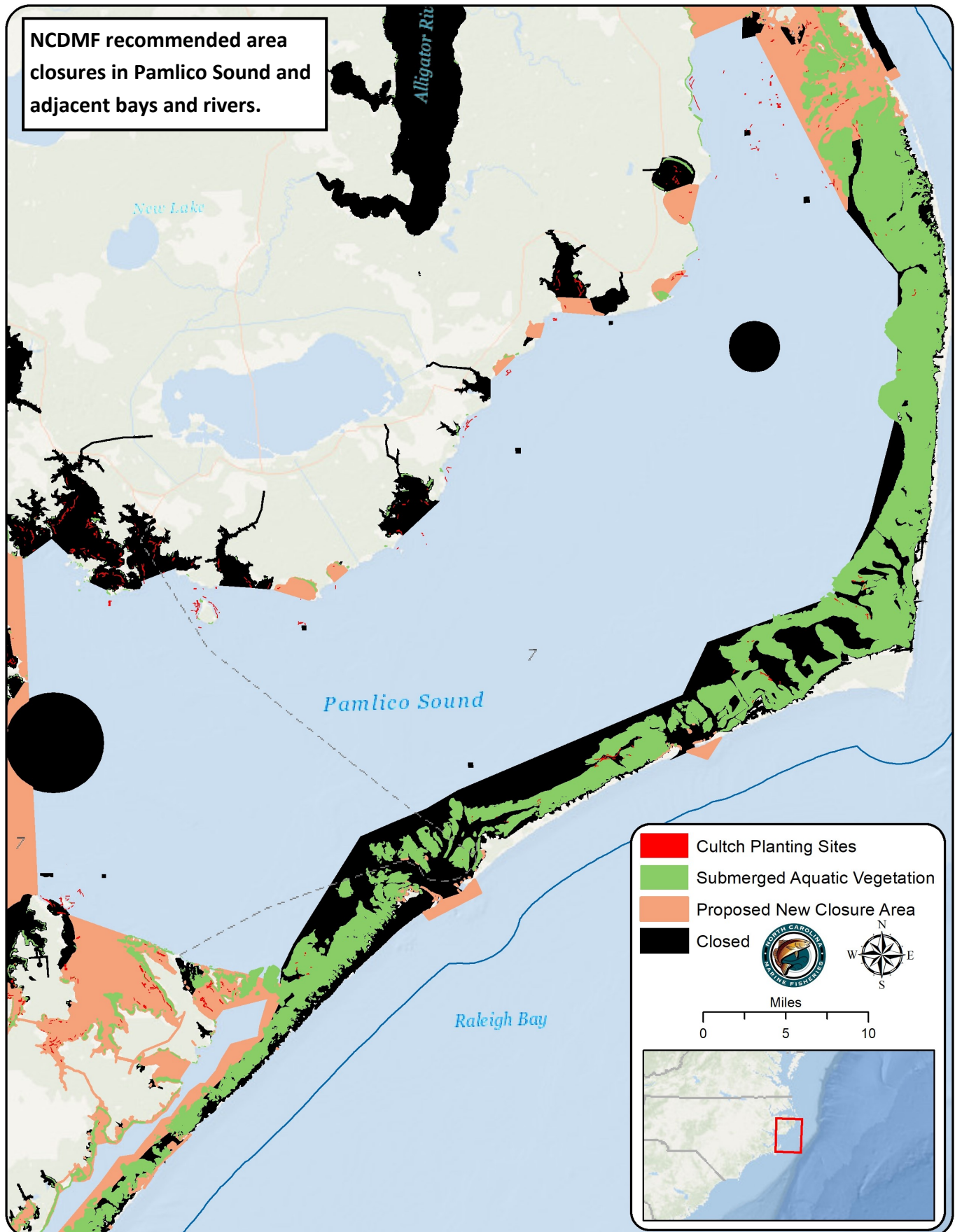
- Closing the entire Pamlico Sound or extensive regions of Pamlico Sound is a severe management measure, essentially eliminating half of the multi-million-dollar shrimp fishing industry in North Carolina.
- Closing bays, or the mouths of bays, would be expected to reduce bycatch by creating connectivity between currently closed areas and Pamlico Sound, a larger waterbody where bycatch species can disperse and are less concentrated. Closing these areas moves trawling effort away from areas where bycatch species would be concentrated.
- Closing these areas, particularly in Parched Corn Bay, Berrys Bay, East Bluff Bay, and West Bluff Bay will protect critical shell bottom and SAV habitat.
- The division does not have data about shrimp trawl effort in these specific areas. However, because these are smaller areas, impacts to the shrimp trawl fishery are likely minimal. While the magnitude of benefits is unknown, these closures will protect habitat and are likely to reduce bycatch.
- Access will be limited in some nearshore areas but can shift to nearby areas with less bycatch or critical habitat concerns.
- Overall, the MFC advisory committees did not supported large scale area closures in Pamlico Sound because of unclear benefits and negative impacts to the industry.



Average proportion of commercial landings and value, and number of participants in the North Carolina shrimp fishery in the Pamlico Sound compared to other estuarine waters, 2010-2019. The Pamlico Sound averaged 5,003,274 pounds of shrimp landed, \$10,874,775 of value, and 204 participants from 2010 to 2019.

NCDMF Recommended Management Measures

Pamlico Sound and Adjacent Bays



NCDMF Recommended Management Measures

Pamlico, Bay, and Neuse rivers and West Bay

- Prohibit shrimp trawling in the Pamlico, Bay, and Neuse rivers (*Appendix 2.3, Pages 127-134; Figures 2.3.6-2.3.10; Pages 171-175; Map 3.3, Page 296*).*
- Prohibit shrimp trawling in West Bay (*Appendix 2.1, Page 62; Figure 2.1.8-2.1.9, Pages 89-90; Map 3.5, Page 298*).*

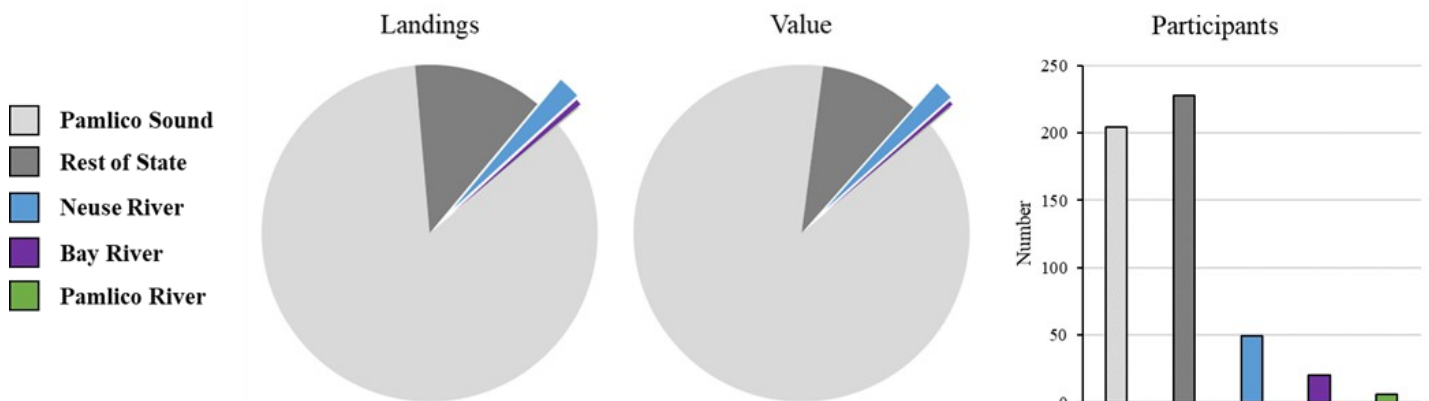
Alternative options include status quo and limited area closures. Full recommendation language and coordinates are on page 146.

Decision Rationale - Pamlico/Pungo and Bay rivers

- Prohibiting trawling in the Pamlico/Pungo and Bay rivers will reduce bycatch by creating connectivity between currently closed areas and Pamlico Sound, a larger waterbody where bycatch species can disperse and are less concentrated. Closing these areas moves trawling effort away from areas where bycatch species would be concentrated.
- Closing these areas, particularly Bay River will protect critical shell bottom and SAV habitat.
- Closing the Pamlico and Bay rivers will impact the commercial shrimp fishery by reducing access.
- While estimates of recreational shrimp trawl effort are not available, these areas are important to the recreational shrimp fishery.
- Overall, the Pamlico River and Bay rivers contribute minimally to the shrimp fishery in North Carolina.

Decision Rationale - Neuse River and West Bay

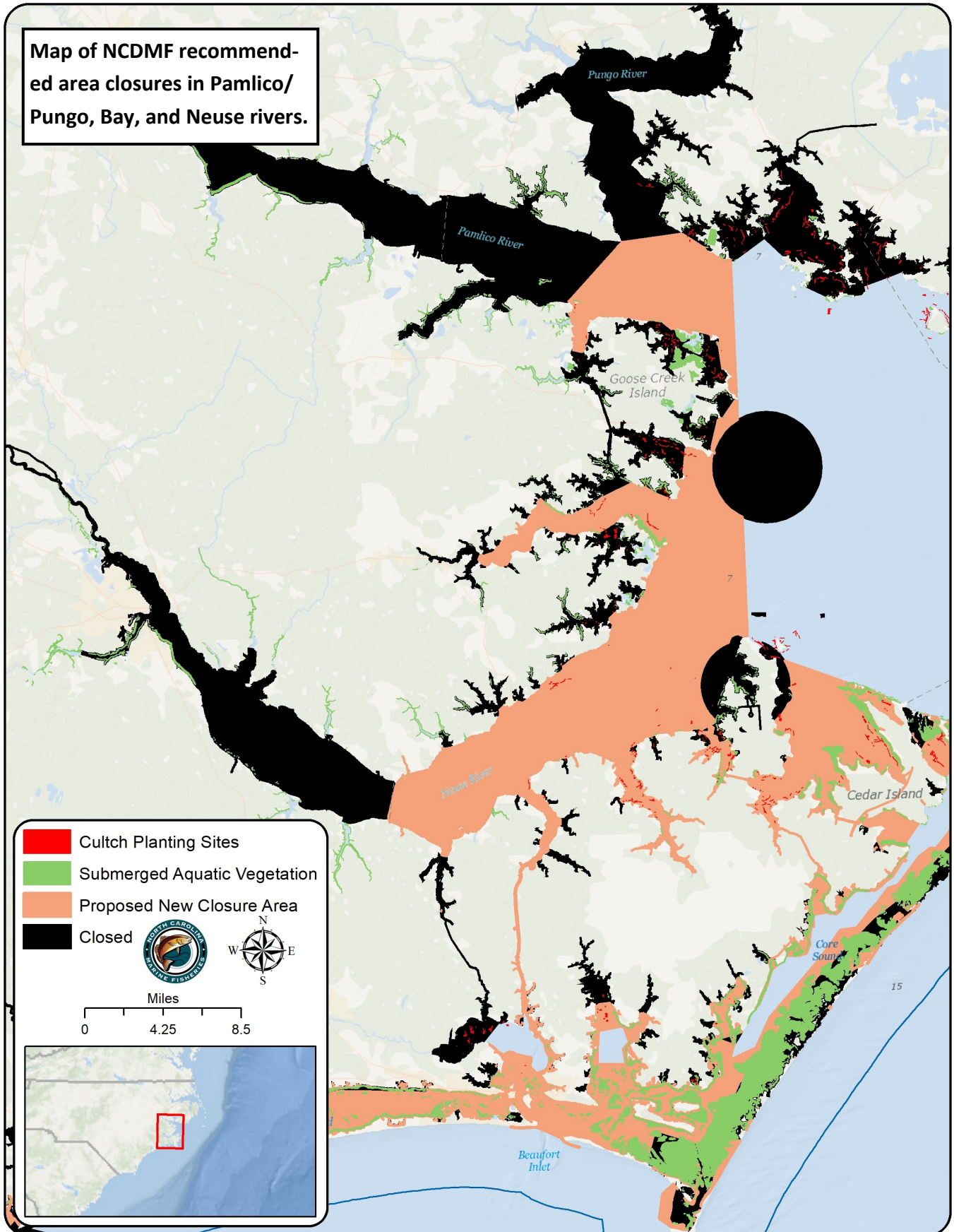
- Permanently prohibiting trawling in the Neuse River and West Bay creates further connectivity with Pamlico Sound, a larger waterbody where bycatch species can disperse and are less concentrated.
- Closing these areas, particularly South River and West Bay will protect critical shell bottom and SAV habitat.
- The division does not have data about shrimp trawl effort in specific Neuse River tributaries. However, many of these tributaries are popular areas for commercial and recreational shrimp trawlers. While the magnitude of benefits is unknown, these closures will reduce bycatch and protect critical habitat.
- Overall, the Neuse River and West Bay contributes minimally to the shrimp fishery in North Carolina but is an important access point in the Rivers Area, accounting for most of the landings, value, and participants.



Average proportion of commercial landings and value, and number of participants in the North Carolina shrimp fishery in the Neuse, Bay, and Pamlico rivers compared to Pamlico Sound, and the rest of the state, 2010-2019. The Neuse, Bay, and Pamlico rivers averaged 56,983 pounds of shrimp landed, \$98,705 of value, and 57 participants from 2010 to 2019.

NCDMF Recommended Management Measures

Pamlico, Bay, and Neuse rivers and West Bay

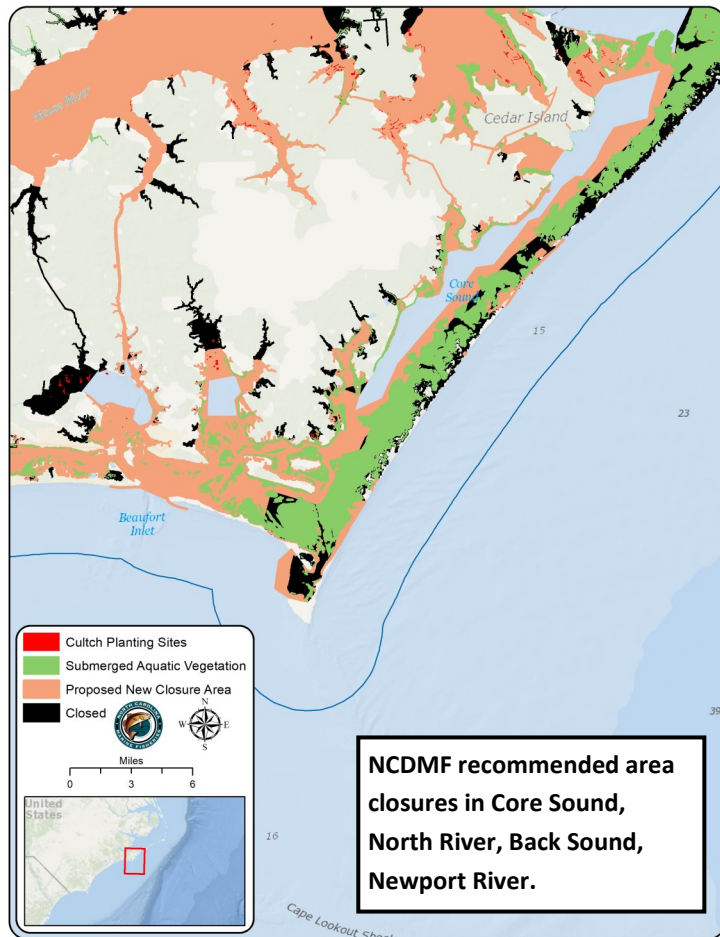


NCDMF Recommended Management Measures

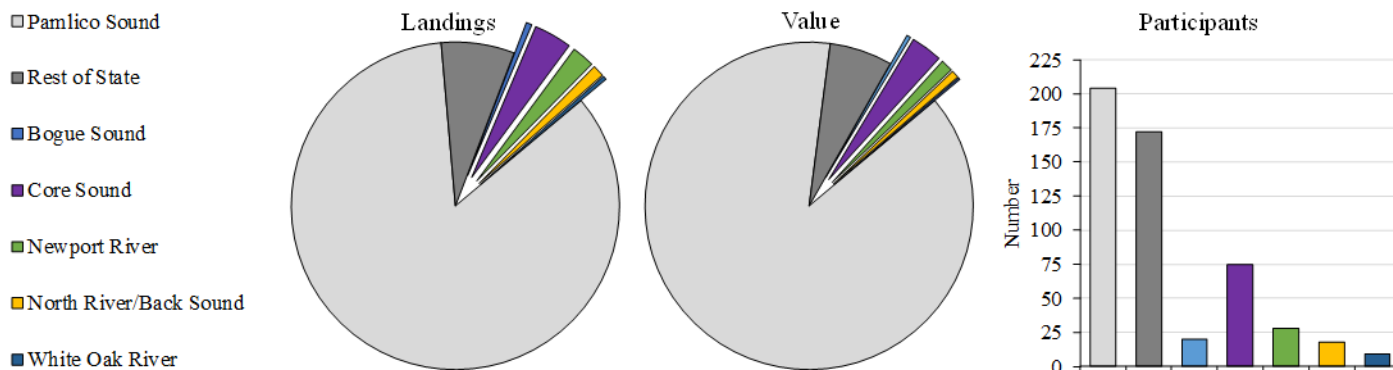
Central Region

The Central Region includes Core Sound, North River, Back Sound, Newport River, Bogue Sound, and White Oak River and their tributaries.

- Prohibit shrimp trawling in Core Sound and its tributaries except for the Mechanical Clam Harvest Area (MCHA) (*Appendix 2.3, Page 137; Figure 2.1.3, Page 84; Map 3.5, Page 298*).*
- Prohibit shrimp trawling in North River, Back Sound, and their tributaries except for the MCHA in North River (*Appendix 2.3, Page 139; Figure 2.1.4, Page 85; Map 3.6, Page 299*).*
- Prohibit shrimp trawling in the Newport River and its tributaries except for the MCHA and waters north and west between the MCHA and the Trawl Net Prohibited Area (*Appendix 2.3, Page 139; Figure 2.1.1e, Page 80; Map 3.5, Page 298*).*
- Prohibit shrimp trawling in Bogue Sound and its tributaries except for the Intracoastal Waterway (IWW) (*Appendix 2.3, Page 138; Figure 2.1.7, Page 88; Map 3.5-3.6, Pages 298-299*).*
- Prohibit shrimp trawling in the White Oak River and its tributaries (*Figure 2.1.1f, Page 81; Maps 3.5-3.7, Page 298-300*).*



A total of 68,919 acres would close to shrimp trawling if selected as the commission preferred management option. Alternative options include status quo (no additional area closures) and complete closures of Core Sound, Back Sound, North River, Newport River, Bogue Sound, and White Oak River. Full recommendation language are on page 64.

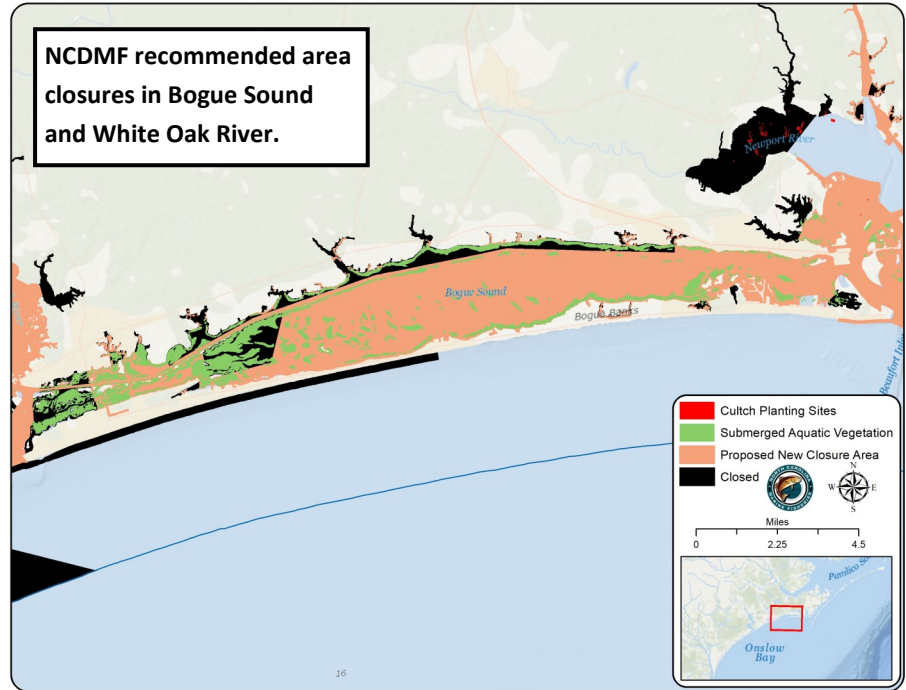


Average proportion of commercial landings and value, and number of participants in the North Carolina shrimp fishery in the Central Region compared to other state estuarine waters, 2010-2019. The Central Region averaged 476,296 pounds of shrimp landed, \$696,000 of value, and 119 participants from 2010 to 2019.

NCDMF Recommended Management Measures

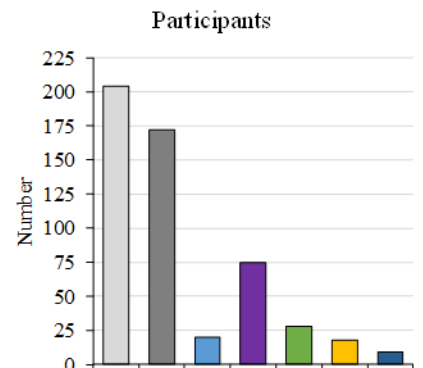
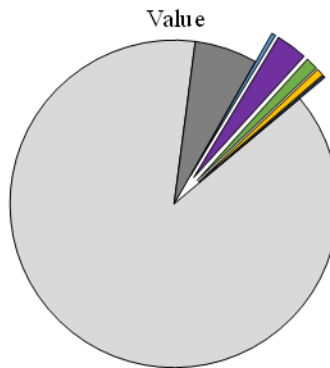
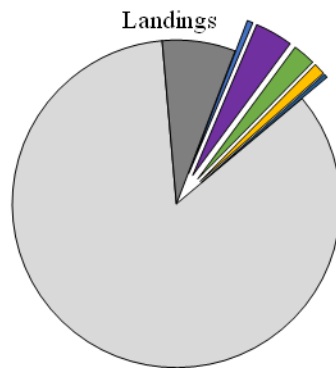
Decision Rationale - Central Region

- Closing Bogue Sound and its tributaries outside of the IWW will protect critical SAV habitat, create connectivity between closed areas and the ocean inlets, and reduce bycatch.
- Closing the White Oak River and its tributaries will create connectivity between closed areas and the ocean inlets and reduce bycatch.
- Generally, waterways in the Central Region are small and closing these areas will allow bycatch species to disperse to larger waterbodies, like ocean waters, where bycatch species are less concentrated.



- Overall, the Central Region contributes 8.1% of the landings, 5.6% of the value, and 119 participants to the estuarine shrimp fishery in North Carolina.
- Within the Central Region, Core Sound contributes 46.4% of the landings, 54.9% of the value, and 75 participants to the estuarine shrimp fishery.
- Leaving the MCHAs in Core Sound, North River, and Newport River and the IWW in Bogue Sound open to trawling will provide access to fishermen and have minimal impact to soft bottom habitats that are impacted by other fisheries or dredged for navigation.

- Pamlico Sound
- Rest of State
- Bogue Sound
- Core Sound
- Newport River
- North River/Back Sound
- White Oak River



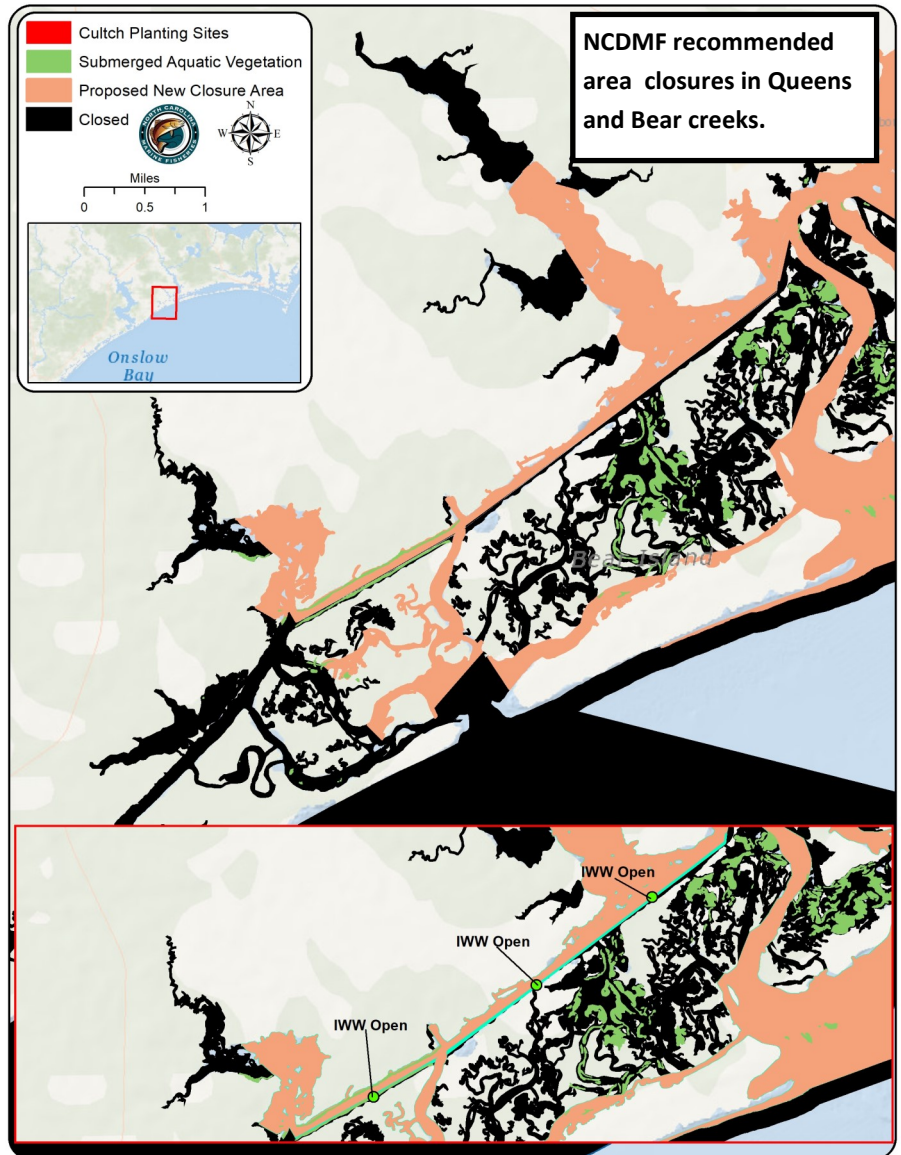
Average proportion of commercial landings and value, and number of participants in the North Carolina shrimp fishery in the Central Region compared to other state estuarine waters, 2010-2019. The Central Region averaged 476,296 pounds of shrimp landed, \$696,000 of value, and 119 participants from 2010 to 2019.

NCDMF Recommended Management Measures

Southern Region

The Southern Region includes the Cape Fear River, IWW, Lockwood's Folly, Masonboro Sound, New River, Shallotte River, Stump Sound, and Topsail Sound and their tributaries.

- Prohibit shrimp trawling in Queens and Bear creeks (*Appendix 2.3, Page 141; Map 3.6-3.7, Page 299-300*).*
- Prohibit shrimp trawling in the channels that connect to the Atlantic Ocean [Banks Channel (Topsail Sound), Green Channel, Nixon Channel, Mason Channel, Stokley Cut/Old Moores Inlet Channel, Lee's Cut/Spring, Landing Channel, Banks Channel (Wrightsville Beach), Mott Channel, Muddy Slough, Dutchman Creek, Elizabeth River, Eastern Channel (Montgomery Slue), Jinks Creek, and Bonaparte Creek] (*Appendix 2.3, Pages 142-147; Maps 3.9-3.12, Pages 302-305*).*
- Prohibit shrimp trawling in the Carolina Beach Yacht Basin (*Appendix 2.3, Pages 143; Map 3.11, Page 304*).*



A total of 17,553 acres would close to shrimp trawling if selected as the commission preferred management option. Alternative options include status quo (no additional area closures in the IWW, New and Cape Fear rivers) and complete closures of IWW, New River, and Cape Fear River. Full recommendation language and channel names are on page 146.

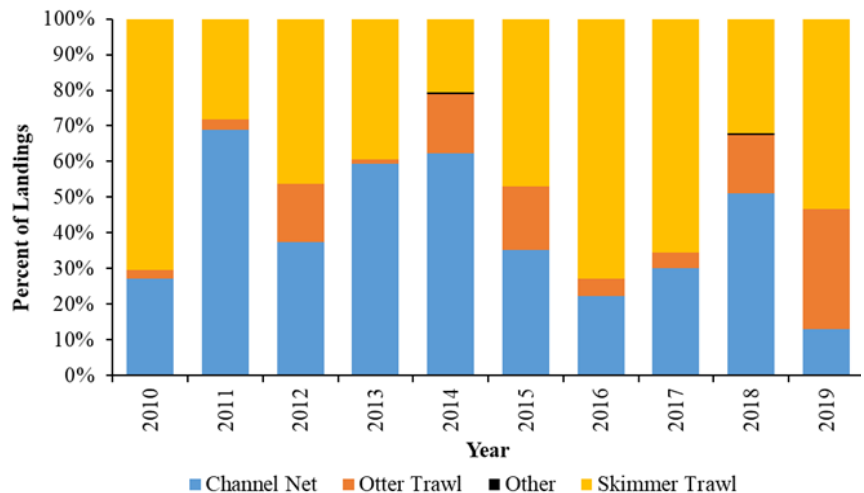
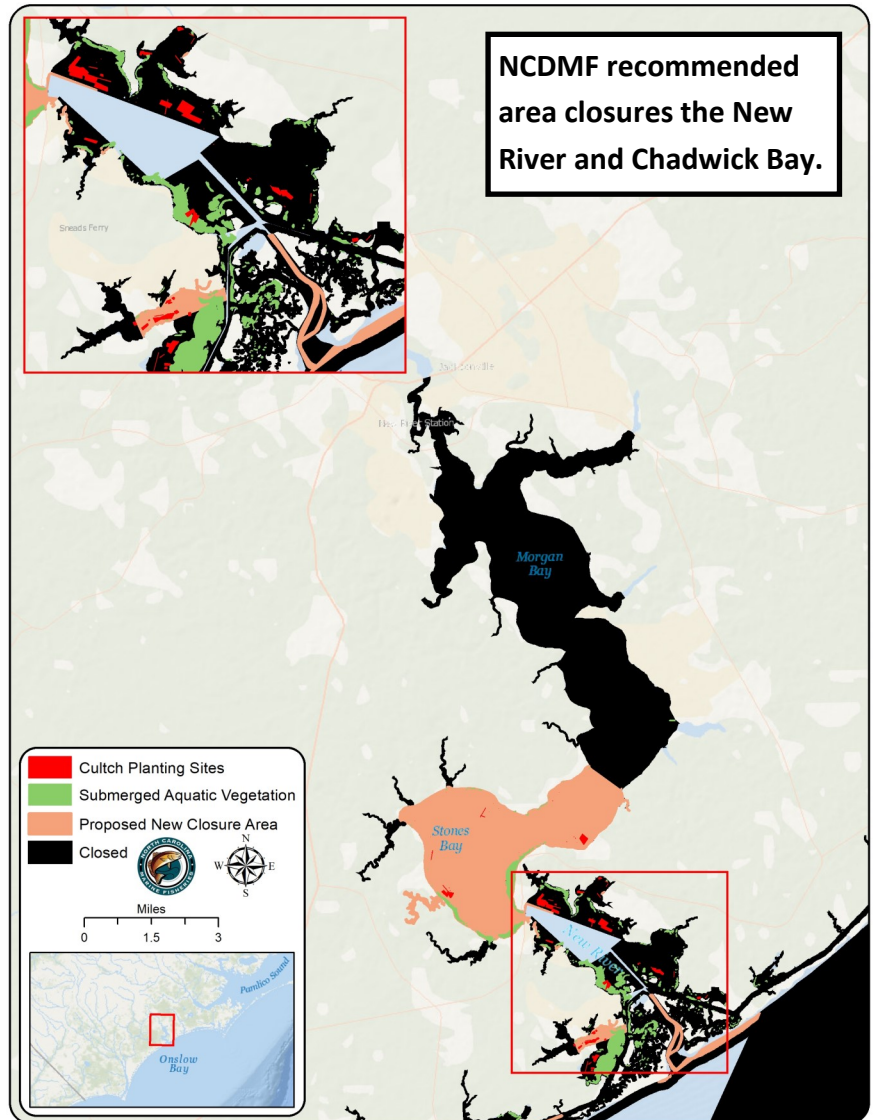
Decision Rationale - Queens & Bear Creek

- Closing Queens and Bear creeks would reduce bycatch and increase connectivity with existing Trawl Net Prohibited Areas (TNPA) and designated crab spawning sanctuaries. Closing these creeks would impact small commercial and recreational shrimp trawlers; however, trawling would be allowed in the main channel of the IWW adjacent to Queens and Bear creeks.

NCDMF Recommended Management Measures

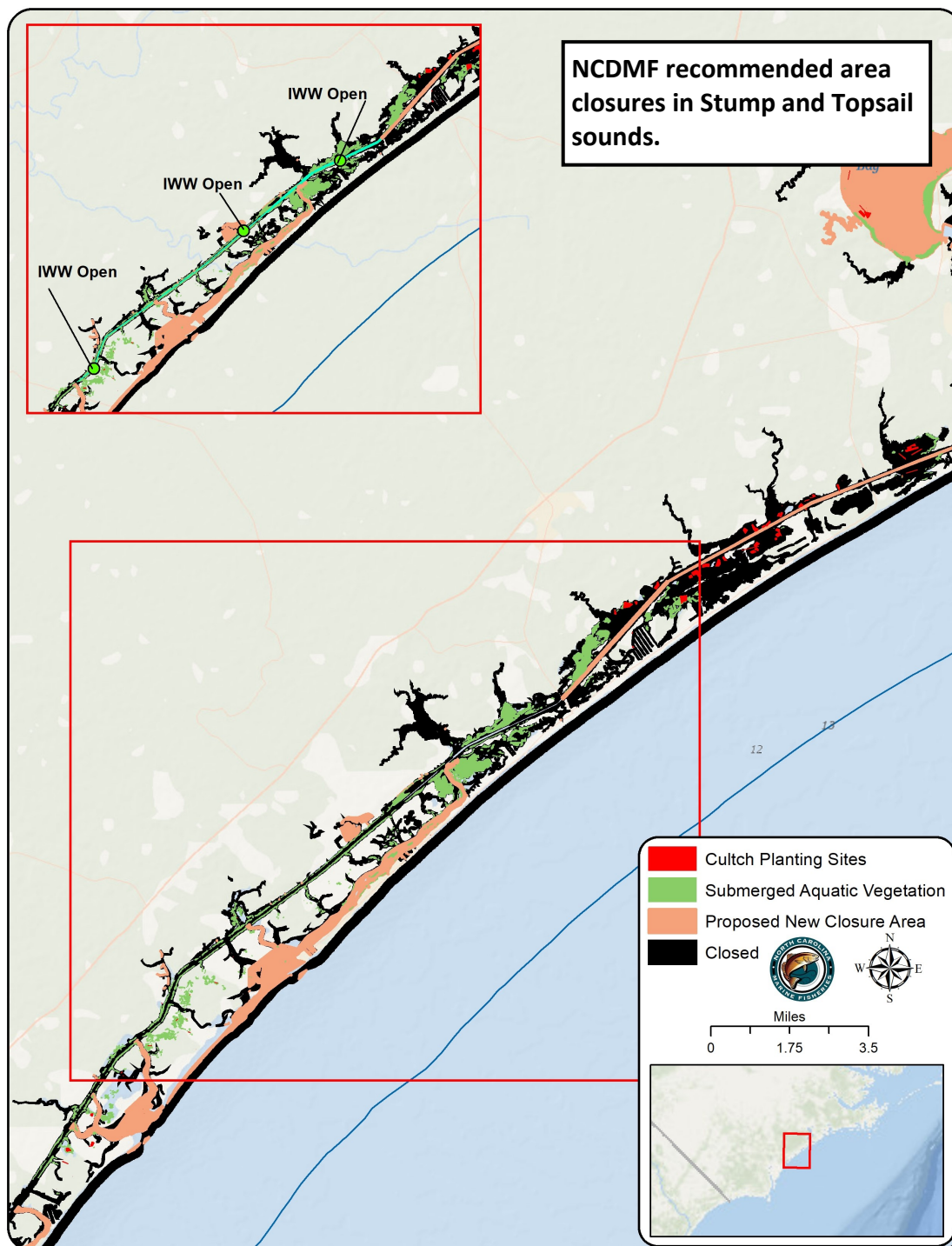
Decision Rationale - New River and Chadwick Bay

- Changing the designation of all SSNAs would permanently close the New River and Chadwick Bay SSNAs to all trawling.
- Would impact small commercial and recreational shrimp trawlers; however, trawling would be allowed in the IWW.
- The New River accounts for 2.0% of the estuarine shrimp landings; however, it accounts for nearly half of the landings and value in the Southern Region from 2010-2019.
- Landings data from the New River SSNA could not be identified; however, landings from skimmer trawls account for approximately 48% of the landings from 2010-2019. Most effort with skimmer trawls occurs above the Highway 172 Bridge. Otter trawls were phased out in the New River SSNA in 2010 and trawling is limited to day-time only.
- Leaving the MCHA in the New River (below Highway 172 Bridge) open to trawling will provide access to fishermen while allowing juvenile finfish and crustaceans to disperse into lower river.
- Landings data from the Chadwick Bay SSNA could not be identified. Chadwick Bay has only opened once since being designated a SSNA in 2011.



Percent contribution of commercial landings by gear in the New River, 2010-2019.

NCDMF Recommended Management Measures



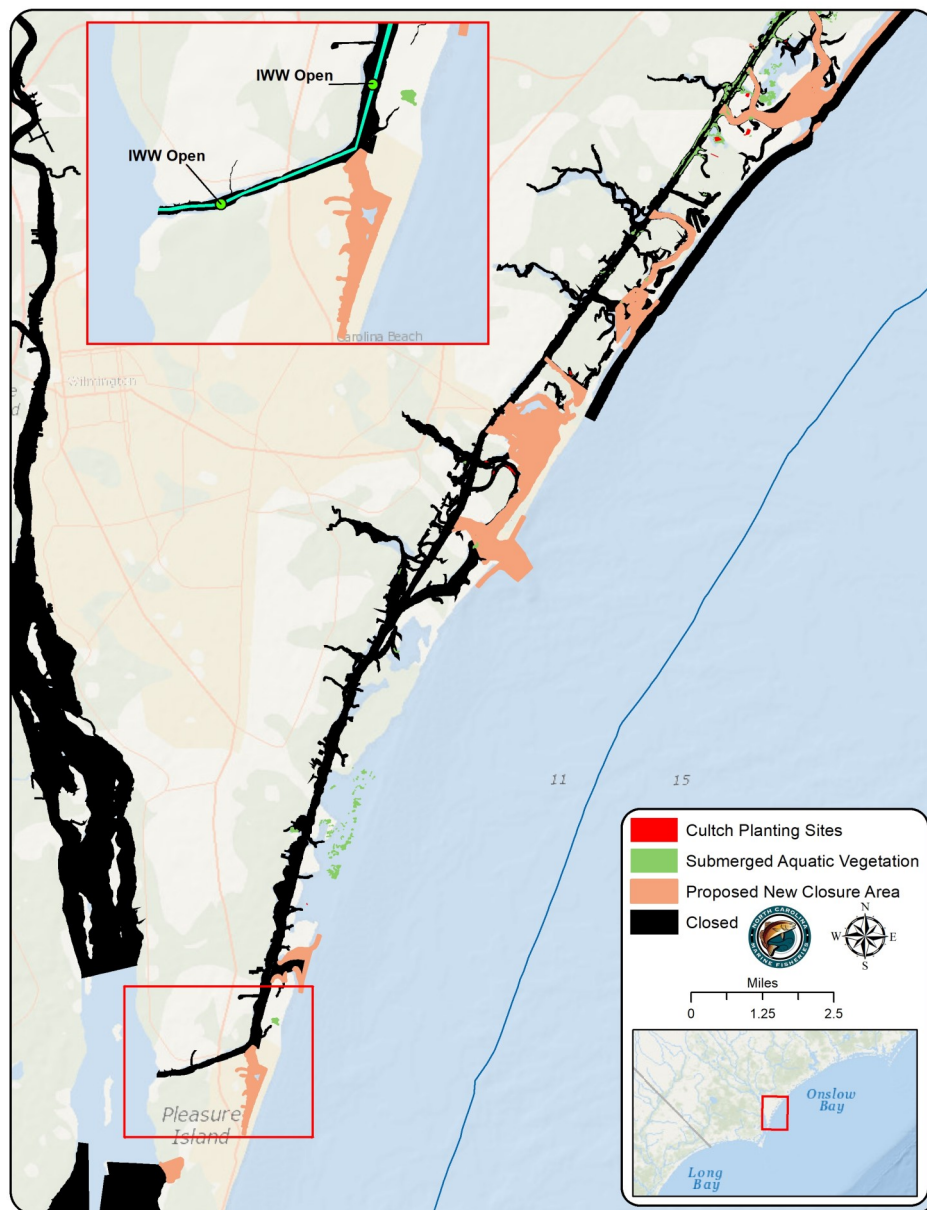
Decision Rationale - Stump and Topsail Sounds

- Landings data from the Stump Sound SSNA could not be identified but are thought to make up a majority of the landings in Stump and Topsail sounds. Within the Southern Region, Stump Sound accounts for 5.5% of the landings, 4.9% of the value and 13 participants from 2010-2019. Topsail Sound accounted for 5.2% landings, 4.4% of the value and 16 participants in the Southern Region from 2010-2019.
- Leaving the remaining portion of the IWW open to trawling will provide access to fishermen and have minimal impact to soft bottom habitats that are dredged for navigation.

NCDMF Recommended Management Measures

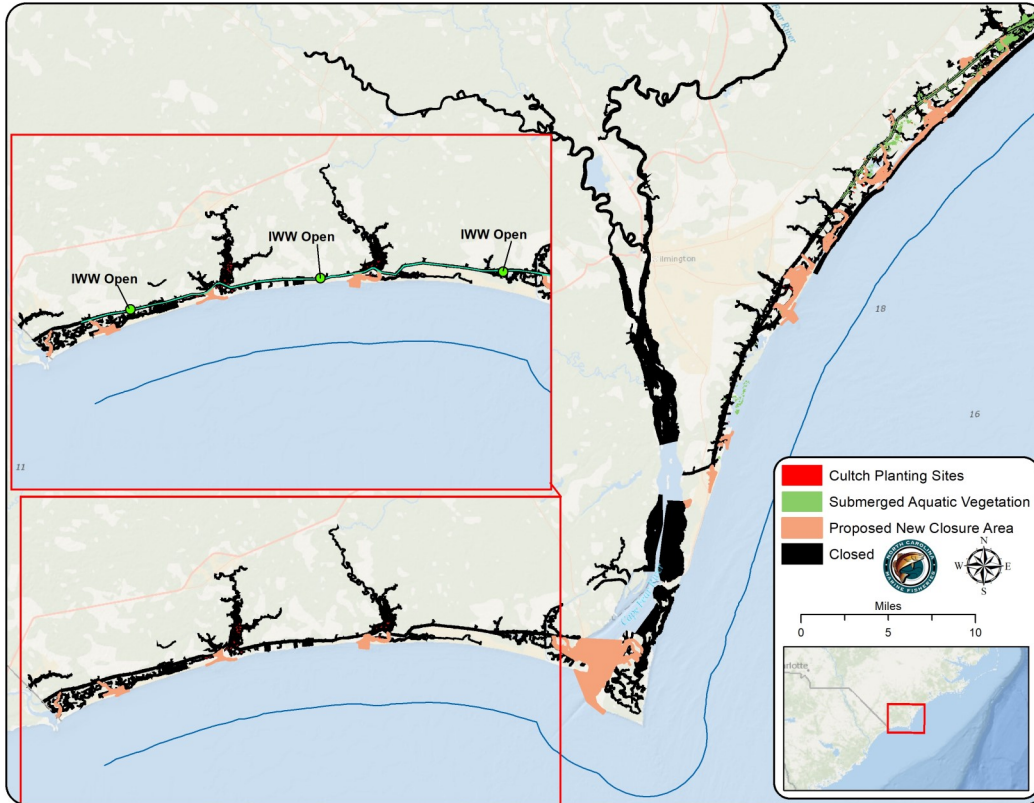
Decision Rationale - Channels connect to Atlantic Ocean and the Carolina Beach Yacht Basin

- Closing channels that connect to the Atlantic Ocean increases connectivity with existing TNPAs and designated crab spawning sanctuaries; however, these closures will impact small recreational and commercial shrimp trawlers, particularly live bait trawlers.
- Closing the Carolina Beach Yacht Basin increases connectivity with existing TNPAs and adjacent PNAs.
- Leaving the IWW open to trawling will provide access to fishermen and have minimal impact to soft bottom habitats that are dredged for navigation.
- Landings data are not available for channels that connect to the Atlantic Ocean and the Carolina Beach Yacht Basin; landings from these areas are thought to make up a small fraction of the landings from Onslow, Pender, New Hanover, and Brunswick Counties.



NCDMF recommended area closures from Rich Inlet to the Carolina Beach Inlet. The main channel of the IWW will remain open to shrimp trawling.

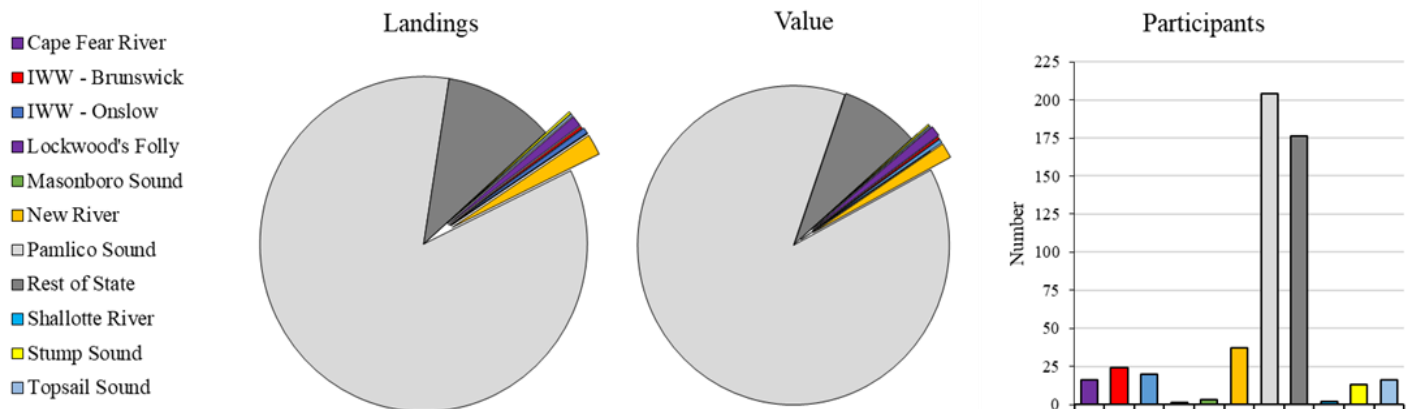
NCDMF Recommended Management Measures



NCDMF recommended area closures in New Hanover and Brunswick counties (i.e., Carolina Beach Yacht Basin and channels that connect to the Atlantic Ocean). The main channel of the IWW will remain open to shrimp trawling.

Decision Rationale - Cape Fear River

- Trawling primarily occurs on the edge of the main channel and has minimal impact to impact to soft bottom habitats that are already dredged for navigation.

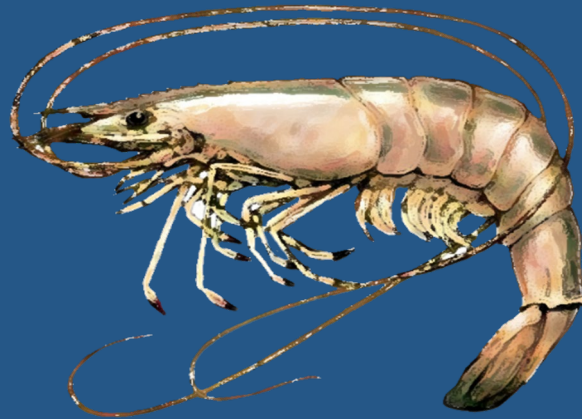


Average proportion of commercial landings and value, and number of participants in the North Carolina shrimp fishery in the Southern Region compared to other state estuarine waters, 2010-2019. The Southern Region averaged 257,645 pounds of shrimp landed, \$447,425 of value, and 96 participants from 2010 to 2019.

DRAFT North Carolina Shrimp Fishery Management Plan Amendment 2

By

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Disclaimer: Data in this Fishery Management Plan may have changed since publication based on updates to source documents.

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS	III
TABLE OF CONTENTS	IV
LIST OF FIGURES	VI
EXECUTIVE SUMMARY	VII
INTRODUCTION.....	1
FISHERY MANAGEMENT PLAN HISTORY	1
MANAGEMENT UNIT	1
GOAL AND OBJECTIVES.....	2
DESCRIPTION OF THE STOCK.....	2
BIOLOGICAL PROFILE	2
STOCK STATUS.....	3
DESCRIPTION OF THE FISHERIES	5
COMMERCIAL FISHERIES	5
SUMMARY OF ECONOMIC IMPACT OF COMMERCIAL SHRIMP FISHING	12
RECREATIONAL FISHERY.....	14
SUMMARY OF ECONOMIC IMPACT OF RECREATIONAL SHRIMP FISHING.....	16
BYCATCH.....	16
ECOSYSTEM PROTECTION AND IMPACTS	17
FISHERY MANAGEMENT PLANS.....	18
COASTAL HABITAT PROTECTION PLAN	18
THREATS AND ALTERATIONS.....	21
RESEARCH NEEDS.....	22
CARRY FORWARDS FROM PREVIOUS PLANS	22
SHRIMP AMENDMENT 2 MANAGEMENT STRATEGY	23
LITERATURE CITED	23
APPENDICES.....	32
APPENDIX 1. SHRIMP TRAWL BYCATCH ASSESSMENT.....	32
APPENDIX 2. ISSUE PAPERS	51
APPENDIX 2.1. MANAGEMENT OF SHRIMP TRAWLING FOR PROTECTION OF CRITICAL SEA GRASS AND SHELL BOTTOM HABITATS.....	51
APPENDIX 2.2. SHRIMP MANGAEMENT IN SPECIAL SECONDARY NURSERY AREAS.....	91
APPENDIX 2.3. REDUCING SHRIMP TRAWL BYCATCH THROUGH AREA CLOSURES THAT INCREASE CONNECTIVITY BETWEEN CLOSED AREAS	116
APPENDIX 2.4. MANAGING EFFORT AND GEAR IN THE NORTH CAROLINA SHRIMP FISHERY TO REDUCE BYCATCH.....	214
APPENDIX 3. MAPS OF CURRENT AREA CLOSURES.....	294

DRAFT – SUBJECT TO CHANGE

APPENDIX 4. COMMERCIAL, BAIT, AND RECREATIONAL SHRIMP TRAWL REGULATIONS FOR SOUTH ATLANTIC AND GULF STATES MAY 2021 306

APPENDIX 5. SUMMARY OF ADVISORY COMMITTEE AND NCDMF RECOMMENDATIONS FOR ISSUE PAPERS IN THE AMENDMENT 2 OF THE SHRIMP FISHERY MANAGEMENT PLAN..... 313

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LIST OF FIGURES

Figure 1.	Comparison of brown shrimp commercial landings in the months of June and July to the brown shrimp Estuarine Trawl Survey index of relative abundance in May and June (number per station), 1999-2019.	4
Figure 2.	Comparison of white shrimp commercial landings in October to the relative abundance (number per station) of white shrimp in the Estuarine Trawl Survey in June, 1999-2019.	5
Figure 3.	Schematic of otter trawl components.	6
Figure 4.	Schematic of skimmer trawler components.	7
Figure 5.	Schematic of channel net components.	8
Figure 6.	Schematic of shrimp pound (A) and shrimp pot (B) components.	9
Figure 7.	North Carolina annual shrimp commercial landings (pounds) and value (\$), 1950-2019.	10
Figure 8.	Annual number of commercial trips reported for all three species by area, 1994-2019. Data from the NCDMF Trip Ticket Program.	11
Figure 9.	Annual commercial shrimp landings (pounds) by area for all three shrimp species combined in North Carolina, 1994-2019. Data from the NCDMF Trip Ticket Program.	11
Figure 10.	Economic impact estimates to the state of North Carolina from commercial shrimp harvest, 2008-2019. Estimates are generated using IMPLAN economic modelling software, data from NOAA’s Fisheries Economics of the U.S. Reports, and NCDMF Trip Ticket data. Income impacts represent the total additional income generated in NC by the commercial shrimp industry (includes wages, benefits, and proprietor income). Value-added impacts represent the total value of the commercial shrimp industry’s economic production to NC. Sales impacts represents the output value of the commercial shrimp industry and is the closest proxy of the industry’s contribution to NC’s annual gross domestic product (value added through the production of goods and services). These various impact estimates are not additive and should be considered independently. Note: expenditure data from NOAA’s “Fisheries Economics of the U.S.” is only available beginning in 2008.	13
Figure 11.	The number of Recreational Commercial Gear License (RCGLs) issued 2001-2019.	15
Figure 12.	Annual number of shrimp harvested and trips taken from cast nets and seines for recreational purposes, 2012-2019.	16
Figure 13.	Effects of threats and alterations on water quality and coastal habitats and their ultimate impact on the growth and survival of various species.	18
Figure 14.	Depiction of the nursery area concept – the location where abiotic and habitat conditions, as well as the landscape setting are optimal for productivity. Abiotic factors – salinity, temperature, depth, currents; Habitat factors – wetlands, shell bottom, SAV, substrate; Landscape setting – geomorphology of the waterbody, proximity to inlets or adult habitat, habitat connectivity (adapted from Peterson 2003 and Beck et al. 2001).	20

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EXECUTIVE SUMMARY

This section to be completed prior to final adoption of the plan.

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INTRODUCTION

This is Amendment 2 to the Shrimp Fishery Management Plan (FMP). By law, each FMP must be reviewed at least once every five years (G.S. 113-182.1). The N.C. Division of Marine Fisheries (NCDMF) reviews each FMP annually and a comprehensive review is undertaken about every five years. The last comprehensive review of the plan (Amendment 1) was approved by the N.C. Marine Fisheries Commission (NCMFC) in 2015. FMPs are the ultimate product that brings all information and management considerations into one document. The NCDMF prepares FMPs for adoption by the NCMFC for all commercially and recreationally significant species or fisheries that comprise state marine or estuarine resources. The goal of these plans is to ensure long-term viability of these fisheries. All management authority for the North Carolina shrimp fishery is vested in the State of North Carolina. The NCMFC adopts rules and policies and implements management measures for the shrimp fishery in Coastal Fishing Waters in accordance with G.S. 113-182.1. Until Amendment 2 is approved for management, shrimp are managed under Amendment 1 (NCDMF 2015) and the May 2018 and May 2021 revisions to Amendment 1 of the Shrimp FMP (NCDMF 2018, 2021).

FISHERY MANAGEMENT PLAN HISTORY

Original FMP Adoption:	April 2006
Amendments:	Amendment 1 – February 2015
Revisions:	May 2018 May 2021
Supplements:	None
Information Updates:	None
Schedule Changes:	Timeline moved forward one year to start comprehensive review in 2019
Next Comprehensive Review:	Five years after adoption of Amendment 2

Past versions or revisions of the Shrimp FMP (NCDMF 2006, 2015, 2018, 2021) are available on the NCDMF website at: <http://portal.ncdenr.org/web/mf/fmps-under-development>

MANAGEMENT UNIT

The management unit includes the three major species of shrimp: brown (*Farfantepenaeus aztecus*), pink (*F. duorarum*), and white (*Litopenaeus setiferus*) and their fisheries in all coastal fishing waters of North Carolina, which includes the Atlantic Ocean offshore to three miles.

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GOAL AND OBJECTIVES

The goal of Amendment 2 to the N.C. Shrimp FMP is to manage the shrimp fishery to provide adequate resource protection, optimize long-term harvest, and minimize ecosystem impacts. The following objectives will be used to achieve this goal.

- Reduce bycatch of non-target species of finfish and crustaceans, as well as protected, threatened, and endangered species.
- Promote the restoration, enhancement, and protection of habitat and environmental quality in a manner consistent with the Coastal Habitat Protection Plan (CHPP).
- Develop a strategy through the CHPP to review current nursery areas and to identify and evaluate potential areas suitable for designation.
- Use biological, environmental, habitat, fishery, social, and economic data needed to effectively monitor and manage the shrimp fishery and its ecosystem impacts (i.e., bycatch, habitat degradation).
- Promote implementation of research and education programs designed to improve stakeholder and the general public's understanding of shrimp trawl bycatch impacts on fish population dynamics.

DESCRIPTION OF THE STOCK

BIOLOGICAL PROFILE

There are three species that make up the shrimp fishery in North Carolina. They are the brown shrimp, pink shrimp, and white shrimp. Brown shrimp occur from Massachusetts to the Florida Keys and into the Gulf of Mexico to northwestern Yucatan (Larson 1989; Williams 1984). High abundances of brown shrimp occur in the Gulf of Mexico supporting a major commercial fishery along the South Atlantic coast, primarily in North and South Carolina. Pink shrimp are found from southern Chesapeake Bay to the Florida Keys, and around the coast through the Gulf of Mexico to Yucatan (Bielsa et al. 1983). The largest population of pink shrimp is off southwestern Florida in the Tortugas and Sanibel as well as in the southeastern portion of Bay of Campeche. Significant quantities of pink shrimp have historically been reported off the North Carolina coast and the northeast Florida coast; however, since the late 1990s their abundance has declined in North Carolina (NCDMF 2015; NCDMF unpublished data). White shrimp occur along the Atlantic coast from New York to Florida and throughout the Gulf of Mexico (Muncy 1984; Steele 2002).

The lifecycle of these species is similar in that adults spawn offshore and eggs are hatched into free-swimming larvae. Larvae develop through several stages into post-larvae. Once post-larval shrimp enter estuaries, growth is rapid and is dependent on salinity and water temperature. As shrimp increase in size, they migrate from the upper reaches of small creeks to deeper saltier rivers and sounds. By late summer and fall, they return to the ocean to spawn. The maximum life span of shrimp can range from 16 to 24 months and may reach a size of seven to 11 inches, depending on species (Eldred et al. 1961; Gunter 1961; McCoy and Brown 1967; McCoy 1968, 1972; Williams 1984).

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Significant weather events such as droughts, hurricanes, and changes in climate can influence the occurrence and distribution of marine organisms and habitat. While extreme weather events have always occurred, there is scientific consensus that climate change is occurring in North Carolina. Some of the expected weather related changes on the east coast resulting from climate change include increasing water temperatures, frequency of heavy rain events, severity of tropical storms, rate of sea level rise, and non-storm event nuisance flooding with more long-term effects on the estuarine system (Paerl et al. 2006; Melillo et al. 2014; Sweet et al. 2014; IPCC 2018; Kunkel et al. 2020). As the climate changes and waters warm, shrimp abundance and distribution shifts can occur. It has been predicted the ranges of hundreds of finfish and invertebrate species will shift or expand northward due to increasing temperatures caused by climate change (Morley et al. 2018).

In recent years, some monitoring programs are showing the expansion of white shrimp at the mouth of the Chesapeake Bay and off the coast of Cape Hatteras. Water temperatures have increased with milder winters and may be contributing to higher white shrimp abundance at the northern end of their range (Delancey et al. 2008; Kimbell et al. 2020; VIMS 2020). Warming winter temperatures may have the opposite effect on brown shrimp disrupting recruitment of post-larvae into the estuaries (David Whitaker, SCDNR (retired), personal communication). Post-larvae brown shrimp bury into bottom sediments as temperatures decline and then emerge as temperatures rise in late winter or early spring (Aldrich et al. 1968). If winter water temperatures do not decline enough to elicit this bottom-seeking behavior, then the post-larvae may recruit to the estuary throughout the winter, becoming exposed to periodic lethal low water temperature in the shallow tidal creeks.

Rising water temperatures associated with climate change have been linked to a rise in “black gill” infections in white shrimp which are thought to negatively impact penaeid shrimp fisheries in Georgia and South Carolina (Fowler et al. 2018; Frischer et al. 2018). Black gill is a parasitic infection caused by single-celled protozoans called ciliates that cause the shrimp’s immune system to produce an enzyme to fight the infection in a process known as melanization, giving the gills a black appearance (Johnson 1978; Burnett and Burnett 2015; Frischer et al. 2018). This process can impair respiratory function, growth, reproduction, and enhance the shrimp’s susceptibility to environmental factors and predation (Gooding et al. 2020). Black gill has been observed in pink, brown, and white shrimp and is not harmful to humans (Johnson 1978).

Shrimp are preyed upon by numerous finfish, invertebrates, and a wide variety of coastal and wading birds (NCDMF 2015). Predation is cited as a major source of natural mortality for juvenile shrimp and decreases as they grow (Zimmerman et al. 2000; Ramirez-Rodriguez and Sanchez 2003; Baker and Minello 2010; Leo et al. 2016). Trends in natural mortality are thought to be the result of age specific predation rates, physiological requirements, and the physical environment acting on different life history stages of penaeid shrimp (Ramirez-Rodriguez and Sanchez 2003).

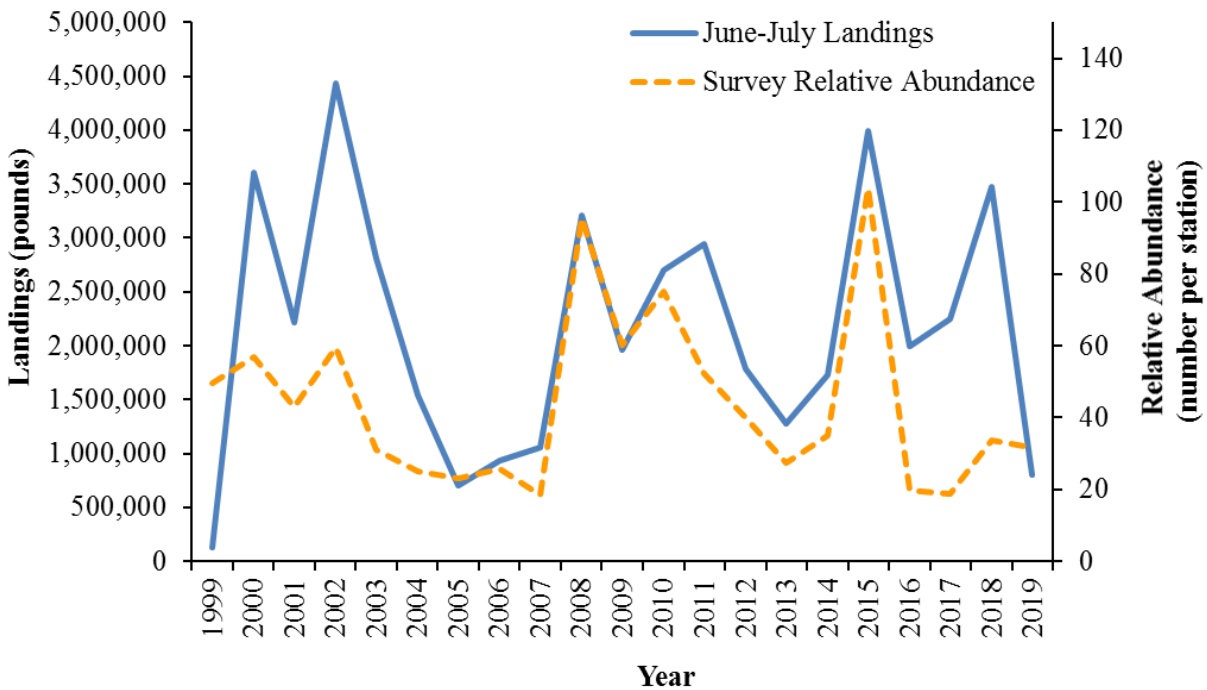
STOCK STATUS

Stock status is not available for all species of shrimp as they are considered an annual crop in North Carolina. Estimates of population size are not available but since shrimp are considered an annual crop and fished at near maximum levels, annual landings are probably a good indication of relative abundance. Population size is controlled by environmental conditions, and while fishing reduces the population size over the season, fishing is not believed to impact year class strength unless the

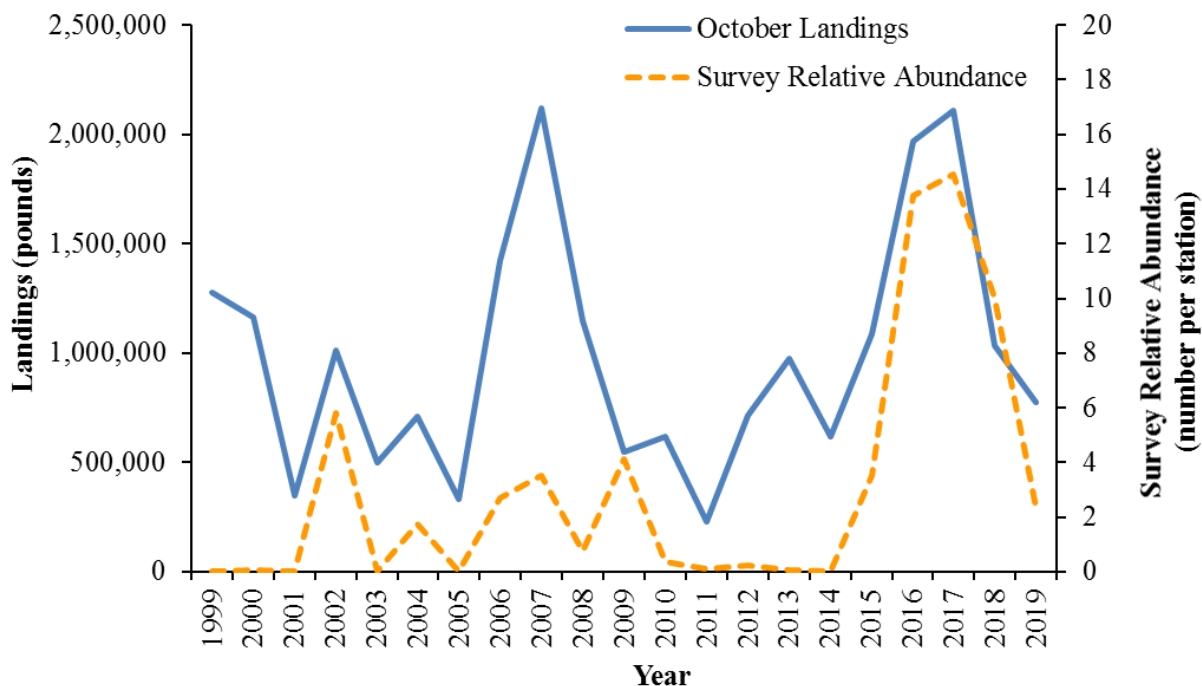
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spawning stock has been reduced below a minimum threshold level by environmental conditions. Annual variations in catch are presumed to be due to a combination of environmental conditions, fishing effort, and the effects of changes in the economics of the fishery. Because of high fecundity and migratory behavior, the three species are capable of rebounding from very low population sizes in one year to large populations the next, provided environmental conditions are favorable (MacArthur and Wilson 1967; McCoy and Brown 1967; McCoy 1968, 1972; Perez-Farfante 1969; Purvis and McCoy 1972; Whitaker 1981, 1982, 1983).

The division's Estuarine Trawl Survey (Program 120) is a fishery-independent multispecies monitoring program that has been ongoing since 1971 in the months of May and June. One of the key objectives of this program is to provide long-term indices of annual juvenile recruitment for multiple species. From this survey, annual trends in brown shrimp abundance measured as the number of brown shrimp per station (relative abundance) shows fluctuations from year to year. Estimates of year class strength can be inferred from the annual brown shrimp index of relative abundance and track brown shrimp landings in June and July, months where brown shrimp make up most of the landings (Figure 1). Currently, there are no juvenile indices for white and pink shrimp in North Carolina because sampling does not cover their recruitment time period. However, in recent years, higher abundances of white shrimp have been observed in the estuarine trawl survey in June and also track with peak white shrimp landings in October (Figure 2).



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DESCRIPTION OF THE FISHERIES

Additional in-depth analyses and discussion of North Carolina’s commercial and recreational shrimp fisheries can be found in earlier versions of the Shrimp FMP (NCDMF 2006, 2015, 2018); all documents are available on the NCDMF website at: <https://deq.nc.gov/about/divisions/marine-fisheries/public-information-and-education/managing-fisheries/fmp> and the License and Statistics Annual Report (NCDMF 2020) produced by the NCDMF which can be found at: <https://deq.nc.gov/about/divisions/marine-fisheries/science-and-statistics/fisheries-statistics>.

COMMERCIAL FISHERIES

Historical landings statistics were collected on a voluntary basis and methodology varied through time until 1994 when the NCDMF implemented a mandatory Trip Ticket Program to monitor commercial landings and fishing effort (Lupton and Phalen 1996). While commercial shrimp fishery data exists for small geographic areas and short windows of time, commercial landings and associated effort from the Trip Ticket Program is the only statewide data source with a long time series. Commercial shrimp harvest for NC’s estuarine and state ocean waters requires a fisherman to hold a Standard Commercial Fishing License (SCFL) or a Retired Standard Commercial Fishing License (RSCFL). A Land or Sell License can be used to commercially harvest shrimp from ocean waters greater than three miles from shore and for a vessel that is registered in another state, as well as the SCFL and RSCFL.

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A variety of methods are used to catch shrimp including otter trawls, skimmer trawls, channel nets, shrimp pounds, and cast nets. Otter trawls derived their name from the two trawl doors (otter doors/boards) that attach to the bridle that are hydro-dynamically designed to hold the wings of the net open (Figure 3). As the net is pulled along the bottom, the otter boards plane in opposite directions holding the net open. Otter trawls are used for all three species in both the estuary and the ocean with two-seam trawls used for brown and pink shrimp and four-seam and tongue trawls for white shrimp, which tend to swim higher in the water column and will jump to the surface when disturbed. Skimmer trawls consist of two rigid frames attached to each side of a vessel with nets attached along the two sides of the frame (Figure 4). Metal skids keep the frames off the bottom as the nets are pushed through the water column. Unlike otter trawls, the tailbags of skimmer trawls can be checked while fishing. Skimmer trawls are primarily used for white shrimp and are capable of fishing waters as shallow as two feet.

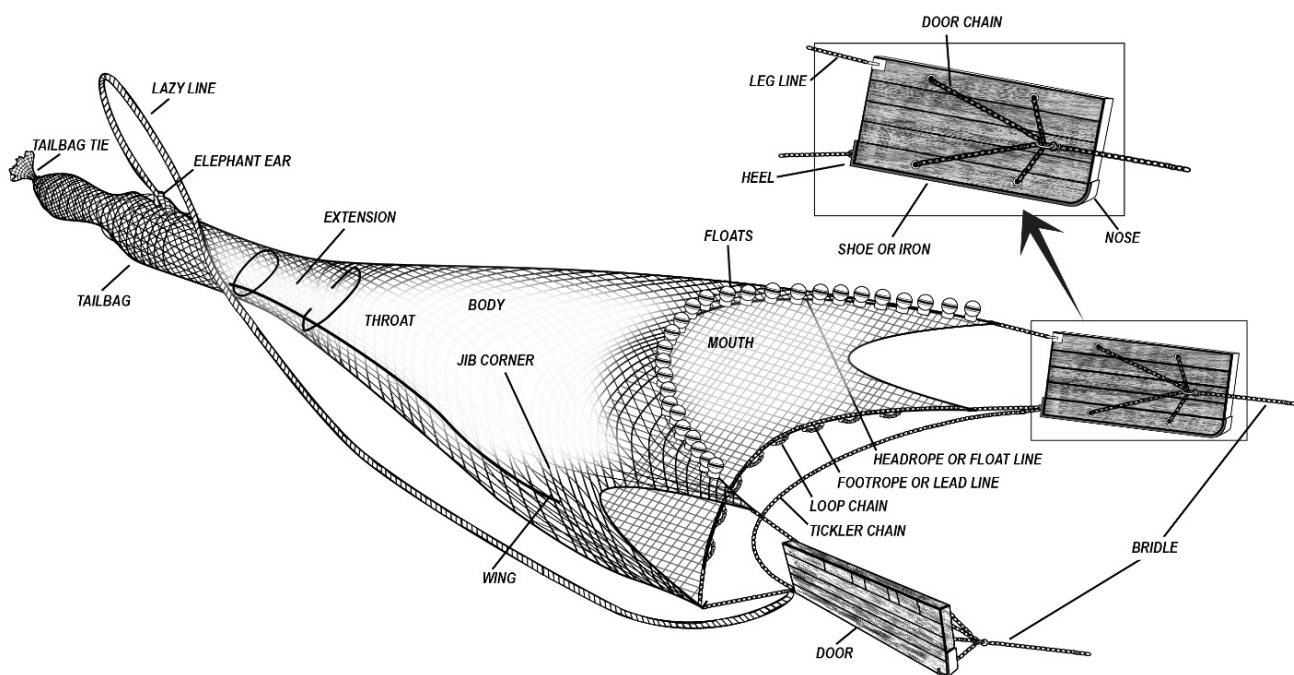


Figure 3. Schematic of otter trawl components.

A channel net is a stationary net that uses tidal currents to fish the surface and middle depths of the water column (Figure 5). The mouth of the net is held open by upright wooden shafts attached to a buoy and anchor on one side and a small vessel on the other. Float and butterfly nets also make use of tidal currents to push shrimp into the nets and offer the advantages of less fuel consumption and less bycatch than traditional shrimp trawls. To shrimp with a “float net”, fishermen attach large floats to the doors and top lines of trawls to make the net fish up in the water column and are pulled slowly forward to harvest shrimp that are migrating to the inlets at night. Butterfly nets use this same harvest strategy but are attached to a metal frame and are held stationary in the water

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column to capture shrimp as the current carries them into the net. Trawls, cast nets, and seines are used to harvest live shrimp for the commercial bait fishery. As of 2019, otter trawls account for most of the commercial shrimp harvest with skimmer trawls and channel nets ranking a distant second and third. From 2004 to 2019, approximately 93% of shrimp landings have been from otter trawls, 5% from skimmer trawls, and 2% from channel nets. Landings from other gears account for less than 1% of the total landings which include shrimp pots (Figure 6A), pound nets (Figure 6B), cast nets, and gill nets.

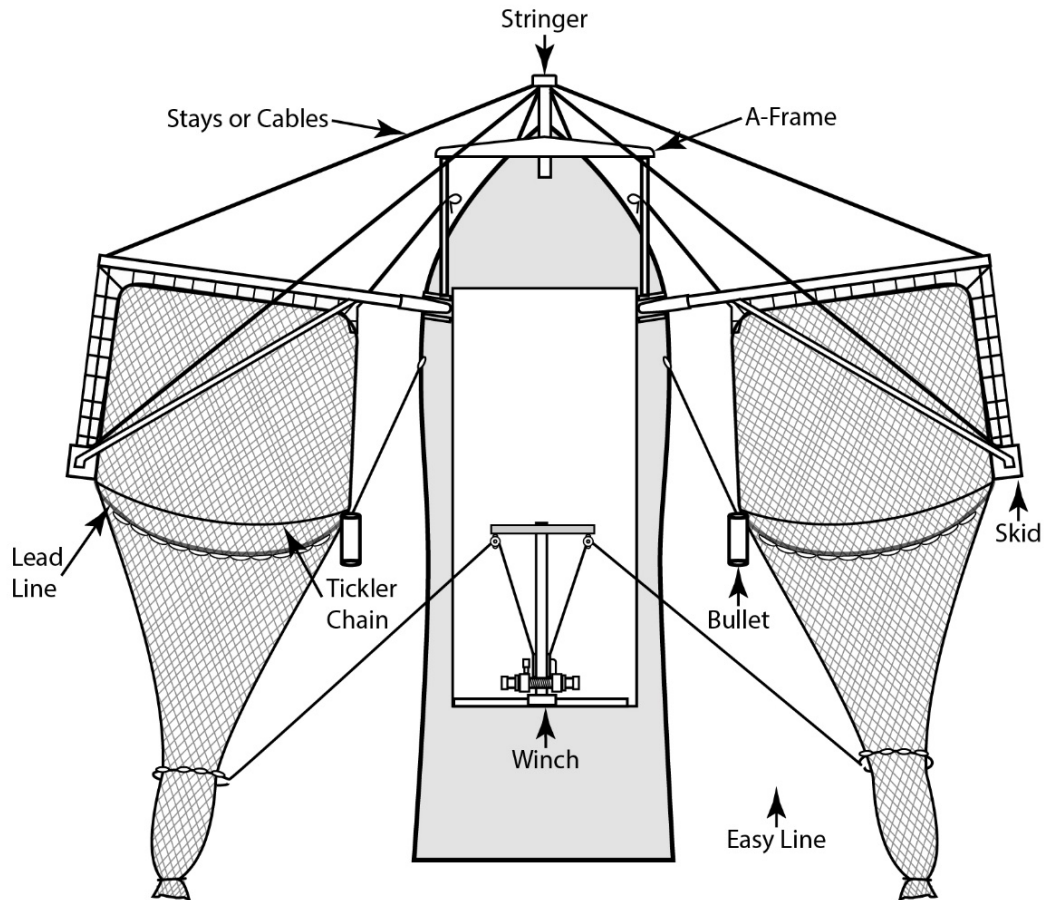


Figure 4. Schematic of skimmer trawler components.

North Carolina's shrimp fishery is unusual in the southeast U.S. because all three species are harvested and most of the effort occurs in internal waters. While South Carolina, Georgia, and Florida allow limited shrimping in internal waters, much of their fisheries are conducted in the Atlantic Ocean and white shrimp comprise most of their harvest (NCDMF 2015). Most of the vessels that operate in the NC commercial shrimp fishery are registered in NC. The number of NC registered vessels ranged from 394 in 2011 to 606 in 2004. The number of vessels registered in other states ranged from five in 2005 to 39 in 2017. In 2019, the 16 vessels registered in other states landed 4.4% of the total shrimp landings.

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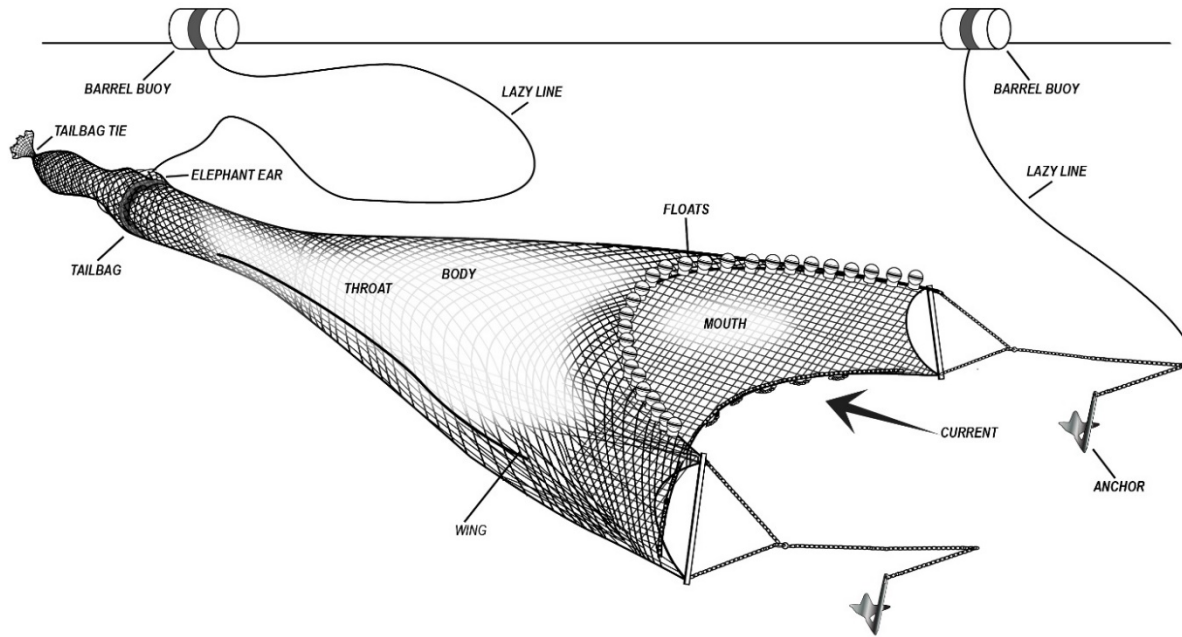


Figure 5. Schematic of channel net components.

Larger vessels are mostly used to trawl in the deeper waters in Pamlico Sound, the mouths of the Neuse, Pamlico, Pungo, and Bay rivers, and the ocean. Smaller vessels are more often used to trawl in the smaller sounds (Croatan, Roanoke, and Core sounds) and rivers (Newport, North, and White Oak rivers). Channel nets are popular around Harkers Island in the Straits and North River while skimmer trawling is very popular in Newport River and Bogue Sound. In the southern portion of the state, the fishery is mostly small boats fishing primarily the Intracoastal Waterway, New, and Cape Fear rivers and larger vessels fishing the Atlantic Ocean primarily off New River, Carolina Beach, and Brunswick County. Many of the small boats are fished by individuals who shrimp part-time or for personal consumption. Channel nets are fished extensively in the areas around New River and Topsail inlets. As the abundance of white shrimp has increased in recent years skimmer trawls have become more popular in the New River and Stump and Topsail sounds.

Historically, landings decline during the late fall and through the winter. However, in recent years, landings in December and January have increased substantially due to an abundance of white shrimp in near shore ocean waters north of Cape Hatteras from Oregon Inlet to the NC-VA state line. Landings of shrimp are lowest during the late winter and early spring months. Average monthly landings and dockside value are highest in the summer and early fall months from July through October.

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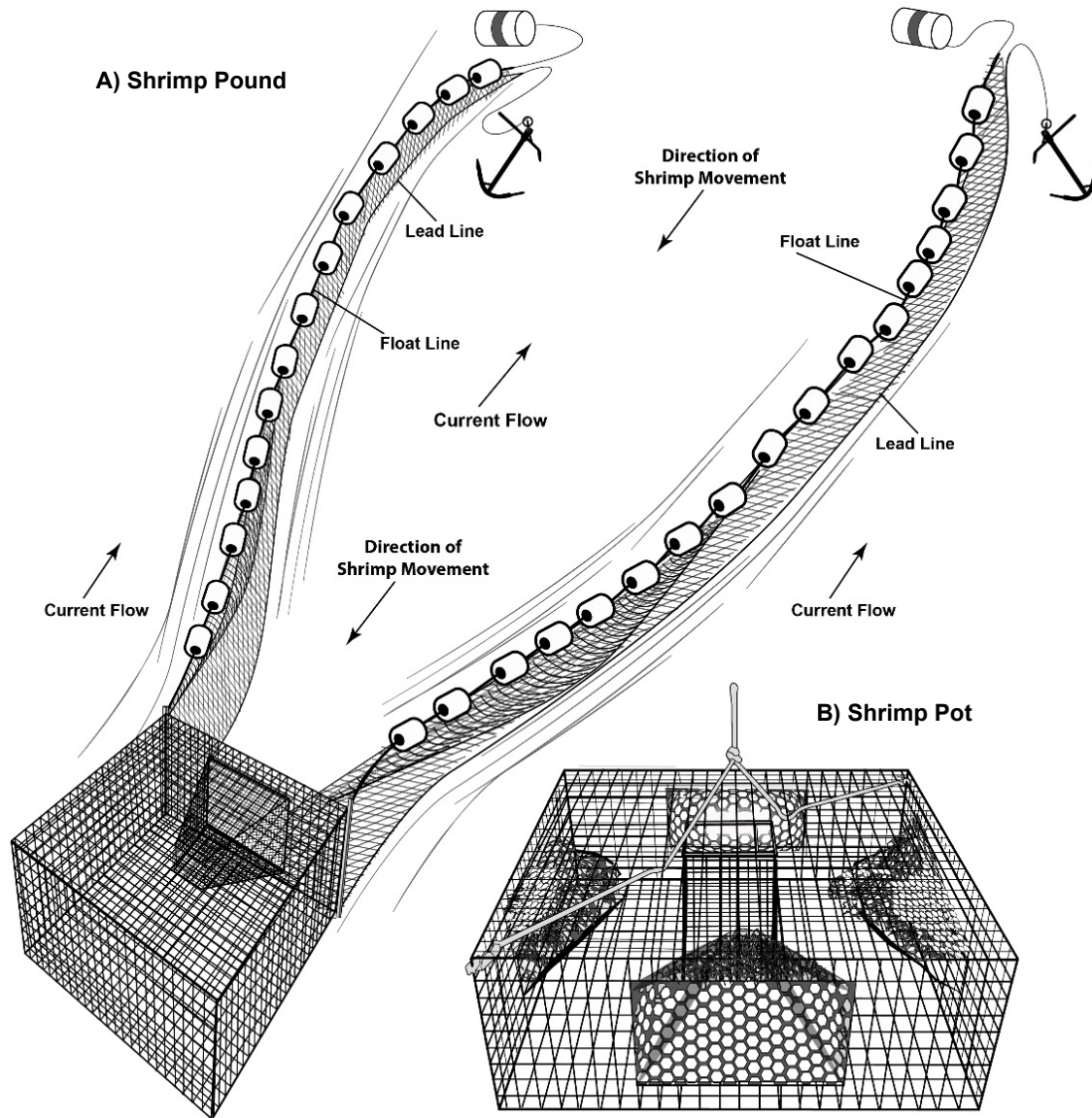


Figure 6. Schematic of shrimp pound (A) and shrimp pot (B) components.

Trends are shown for the dockside (ex-vessel) value and harvest volume presented as heads-on weight in pounds for shrimp. Total landings of all three shrimp species combined from 1994 to 2019 have averaged 7,430,164 pounds per year (Figure 7). The lowest landings during this period was 2.36 million pounds in 2005 and the highest was 13.91 million pounds in 2017. Shrimp landings have increased in recent years exceeding 9 million pounds since 2015. Annual dockside value of commercial shrimp landings averaged \$15.46 million from 2004 to 2019. Annual dockside value was lowest in 2005 at \$4.41 million and reached a high of over \$30.32 million in 2017.

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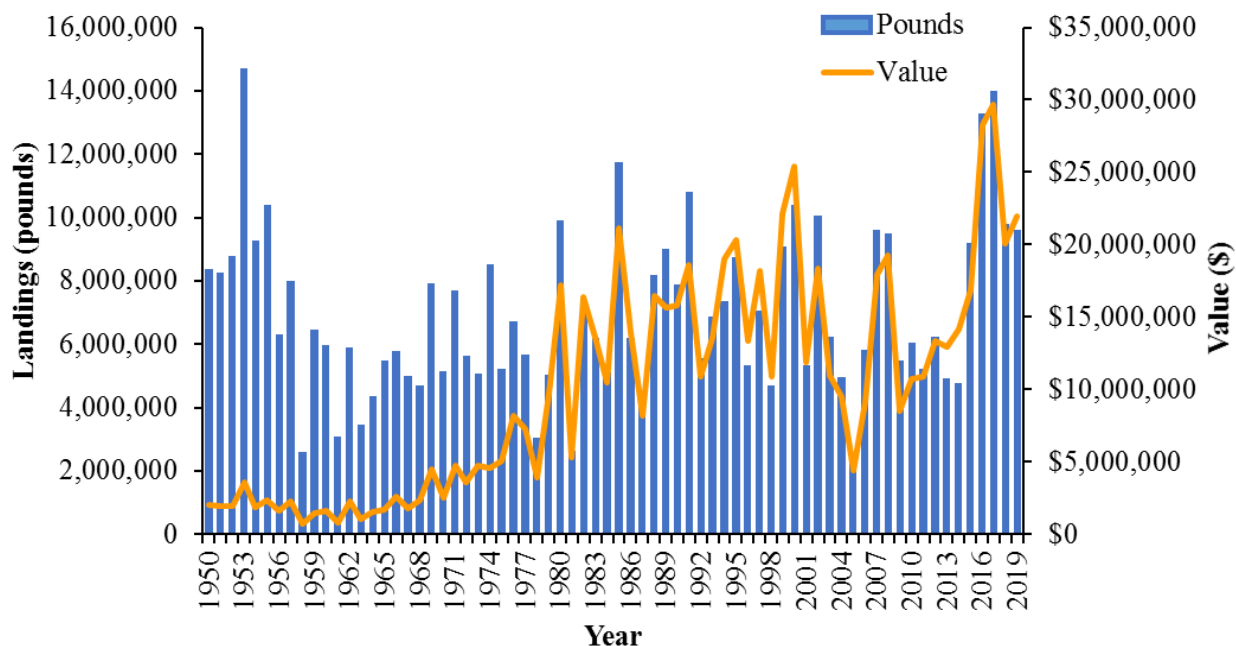


Figure 7. North Carolina annual shrimp commercial landings (pounds) and ex-vessel value (\$), 1950-2019.

Annual shrimping effort (number of trips) has fluctuated with shrimp abundance but has gradually declined since 1994 due to several factors including cheaper imported shrimp prices, increasing fuel prices, and fishermen retiring (NCDMF 2015; Figure 8). The number of trips decreased 2% from 2018 to 2019 (Figure 8). Landings in 2005 were lowest on record, likely because of several reasons including; many large trawlers remained scalloping instead of shrimping because prices were high and the days at sea were extended (NCDMF 2015), Hurricanes Katrina (Aug. 29, 2005) and Rita (Sept. 4, 2005) hit the Gulf coast, negatively affecting the fishing industry, shrimp breeding operations in the Gulf shut down with only one operational in September and some North Carolina shrimpers could not sell their product (NCDMF 2015). Hurricane Florence (Sept. 17, 2018) directly hit North Carolina, likely contributing to the decrease in landings in 2018.

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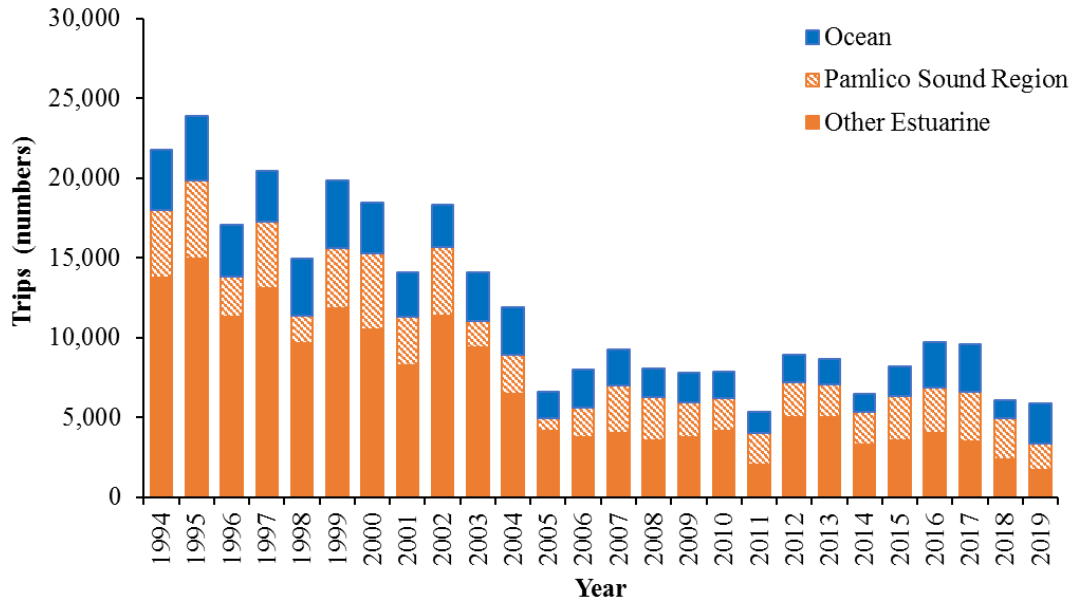


Figure 8. Annual number of commercial trips reported for all three species by area, 1994-2019. Data from the NCDMF Trip Ticket Program.

In 2018, 82% of the harvest occurred in estuarine waters (Pamlico Sound and other estuarine waters); however, only 36% occurred in estuarine waters in 2019 (Figure 9). Since 1994, Pamlico Sound has accounted for roughly 56% of total commercial shrimp landings in North Carolina. Landings in the Atlantic Ocean (less than 3 miles from shore) increased 251% in 2019 and were well above the times series average.

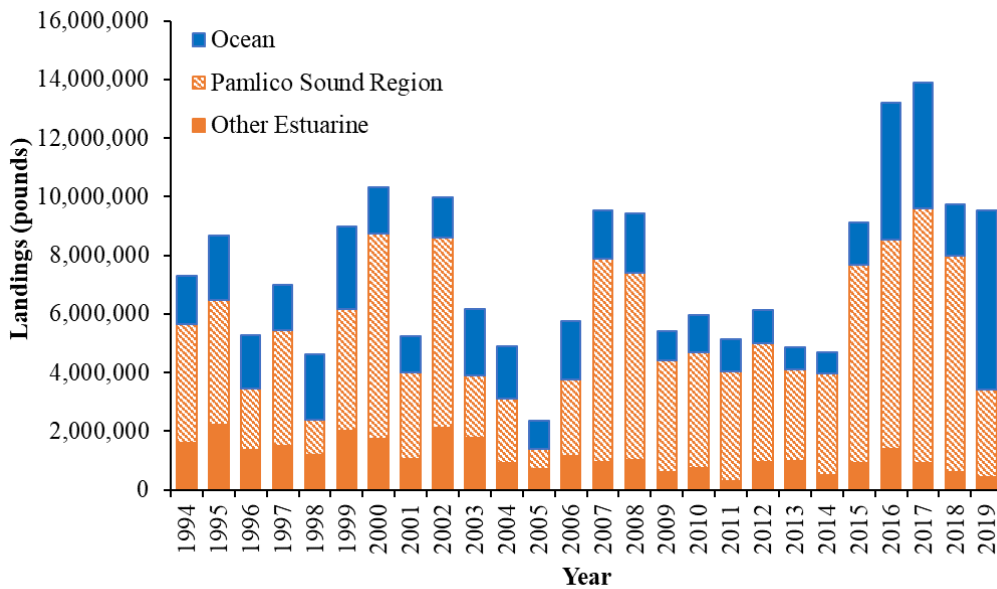


Figure 9. Annual commercial shrimp landings (pounds) by area for all three shrimp species combined in North Carolina, 1994-2019. Data from the NCDMF Trip Ticket Program.

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See *Appendix 2.3: Area Restrictions to Reduce Shrimp Trawl Bycatch in North Carolina* and *Appendix 2.4: Managing Effort and Gear Modifications in the Shrimp Fishery to Reduce Bycatch* for detailed commercial landings by gear and area.

Summary of Economic Impact of Commercial Shrimp Fishing

As one of the largest and most valuable commercial fisheries in the state, shrimp is a strong economic driver for the industry, supporting year-round seafood production, in-state consumption, and national exports. From 2004 to 2019, the value of the commercial shrimp harvest constituted roughly 20% of all commercial landings, with that proportion increasing to 25 to 30% in recent years. However, this valuable fishery is relatively concentrated, with fewer than 500 participants recording shrimp harvest most years. In fact, as the total value generated from commercial shrimp harvest increased from 2004 to 2019, the number of participants has decreased slightly, demonstrating an even greater concentration over time.

In addition to catch statistics and associated dockside values, the estimated total economic impact of this industry to the state of North Carolina can be modelled using IMPLAN statistical software. This method takes the direct contribution of the fishery (ex-vessel output and employment) along with federal fisheries data to model the total economic contribution to jobs, income, output, and value-added impacts. For a detailed explanation of the methodology used to estimate the economic impacts please refer to the NCDMF's License and Statistics Section Annual Report (NCDMF 2020).

To capture this total contribution, IMPLAN estimates three types of impacts: direct, indirect, and induced. For commercial shrimp fishing, direct effects are those felt at the fishery level, indirect effects occur from business-to-business spending related to the fishery, such as transport and processing, and induced effects are the state-level impacts of household spending from incomes gained through the commercial shrimp fishery. The values in Figure 10 represent the summed totals of direct, indirect, and induced impacts. While economic impacts can only be estimated starting in 2008, these data reflect the same landings trends of increasing value over time (Figure 10). Despite slight decreases in 2018 and 2019, the commercial shrimp industry helps promote a robust seafood economy, generating nearly \$100 million in state-wide sales impacts. While the number of licensed shrimp fishery participants is low, commercial shrimp harvest helps generate an estimated 1,000 to 2,000 additional jobs annually, underscoring the broader impact to the state's overall economy.

In addition to the economic influences of the global shrimp market, environmental concerns within North Carolina also act as a significant driver of this industry's value. Given the biology and life-histories of shrimp, fishing for this product requires methods that are generally deemed more environmentally destructive, such as trawling (MSC 1996; NCDEQ 2016). The environmental externalities that shrimp harvest incur can drive down demand for wild-caught shrimp, which, along with the need to price-adjust for environmental damages, can ultimately force North Carolina shrimp to sell at a prohibitively high price for many consumers. On top of this, shrimp are highly sensitive to environmental conditions, requiring additional concern for environmental protection when considering shrimp management. In all, these factors help demonstrate many of

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the hidden costs within the North Carolina shrimp harvest, and how that affects both the price and value of these products moving forward.

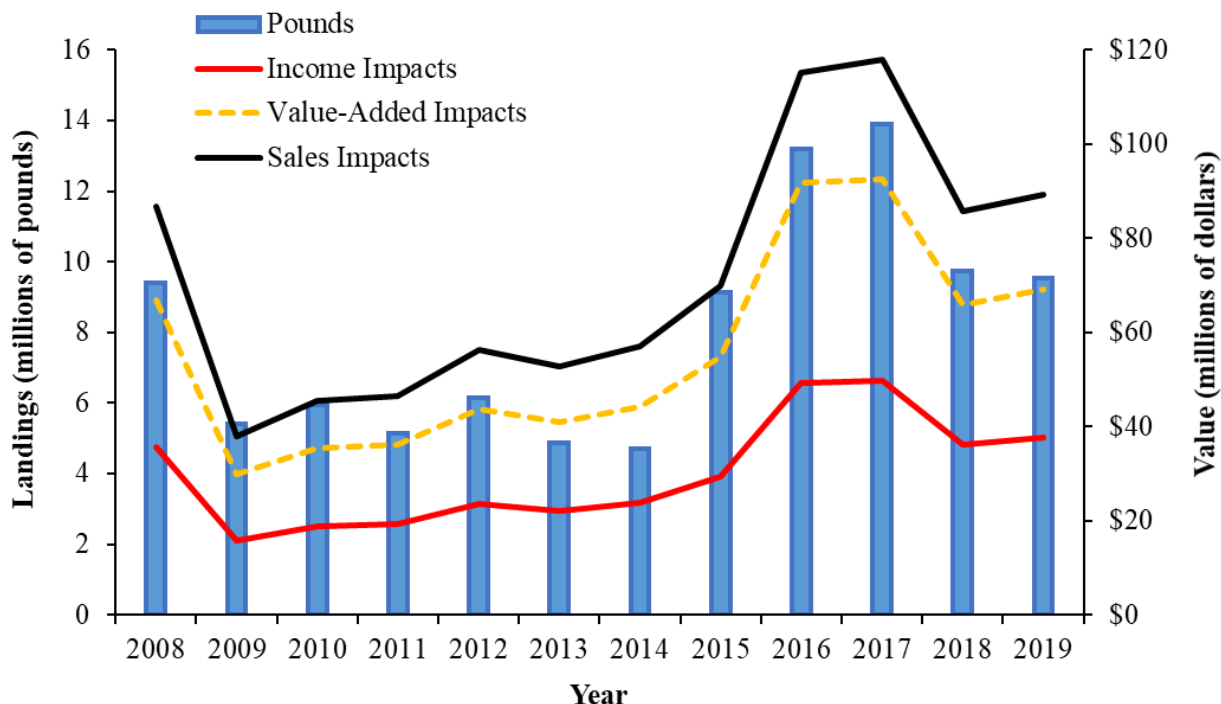


Figure 10. Economic impact estimates to the state of North Carolina from commercial shrimp harvest, 2008-2019. Estimates are generated using IMPLAN economic modelling software, data from NOAA’s Fisheries Economics of the U.S. Reports, and NCDMF Trip Ticket data. Income impacts represent the total additional income generated in NC by the commercial shrimp industry (includes wages, benefits, and proprietor income). Value-added impacts represent the total value of the commercial shrimp industry’s economic production to NC. Sales impacts represents the output value of the commercial shrimp industry and is the closest proxy of the industry’s contribution to NC’s annual gross domestic product (value added through the production of goods and services). These various impact estimates are not additive and should be considered independently. Note: expenditure data from NOAA’s “Fisheries Economics of the U.S.” is only available beginning in 2008.

Lastly, during the shrimp FMP advisory committee process, members discussed NCDMF’s ability to accurately quantify the economic impacts of management changes and questioned what steps would be needed to conduct this analysis. While this quantification may be possible with sufficient data, the division lacks much of the required information to produce a reliable estimate spanning biological, economic, and social data gaps. In order to evaluate the economic impacts of management changes for the shrimp fishery, the division would need highly accurate estimates of the stock status of each species related to the shrimp fishery, projections of how these stocks would react to various management changes, and the holistic value of each of these stocks (including

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commercial, recreational, and non-use values). Beyond this, detailed participant-level data would need to be collected across a range of stakeholders, while the economic value of a variety of indirect components, such as improved water quality, enhanced broodstock habitat, reduced user conflict, or changes in market behavior, would also need to be accurately quantified to incorporate into the calculation. At this time, the division has a strong understanding of how specific management changes would impact the economics of the fishery at a functional level, but a holistic economic impact quantification would require enhanced data streams from a wide set of sources that is not feasible within the timeline of the current FMP.

RECREATIONAL FISHERY

Within the division's Coastal Angling Program (CAP) [consists of the Marine Recreational Information Program (MRIP), Giggling Mail Survey, Cast Net and Seine Mail Survey, and the Recreational Commercial Gear License (RCGL) Survey], the MRIP and Giggling Mail Survey do not collect data with respect to shrimp. Recreational shrimp harvest data are limited to the Cast Net and Seine Mail Survey and the RCGL Survey.

Recreational fishermen harvest shrimp for personal consumption and for use as bait. A RCGL is required to recreationally harvest shrimp using a limited amount of commercial gear. Commercial gear allowed under a RCGL license that target shrimp include otter and skimmer trawls with a headrope length up to 26-feet, a 100-foot seine, one shrimp pound net, and up to five shrimp, crab, and fish pots each. Seines measuring less than 30 feet long and cast nets are exempt from this license. Shrimp harvested under a RCGL license cannot be sold and is for personal consumption only. Recreational fishermen are limited to 48 quarts of head on (30 quarts of head off) shrimp per person, per day or if a vessel is used, per vessel per day (RCGL maximum limit is two per vessel). Cast nets are the only gear allowed in closed shrimping areas, and recreational fishermen can harvest four quarts of head on or two-and-a-half quarts of head off shrimp per person, per day. For additional information on RCGL guidelines and rules, visit:

<https://deq.nc.gov/about/divisions/marine-fisheries/licenses-permits-and-leases/recreational-commercial-gear-license>.

Harvest data from RCGL gears are only available from 2004 to 2008 due to lack of funding for the RCGL survey. The number of licensed individuals participating in the RCGL fishery has steadily decreased from 6,356 in 2001 to 1,980 in 2019 (Figure 11). This is the best indicator currently available of effort in the RCGL fishery. For additional information on licenses see the License and Statistics Annual Report or for RCGL survey analysis see the 2009 License and Statistics Annual Report (NCDMF 2009).

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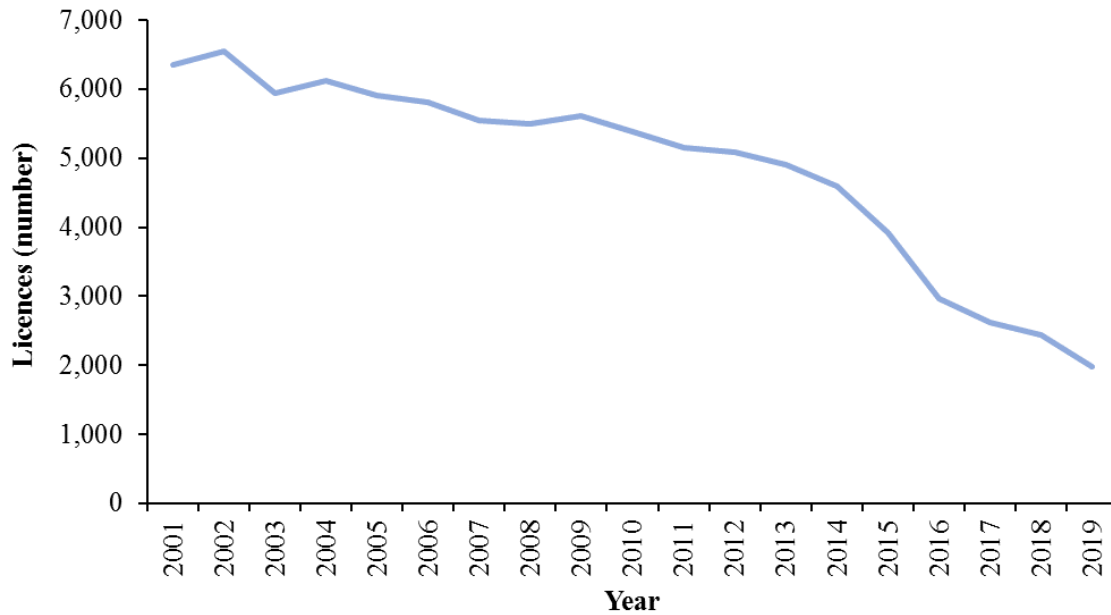


Figure 11. The number of Recreational Commercial Gear Licenses (RCGLs) issued 2001-2019.

From 2012 to 2019, the estimated total number of shrimp caught (harvest and released) using a cast net and/or seine ranged from 90,651 in 2018 to 296,692 in 2016, with an estimated annual average of 189,022 shrimp. Total shrimp harvest ranged from 83,266 in 2019 to 237,433 in 2016 (Figure 12). The estimated average of shrimp harvested annually over this eight-year period was 161,235. The months of July/August had the greatest number of shrimp harvested, closely followed by September/October and May/June. Annual trips ranged from 95,784 in 2018 to 217,484 in 2015 (Figure 12).

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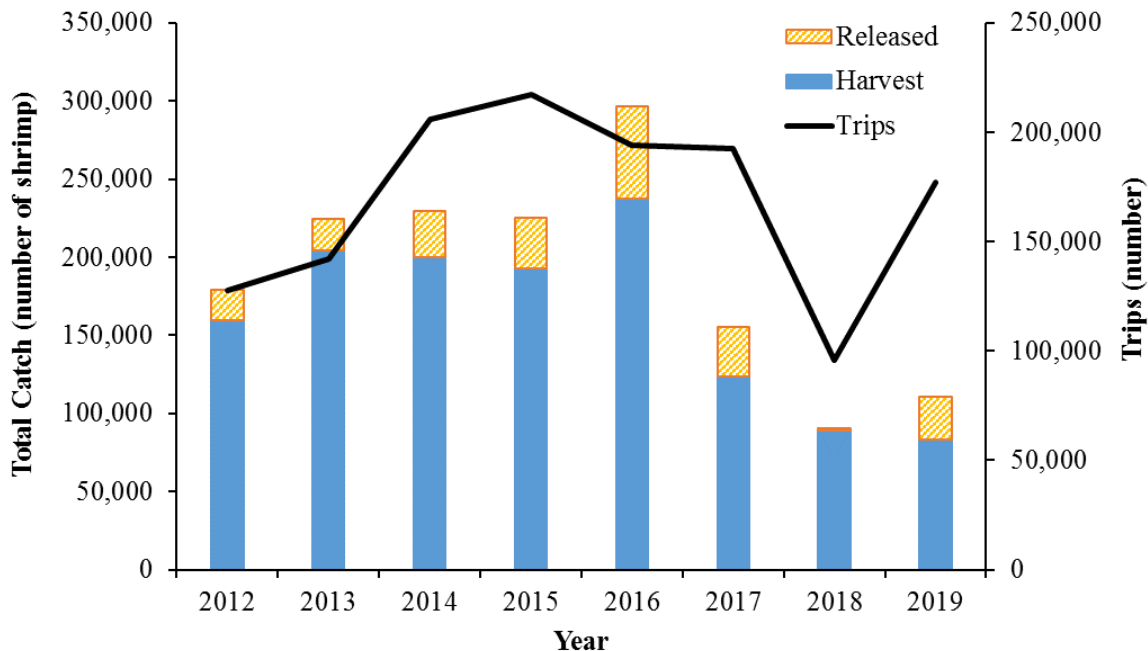


Figure 12. Annual number of shrimp harvested and trips taken from cast nets and seines for recreational purposes, 2012-2019.

Summary of Economic Impact of Recreational Shrimp Fishing

Overall, recreational effort and harvest for shrimp in North Carolina is very difficult to track and quantify. However, shrimp play a significant role in the recreational fishing industry overall in North Carolina, and it is important to note this species' role and how it affects the recreational fishing economy at-large. Specifically, shrimp serve as one of the primary bait species for recreational anglers in the state, and bait shrimp are sold in tackle shops, gas stations, big-box stores, and a variety of other locations. Depending on target species, anglers allocate a significant portion of their bait and tackle spending to shrimp each season, which contributes strongly to the sales of many tackle shops. Additionally, the need to purchase bait shrimp can also lead to spillover spending, as these goods bring anglers into tackle shops and related stores. On top of this, some anglers choose to catch their own bait shrimp via cast nets and seines, which also drives gear purchases throughout the state. In short, shrimp are an important component of recreational angling, and contribute greatly to recreational bait, tackle, and gear spending, which generates significant economic impacts to the state of North Carolina.

BYCATCH

Bycatch is the portion of a catch taken incidentally to the targeted catch because of non-selectivity of the fishing gear to either species or size differences (ASMFC 1994). In North Carolina, numerous studies have been conducted to characterize bycatch in the commercial shrimp trawl fishery (Roelof 1950; Pearce et al. 1988; Diamond-Tissue 1999; Johnson 2003, 2006; Logothetis and McCuiston 2006; Brown 2009, 2010, 2015, 2016; Brown et al. 2017, 2018). While many species of finfish are caught as bycatch in the shrimp trawl fishery, the bycatch of Atlantic croaker

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(*Micropogonias undulatus*), southern flounder (*Paralichthys lethostigma*), summer flounder (*P. dentatus*), spot (*Leiostomus xanthurus*), and weakfish (*Cynoscion regalis*) are of particular concern due to their value as economically important recreational and commercial fisheries as well as concerns about their stock status.

In 1990, NCDMF began testing the use of bycatch reduction devices (BRDs) in shrimp trawls to reduce finfish bycatch. Results from this work led to North Carolina becoming the first state to mandate the use of BRDs in all shrimp trawls in 1992. The use of BRDs installed in shrimp trawls can reduce total bycatch by 30 to 70% (McHugh et al. 2017). North Carolina has continued testing and working with the industry to modify trawl gears to further reduce bycatch.

Federally protected species found in North Carolina, such as sea turtles, sturgeon, and the common bottlenose dolphin (*Tursiops truncatus*) are known or suspected to be incidentally taken in the shrimp fishery. Turtle Excluder Devices (TEDs) in trawls are estimated to have a 97% exclusion rate of sea turtles with minimal shrimp loss (Watson 1981; Federal Register 1987, 1992; Jenkins 2012). The use of TEDs has also shown to reduce finfish bycatch (Brewer et al. 2006; Broome et al. 2011; Price and Gearhart 2011).

While bottlenose dolphins are commonly seen feeding behind shrimp trawlers in North Carolina (Fleming 2004; Johnson 2006; Brown 2009), very few takes have been observed in the shrimp trawl fishery. Bycatch of Atlantic sturgeon (*Acipenser oxyrinchus*) is thought to be the primary source of mortality and biggest threat to the species recovery (ASMFC 2017). Results from the 2017 Atlantic Sturgeon Stock Assessment Report indicate the total and dead bycatch of Atlantic sturgeon from otter trawls has declined since 2002 and the stock is showing signs of recovery (ASMFC 2017). In an evaluation of TED designs used in the Mid-Atlantic croaker flynet fishery, Atlantic sturgeon were observed escaping through TED openings (Gearhart 2010) and may further be excluded from shrimp trawls outfitted with TEDs.

Bycatch in the recreational shrimp fisheries is likely minimal, and effort in this sector has been difficult to quantify. While recreational fishermen holding a RCGL may use trawls up to 26 feet in length, creel limits, and area restrictions further limit their effort and bycatch. The use of non-trawl gears such as cast nets, seines, shrimp pots, and shrimp pounds are popular among recreational fishermen and have been shown to have minimal bycatch (Whitaker et al. 1991; McKenna et al. 1996; Brown 2006; Sessions and Thorpe 2006).

See *Appendix 1: Shrimp Trawl Bycatch Assessment*, *Appendix 2.3: Area Restrictions to Reduce Shrimp Trawl Bycatch in North Carolina*, and *Appendix 2.4: Managing Effort and Gear Modifications in the Shrimp Fishery to Reduce Bycatch* for more information on bycatch and discards of non-target species.

ECOSYSTEM PROTECTION AND IMPACTS

The growth and survival of shrimp within the habitats used are maximized when water quality parameters, such as temperature, salinity, and dissolved oxygen, are within optimal ranges. Additional information on these habitats including threats, water quality degradation and how these relate to the shrimp fishery are discussed below. Additional information can be found in the

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North Carolina CHPP, previous shrimp FMPs, various Division of Water Resources publications (NCDWQ 2000, 2008; NCDEQ 2016), and in the representation shown in Figure 13.

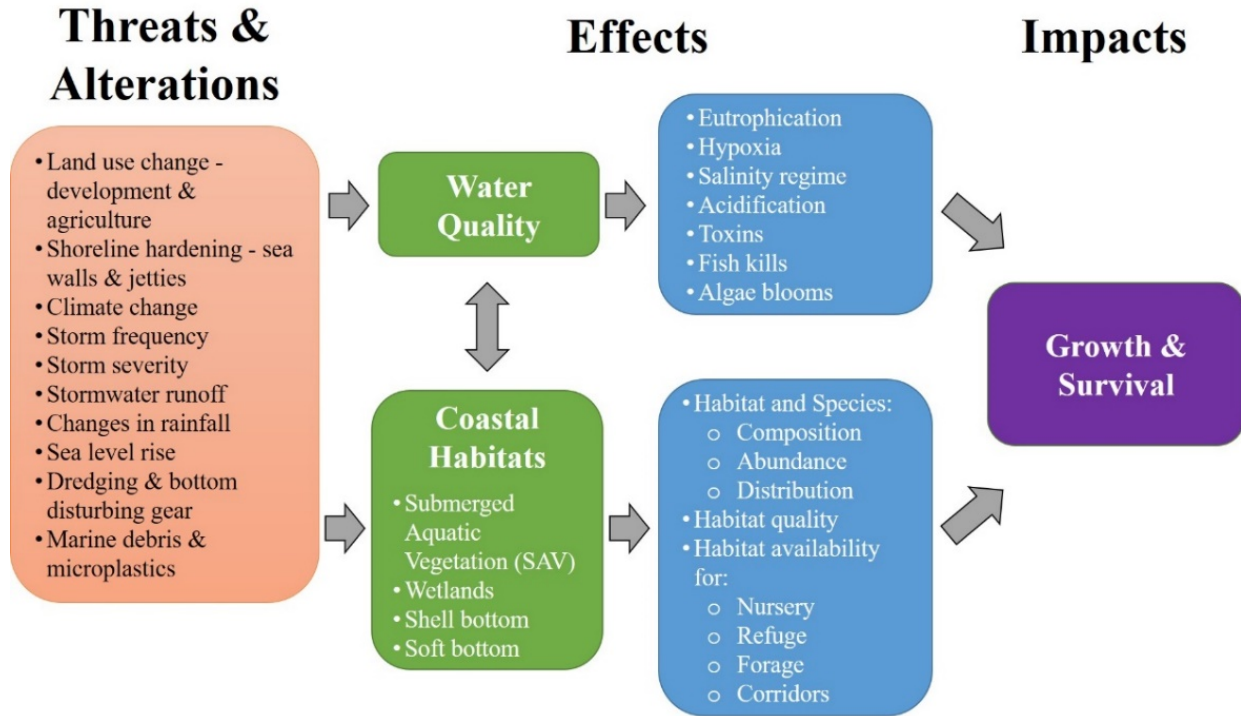


Figure 13. Effects of threats and alterations on water quality and coastal habitats and their ultimate impact on the growth and survival of various species.

FISHERY MANAGEMENT PLANS

State-managed species plans focus on current priority habitat issues specific to their species and target fisheries. The protection of habitat is reviewed in this plan's issue papers in relation to the shrimp fishery and how harvest areas may be adjusted to minimize fishery impacts to SAV, shell bottom, and Special Secondary Nursery Areas (SSNAs).

See *Appendix 2.1 Management of Shrimp Trawling for Protection of Critical Habitats* and *Appendix 2.2: Shrimp Management in Special Secondary Nursery Areas* for more nursery area and habitat information.

Coastal Habitat Protection Plan

The Fisheries Reform Act statutes require that a CHPP be drafted by the NCDEQ and reviewed every five years (G.S. 143B 279.8). The CHPP is intended as a resource and guide compiled by NCDEQ staff to assist the department, Marine Fisheries, Environmental Management (NCEMC), and Coastal Resources (NCCRC) commissions in the development of goals and recommendations

DRAFT – SUBJECT TO CHANGE

for the continued protection and enhancement of fishery habitats of North Carolina. The CHPP helps to ensure consistent actions among these commissions as well as their supporting NCDEQ divisions. The three commissions shall adopt rules to implement the CHPP in accordance with Chapter 150B of the General Statutes. Habitat recommendations related to fishery management can be addressed directly by the NCMFC. Habitat recommendations not under NCMFC authority (e.g., water quality management, shoreline development) can be addressed by the NCEMC and the NCCRC through the CHPP process.

The CHPP Source Document summarizes the economic and ecological value of coastal habitats to North Carolina, their status, and the potential threats to their sustainability (NCDEQ 2016). Current and previous versions of the CHPP and the CHPP Source Document can be viewed and downloaded from: <https://deq.nc.gov/about/divisions/marine-fisheries/habitat-information/chpp>.

The CHPP is undergoing a mandated five-year review, with adoption planned in 2021. The priority issue, “Protection and Restoration of Submerged Aquatic Vegetation (SAV) through Water Quality Improvements” has implications for shrimp stocks. SAV is especially sensitive to water quality impairment from nutrient and sediment pollution and has been considered a “coastal canary”, serving as a valuable bio-indicator of the overall health of coastal ecosystems. The primary mechanism to restore and sustain SAV is by improving water quality. The CHPP strategy for SAV involves modifying water quality criteria, such as chlorophyll-a levels and nutrient standards to reduce nutrient loading, to allow increased light penetration that is critical for SAV. This will not only benefit SAV but address other poor water quality impacts to marine resources. Another priority issue in the CHPP, “Protection and Restoration of Wetlands through Nature-based Solutions”, also has direct implications for shrimp. Turner (1977) found a significant positive relationship between the size of wetlands and shrimp production. The positive relationship between wetlands and shrimp production was later shown to be affected by the extent of marsh edge and flooding duration (Minello et al. 2011). To protect and restore SAV and wetlands, which would benefit shrimp, mapping and monitoring of these habitats is critical to determine and provide direction on necessary protection or restoration actions. The priority issue “Coastal Habitat Mapping and Monitoring to Assess Status and Trends” addresses more specifics regarding needed habitat monitoring.

One of the goals of the CHPP is to identify, designate, and protect Strategic Habitat Areas (SHAs). SHAs are specific locations of individual fish habitats or systems of fish habitats that have been identified to provide exceptional habitat functions or that are particularly at risk due to imminent threats, vulnerability or rarity. NCDMF habitat staff have instituted additional sampling to validate the identified SHAs by employing the creation of a multi-metric index to further evaluate/validate the SHAs. Through this process habitat metrics will be analyzed and refined. A similar process will be used to evaluate the ecological condition of existing nursery areas and non-nursery areas.

In recent years, scientific literature has refined the concept of nursery areas. In earlier days, an entire estuary was considered a nursery area because of the occurrence of juveniles. But as ecosystem sciences advance, it has been found that in addition to density, other factors such as growth, predator protection, and movement out of the nursery into the adult habitat influence determination of nursery areas. Based on Beck et al. (2001), Peterson (2003) and Dahlgren et al. (2006), nursery areas are a subset of juvenile habitat that contribute disproportionately more to the

DRAFT – SUBJECT TO CHANGE

production of juveniles that recruit into a population than another area of similar size. Shallow habitats with structure, such as wetlands, SAV, and oyster reefs, provide more predator protection and food than soft bottom habitat, enhancing growth and survival (Lehnert and Allen 2002; Ross 2003; Grabowski et al. 2005). However, juvenile species require specific, optimal abiotic conditions, such as salinity and temperature, to maximize growth. Productive or optimal nursery areas occur where ideal abiotic factors, structured habitat, and landscape position overlap (Figure 14). While all waterbodies may have juvenile fish present at any given time, the combination of the above noted factors may not align, resulting in low nursery value (Beck et al. 2001; Peterson 2003). Shrimp trawling is restricted in most of these optimal nursery areas through habitat designations and area and gear restrictions.

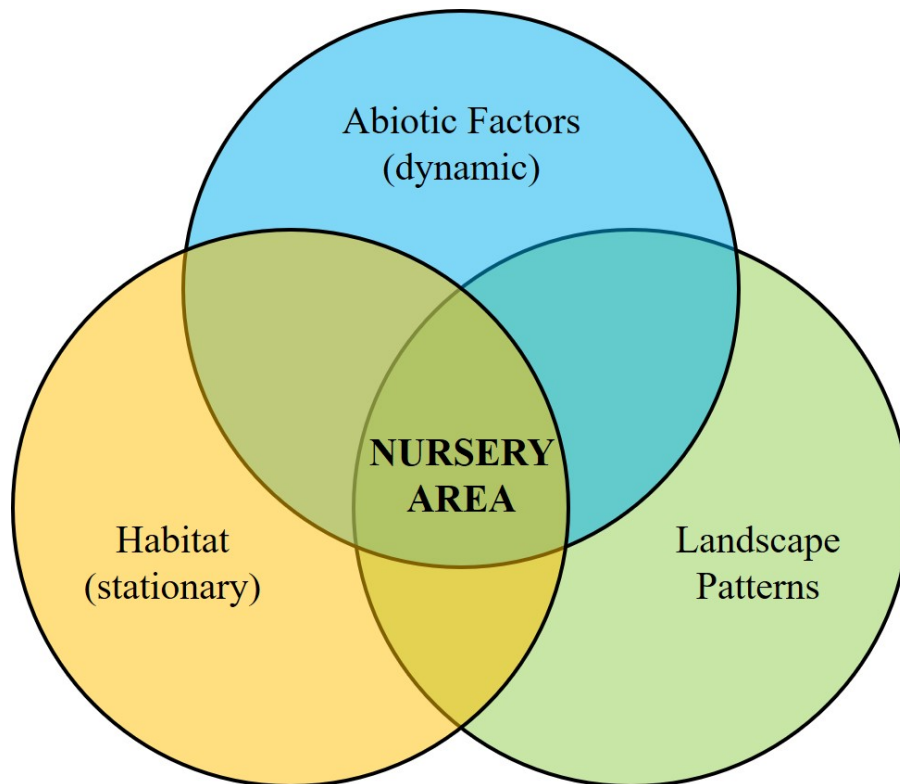


Figure 14. Depiction of the nursery area concept – the location where abiotic and habitat conditions, as well as the landscape setting are optimal for productivity. Abiotic factors – salinity, temperature, depth, currents; Habitat factors – wetlands, shell bottom, SAV, substrate; Landscape setting – geomorphology of the waterbody, proximity to inlets or adult habitat, habitat connectivity (adapted from Peterson 2003 and Beck et al. 2001).

Protecting existing coastal wetlands and SAV and taking steps to address losses is critical to maintaining production of shrimp. It is imperative the fishing community actively participate in the ongoing CHPP initiatives and add their voice to support the actions outlined in the CHPP.

Two objectives in this amendment relate directly to habitat protection and the CHPP:

DRAFT – SUBJECT TO CHANGE

- Promote the restoration, enhancement, and protection of habitat and environmental quality in a manner consistent with the CHPP.
- Develop a strategy through the CHPP to review current nursery areas and to identify and evaluate potential areas suitable for designation.

THREATS AND ALTERATIONS

Shrimp use a variety of estuarine and coastal ocean habitats and are found in most habitats identified by the CHPP (NCDEQ 2016). Adequate water quality is necessary to maintain the chemical properties of the water column required by shrimp, and the various habitats that support them (wetlands, submerged aquatic vegetation, shell bottom, and soft bottom). Human activities that degrade water quality or alter water flow can negatively impact shrimp growth or survival. Human activities and land use that increases nutrient loading can lead to prolonged periods of oxygen depletion in large areas of habitat (Jordan et al. 2018). Tidal creeks are considered critical nursery habitat for shrimp and can be particularly sensitive to land use and urban development (Sanger et al. 2015). As land modification occurs and impervious surfaces increase in areas adjacent to natural ecosystems, sedimentation, channelization, and toxin runoff events occur with greater frequency and severity. These events often become compounded since tidal creeks function as hydrological links to our estuaries (Sanger et al. 2015). As a result, low dissolved oxygen events, toxin contamination of sediments, and tidal creek channelization are probably the greatest water quality concerns for shrimp. For more information on other sources of water quality degradation, please refer to the CHPP (NCDEQ 2016).

Submerged aquatic vegetation (SAV), wetlands, shell bottom, and soft bottom, including inlets and the ocean floor, are habitats of particular importance as nursery, refuge, foraging grounds, and movement corridors for shrimp (Williams 1955; Williams 1958; Weinstein 1979; Rulifson 1981; Bielsa et al. 1983; Murphey and Fonseca 1995; Steele 2002). Portions of these habitats have been degraded or lost over time by a variety of anthropogenic activities. Although it is difficult to quantify how, and to what extent, habitat degradation may alter annual shrimp populations, it remains important for management to understand the impacts of habitat degradation on other estuarine species that rely on similar habitat for survival.

The primary gear used in the shrimp fishery is shrimp trawls. Bottom disturbing fishing gear can impact ecosystem function through habitat degradation and is well documented (NCDMF 1999; NCDMF 2015; NCDEQ 2016). Extensive damage to SAV can occur from trawl doors that dig into the sediment and uproot plants. The dragged chain can cut or damage the above-ground leaves, but this does not always result in complete mortality (ASMFC 2000). Shrimp trawls can elevate turbidity, reducing water clarity needed for SAV growth and survival. Loss and damage to SAV is detrimental to the estuarine system due to the large diversity of fish and invertebrates that are dependent on it as a nursery and foraging area (NCDEQ 2016). Shrimp trawling can cause structural damage to oyster reefs (Berrigan et al. 1991). Similarly, shrimp trawling can cause structural damage to ocean hard bottom. This habitat, consisting of exposed limestone rock encrusted with live organisms such as coral, sponges, and other invertebrates, is critical for supporting reef fish communities.

DRAFT – SUBJECT TO CHANGE

RESEARCH NEEDS

The research recommendations listed below (in no particular order) are offered by NCDMF to improve future management strategies of the shrimp fishery. They are considered high priority as they will help us to better understand the extent of bycatch from shrimp trawls, better manage the shrimp fishery, and meet the goal and objectives of the FMP. A more comprehensive list of research recommendations is provided in the annual FMP Review document and can be found at: <https://deq.nc.gov/about/divisions/marine-fisheries/managing-fisheries>.

- Create a long-term shrimp trawl observer program to characterize bycatch across all strata (for example: dominant species, protected species, season, areas, gear type, vessel type, number of nets/rigs, headrope length, TED position, etc.).
- Improve accuracy of self-reported license gear survey data or investigate other means of accurately obtaining shrimp fleet characteristics.
- Collect improved effort data (e.g., headrope length, number of nets, tow time, number of tows) to provide bycatch estimates based on actual time fished (or number of tows), rather than number of trips.
- Create and validate juvenile abundance indices for white and pink shrimp.
- Determine the cumulative impacts of shrimp trawl bycatch on individual species population dynamics and the ecosystem.

To gain a better understanding of the current magnitude and composition of discards in the shrimp trawl fishery, at sea observations are needed across all seasons, areas, and gears. Expanded characterization data across all segments of the fishery provides insight on gear selectivity and can aid in the development of new gear configurations to reduce bycatch. Due to the high variability of shrimp trawl bycatch data, additional information on tow duration and number of tows made during a trip is needed to expand discard estimates. Improved data on fleet characteristics and effort further allows fisheries managers to estimate total removals of bycatch species and produce more accurate stock assessments. Better estimates of shrimp trawl bycatch also allow managers to better understand how these removals alter the community structure of ecosystems. Fishery-independent monitoring programs need to be expanded to create juvenile abundance indices for white and pink shrimp to help managers estimate year class strength of all penaeid shrimp and further evaluate nursery areas.

CARRY FORWARDS FROM PREVIOUS PLANS

There are a few management measures that will be carried forward from previous plans and revisions to the N.C Shrimp Fishery Management Plan (NCDMF 2015, 2018) depending on the outcome of this amendment. These include: 1) requiring shrimp trawls, with the exception of skimmer trawls, to use BRDs or gear configurations that reduce finfish bycatch by at least 40% over a standard shrimp trawl consisting of a Florida fisheye BRD, a federally approved TED, and a 1.5-inch stretch mesh tailbag, 2) allowing any federally certified BRD to be used in areas where new BRD or gear configurations have not been established, and 3) requiring two approved BRDs to be used in shrimp trawls in areas where new BRD or gear configurations have not been established.

DRAFT – SUBJECT TO CHANGE

SHRIMP AMENDMENT 2 MANAGEMENT STRATEGY

This section to be completed when the NCMFC selects their preferred management strategies that are taken out to review by the DEQ secretary, Gov Ops, AgNEER, and fiscal research division.

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DRAFT – SUBJECT TO CHANGE

APPENDICES

APPENDIX 1. SHRIMP TRAWL BYCATCH ASSESSMENT

The focus of this appendix is to discuss: 1) methods and data needed to estimate the amount of bycatch in the shrimp trawl fishery and 2) methods for estimating bycatch reduction and the impacts to common bycatch species.

Calculating Bycatch Estimates

Though the need is widely recognized, characterizing the nature, composition, and magnitude of bycatch in the shrimp trawl fishery has proven difficult (Diamond et al. 2000; Davies et al. 2009; Wang et al. 2019). These difficulties are generally attributed to inadequate monitoring of many pertinent fishery characteristics including actual bycatch levels, effort of the directed fishery, variable fishing behavior, distribution and abundance of bycatch species, and the mortality rate of discarded species. The problem is exacerbated by the patchy distribution of fishing effort and juvenile finfish in both time and space. The amount of bycatch generally varies from tow to tow (and depends on many factors), with many tows having some bycatch and fewer tows with high bycatch (Diamond 2003; Fernandes et al. 2015).

Two methods are typically used to estimate shrimp trawl bycatch. One common method of estimating bycatch is the ratio method (fish:shrimp). While there are numerous ways to calculate the ratio, all forms of this method use some information about the ratio of kept and/or discarded bycatch to the target catch, usually at the tow, day, or trip level (i.e., per sample) caught by a gear or fishery and uses the reported landings of the target species multiplied by the ratio to estimate the total amount of bycatch (Diamond 2003; SEDAR 2014a). The main assumption with the ratio method is there is a direct linear relationship between the bycatch species and the target species, which often is not the case. For example, using data from NCDMF observer studies conducted from 2012 through 2017 (Brown 2015, 2016, 2017, and 2018), a linear regression was used to model the relationship between the observed daily spot (*Leiostomus xanthurus*) and shrimp catch (Figure 1.1). The results showed a weak, positive linear relationship with a r^2 of 0.23. This means only 23% of the variability in the catch data is explained by the linear relationship between spot and shrimp in the catch. Additionally, as more effective bycatch reduction devices (BRDs) are developed the relationship between the retained catch and the discarded catch will change (Wang et al. 2019). Another method used to estimate bycatch is the catch-per-unit-effort (CPUE) also called the bycatch-per-unit-effort (BCPUE) method. This method relies on fishery effort data and observer data or fishery-independent proxy data. Fishery-independent data used as a proxy may help characterize bycatch, but it is important to determine gear type/comparability caveats of any fishery-independent data used versus fishery-dependent data (SEDAR 2014a).

A comparison among several ratio methods and a CPUE method found the four ratio methods tested were more biased than the CPUE method. Additionally, the four ratio methods were more influenced by the mean or variance of the catch, observer coverage, and correlation between the bycatch and target catch (Diamond 2003). Similarly, Edwards et al. (2015) found that model-based bycatch estimates were preferred because they showed less bias than ratio estimators. Carbonell et al. (2017) furthered the use of CPUE based estimates by incorporating environmental variables

DRAFT – SUBJECT TO CHANGE

into their model to determine what environmental characteristics were related to higher rates of bycatch. However, in most cases the data needed to calculate reliable CPUE estimates for bycatch species are lacking. During the SEDAR (2014a) Procedural Workshop to evaluate shrimp data for assessment purposes and for bycatch estimation, several data requirements were identified based on methods used and can be found in Table 1.1.

The SEDAR (2014a) workgroup panel determined the ratio method was not the preferred method for bycatch estimation and noted it should be phased out as fishery effort time series become more reliable. The following issues were identified as potential problems with the ratio method:

- Difficult to separate fishing trends from fish population trends.
- Shrimp and fish populations are often on different trends. Unless there is a correlation between shrimp and the species of interest, should not use the ratio method.
- Should only use the ratio method when you have fishery-independent indices for shrimp and the fish species of interest so the ratio can be scaled.

The use of fishery-independent surveys to develop BCPUE estimates are not proxies alone for commercial BCPUE effort estimates but may be useful when combined with observer data. Fishery-independent surveys that use shrimping vessels and nets (e.g., SEAMAP) show much higher rates of BCPUE than observer programs, most likely due to differences in gear configuration, timing of sampling (day vs. night), and areas fished (randomly selected). However, fishery-independent indices may be correlated with commercial BCPUE, since both may reflect the abundance and availability of non-shrimp species. The Shrimp SEDAR Workgroup (2014a) recommended exploring the use of fishery-independent indices to tune BCPUE estimates where observer sample size is not adequate to produce year-specific BCPUE estimates.

Commercial shrimp trawl effort data currently collected through the NCDMF Trip Ticket Program include the number of trips and trip duration (not days fished) and may be insufficient to calculate reliable bycatch estimates depending on the desired effort metric for the fishery. The NCDMF and most other agencies do not typically collect more detailed effort data (e.g., number of fishing days, number of tows made during a trip or per day); although a few fisheries use logbooks to record effort metrics like tow time (Broadhurst et al. 2006; A. Bianchi, NCDMF, personal communication). Many of these more specific effort characteristics can be significant factors when estimating bycatch losses (e.g., mortality). Gear characteristics [i.e., number of nets, headrope length, BRD and turtle excluder device (TED) type and position, etc.] and strata (e.g., depth, season, area) are also important in calculating fishing effort (SEDAR 2014a).

While using the number of tows to represent effort rather than the number of trips or fishing days may be preferred it could present statistical problems. The variance in bycatch among tows in single day trips is likely less than for multi-day trips where tows are spread out over several days and likely over a broader spatial range. If the tows are not truly independent samples, then pseudoreplication would be a concern and result in imprecise variance estimates (Cochran 1977; Hurlbert 1984; Diamond 2003). Pseudoreplication occurs when samples are heavily dependent on each other. Since most trips in the North Carolina shrimp trawl fishery are single day trips (approximately 74% for otter trawls and 97% for skimmer trawls from 2012 through 2017; see Figure 2.4.5 in Appendix 2.4), there may be a high degree of covariance among tows in a trip. For example, if several tows are made in the same general area on the same day due to high catch rates

DRAFT – SUBJECT TO CHANGE

of shrimp, the tows, and therefore the amount of bycatch caught, would not be considered independent samples, and the resulting bycatch estimates may be biased as the variance in bycatch would be underestimated (Diamond 2003). In this instance, using the number of trips or number of fishing days rather than the number tows may be preferred. Additionally, assuming there is less than 100% observer coverage, there would need to be an independent estimate of the average number of tows per trip available to use as an expansion factor for unobserved trips (Diamond 2003).

Data Collection Methods

There are several methods for collecting the data needed to estimate discards including onboard observers, logbooks, fishery-independent surveys, and fisher interviews. The best method for collecting data on bycatch species is through an onboard observer program (Kennelly 1995; Babcock et al. 2003; Suuronen and Gilman 2020; Curtis and Carretta 2020). Other methods, like the ratio method, have been shown to produce unreliable discard estimates (Suuronen and Gilman 2020). Several studies give general guidance concerning the percentage of observer coverage needed to produce reliable bycatch estimates or methods for determining the percent coverage needed for the fishery or species of interest (Babcock et al. 2003; Borges et al. 2004; Curtis and Carretta 2020). SEDAR (2014a) recommended that observer coverage be increased with special attention to temporal and spatial factors such as seasons, day vs. night, and coverage of various fleets without compromising statistical design.

Although onboard observers are considered the gold standard for collecting reliable discard data, there are potential biases. Babcock et al. (2003) identified potential sources of bias such as non-random sampling (many programs are opportunistic and vessels volunteer to carry an observer) as well as changes in fishermen behavior in the presence of observers, among others. One way to check the latter is to compare catches of observed and unobserved trips. If the samples are unbiased, Babcock et al. (2003) suggests observer coverage levels of at least 20% for common species and 50% for rare species in fisheries with more than a few thousand trips per year (the NC shrimp trawl fishery averaged 7,248 trips per year from 2012 through 2017). Although, the actual level of coverage needed may be higher or lower depending on the size of the fishery, distribution of the catch and bycatch, and spatial stratification of the fishery.

Borges et al. (2004) evaluated optimum sampling levels in an observer program that considered both cost and precision objectives simultaneously and explored the dependence of sampling levels on both variables. They found that small budget reductions would result in marginal decreases in precision. However, increasing the precision by 50% would require unrealistic increases in sampling and associated program costs.

Due to the challenges of documenting rare-event bycatch, Curtis and Carretta (2020) developed a software package to help assess how much observer coverage is needed to estimate bycatch of rare-event species. In the North Carolina shrimp trawl fishery these may include species such as sheepshead (*Archosargus probatocephalus*), black drum (*Pogonias cromis*), Spanish mackerel (*Scomberomorus maculatus*), and sea turtles. The package predicts observer coverage performance based on three metrics: 1) the conditional probability of observing any bycatch given that bycatch occurred in the fishery and the probability of any bycatch in the total fishery effort, 2) the upper

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confidence limit for total bycatch when none is observed, and 3) precision of the bycatch estimate. The tool allows the user to explore how observer coverage targets may vary with total effort, bycatch per unit effort (BCPUE), and dispersion index.

The NCDMF does have limited shrimp trawl observer data that could be analyzed to help determine optimum observer coverage for the shrimp trawl fleet but with the low observer coverage in these studies its usefulness may be limited (Brown 2015, 2016, 2017, 2018). Likely stratifications for an observer program would include gear, season, and area to ensure estimates are unbiased and representative of the fleet. Vessel size is also a factor that could be considered when determining how to allocate observer coverage. One decision point that would need to be made is which species or suite of species should be used to determine the optimum percent observer coverage for the shrimp trawl fishery. Some potential species to use for determining the appropriate amount of observer coverage include Atlantic croaker, spot, and weakfish. Another decision to be made would be the minimum level of precision desired for bycatch estimates as more precise estimates will require more observer coverage and therefore make the program more expensive to operate.

Observer Program Logistics

Starting an observer program specifically for the shrimp trawl fleet would be similar to the one currently in place for estuarine gill nets. Past observer studies of the shrimp trawl fleet were done on a voluntary basis but to produce reliable estimates of bycatch participation in the program would need to be mandatory for fishermen/vessel operators. From past observer studies (Brown 2015, 2016, 2017, and 2018), 2014 was the year with highest percent observer coverage at 1.7% where 149 out of 8,531 trip days were observed (Table 1.2). The cost for this study was approximately \$150,000. To reach the 20% coverage recommended by Babcock et al. (2003), approximately 1,684 trip days would need to have been observed in 2014.

The number of observed trips days that would have been needed to achieve 20% observer coverage in 2014 was used here to estimate the additional resources needed by the division to operate a successful shrimp trawl fishery observer program. The high number of trip days in the shrimp trawl fishery necessitates the need for additional staff (14 permanent and 14 temporary) due to the number of observed trip days that would be needed annually. Additional staff would likely consist of 13 permanent technicians, 14 6-month temporary technicians, and one permanent biologist. In addition to funds for new staff, operating funds would also be needed to purchase and maintain field and office equipment, cover travel costs for sampling operations, and other expenses. The total estimated cost is approximately \$1.4 million (Table 1.3). Table 1.4 shows a breakdown of how many trip days per month on average each new staff member would need to observe to meet 20% observer coverage based on the number of trip days in 2014. The estimated number of trip days that would be observed annually is 1,728 and would have resulted in 20.3% observer coverage in 2014 (Table 1.5). Since 2014 had the lowest amount of trip days in the shrimp trawl fishery from 2012 to 2017, anywhere from 419 (2013) to 1,125 (2016) additional trip days would have to be observed to attain 20% observer coverage in those years. This increase in the number of observed trip days would likely further increase the cost of the observer program.

DRAFT – SUBJECT TO CHANGE

Logbook Program Logistics

A logbook program could be instituted in the commercial shrimp trawl fishery to gather additional effort information such as the number of tows per day or per trip, the total amount of headrope fished, and tow times for each tow. Implementing a commercial shrimp trawl fishery logbook program would be similar to the current North Carolina Trip Ticket Program (NCTTP). The NCTTP has two primary methods for reporting: paper forms and electronic submissions. It would make sense to also allow these two platforms for any potential logbook program (for example it would seem unfair to make all logbooks be reported electronically while trip tickets could still be reported via paper). The trip ticket templates for paper forms are specifically designed by fishery (shrimp, crab, finfish, etc.). Logbook templates may need to be designed for specific sectors of the shrimp trawl fishery and might need to be more specific than the trip ticket templates. For instance, it may be beneficial to have a specific logbook template for the shrimp otter trawl fishery and one for the skimmer trawl fishery, depending on the variables being collected. To report logbooks electronically, the software should be designed to allow for fishermen who are federally permitted to use the same platform to report to the state and the National Marine Fisheries Service (like what is in place for seafood dealers who are federally permitted).

The reporting frequency for any logbook program would also need to be considered. The NCTTP has a requirement for data to be turned in by the 10th of the following month. For a logbook program, a similar requirement would need to be put in place to track compliance (making sure logbooks are coming in when they are supposed to). Having logbooks submitted by the 10th of the following month would also work well because the industry and staff are already used to that schedule.

For the NCDMF Commercial Statistics Program to successfully implement a commercial shrimp trawl fishery logbook program more resources and staff would be needed. In license year 2020, there were 672 seafood dealer licenses issued (NCDMF 2020). Although not all seafood dealers reported trip tickets, all dealers were tracked for compliance purposes (seafood dealers who did not have any business still have to report to the NCTTP that they had no activity by the 10th of the month). In comparison, there were 350 to 450 fishing licenses with commercial shrimp trawl (otter and skimmer) landings in 2018 and 2019 (NCDMF 2020). Although the number of commercial fishing licenses is about 60% of the number of seafood dealers, compliance tracking would be more labor intensive because of the mobile nature of commercial fishermen compared to seafood dealers.

The data collected through a logbook program would be entered into the NCDMF Fisheries Information Network. For this to happen, new data tables would need to be developed as well as a new set of interface screens for NCDMF staff to enter the data. A process for submitting logbooks electronically would need to be developed as would a means to link logbook entries to their associated trip ticket.

The estimated cost to launch a commercial shrimp trawl fishery logbook program in North Carolina would be high. The NCTTP spends about \$15,000 a year to print trip tickets and another \$10,000 a year for a maintenance contract to support the software program used by our seafood dealers. Assuming a logbook would be a three-part form (as opposed to a four-part form used for

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trip tickets) and about two-thirds of commercial shrimp trawl fishermen would report by paper (similar to what we see with seafood dealers), it is estimated that logbook printing would be roughly \$11,250 a year. It is also reasonable to assume the software maintenance contract would increase because it would increase the number of users by 1.5 times (~\$5,000). There would also be additional cost to configure the current software for a logbook program which is estimated to cost about \$60,000. The operational costs of the program would also need to be considered (postage, supplies, computers, etc.) and are estimated at \$46,500. The additional staff needed to administer the program would include one data entry clerk (\$25,000), one data control clerk (\$31,000), two port agents (\$64,000), and one biologist/analyst (\$41,000). The total estimated cost for a commercial fisheries logbook program for North Carolina is \$283,250 (Table 1.6). There is also the additional burden to fishermen to consider for additional time spent recording, verifying, and submitting logbook entries. In some states where logbooks have already been implemented, fisheries managers are scaling back these efforts and relying more on dealer reporting due to the cost of their logbook program (D. Lupton, NCDMF, personal communication).

Quantifying Bycatch Reductions

The NCDMF does not have the minimum data necessary to produce reliable absolute estimates of shrimp trawl bycatch and hence cannot quantify potential reductions in bycatch from various management actions. However, proxies may be examined to give a reasonable estimate of the potential reduction in bycatch for some management measures under consideration. To serve as a proxy for potential bycatch reductions for some area closures under consideration in Amendment 2, data from one or more fishery-independent surveys could be examined as these provide useful information on the species composition and abundance on the fishing grounds (Kennelly 1995). For example, one method to evaluate the bycatch reduction potential of proposed closed areas in Pamlico Sound is to use data from the division's Pamlico Sound Survey to develop a proxy estimate for potential bycatch reductions. This could be done by determining the percent abundance of a particular species typically caught within the proposed closed area compared to the entire area sampled by the survey. While this is not a true estimate of bycatch reduction it would give managers some information about the potential effectiveness of management measures in achieving some level of bycatch reduction. This would have to be done once a potential closed area was identified and data from a recent year or group of years would be used to estimate past abundance and distribution, which can be highly variable. This also assumes the species of interest makes up approximately the same percentage of the catch in the Pamlico Sound Survey as it does in the commercial fishery which may not be the case due to differences in gear (e.g., mesh size, BRDs, TEDs), area fished (depth), time of day fished, and time of year fished (Pamlico Sound Survey only samples in June and September). A similar approach was used by Gücü (2012) to model potential reductions in bycatch based on depth and season closures in the Mediterranean Sea. The study found higher amounts of discards would be expected to occur in shallower depths during certain times of year and that by limiting effort in those areas and times discard losses could be mitigated.

Quantifying Impacts of Reducing Bycatch on Bycatch Species

Quantifying the impacts of reducing bycatch has proven to be a difficult task. Regardless of how large or small the bycatch estimate is for a species, the number is meaningless in the absence of a

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population estimate from a stock assessment (Kennelly 1995). While large populations may be able to withstand large amounts of bycatch losses, a small population may be unable to withstand even small losses (Diamond 2003). Further the life history strategy of a species may also affect its ability to withstand varying levels of bycatch losses. Species that mature quickly and produce large numbers of young (r-selected species), such as spot, may be able to accommodate higher levels of discards than a species that matures slowly and produces few young (k-selected species), such as Atlantic sturgeon (*Acipenser oxyrhyncus*). Even when a stock assessment is available and bycatch estimates are incorporated, reducing mortality from bycatch alone may not have the expected outcome if the bycatch species/life stage is subject to high rates of natural mortality (Kennelly 1995), as was the case with Gulf of Mexico red snapper (*Lutjanus campechanus*) (see below; Galloway et al. 2017; Galloway et al. 2020; Cowan 2010). To properly estimate the impact of bycatch losses for any species, estimates of natural mortality, biomass, length at age, and estimates of discard mortality are needed (Kennelly 1995). Accounting for discard losses is vital for fisheries managers to set accurate harvest limits. In fisheries where discard losses are a large portion of the catch, including or excluding discard losses can impact the yield, effort, and biomass at Maximum Sustainable Yield (MSY) as does the survival rate of the discarded catch (Guillen et al. 2014). Additionally, to gauge any potential positive population impacts of reducing bycatch, a stock assessment is needed that produces estimates of stock size through time to monitor population size prior to and after management action was taken. Given the life history and coast-wide distribution of many bycatch species [e.g., Atlantic croaker (*Micropogonias undulatus*), spot, weakfish (*Cynoscion regalis*)] any benefits to inshore fisheries may not be realized even with reductions in bycatch.

Weakfish in the Atlantic

Weakfish is managed as a single coast-wide stock with all states from Massachusetts through Florida having a declared interest in weakfish. The first stock assessment for weakfish occurred in 1991 and found the stock was overfished and overfishing was occurring (Vaughn et al. 1991). Management responded by requiring all states to 1) reduce exploitation (mortality) of weakfish by 15 to 25% in 1992, 2) implement minimum size limits of 10 inches in 1992, 11 inches in 1993, and 12 inches in 1994, 3) further reduce exploitation by 25% in 1993 and 1994, 4) South Atlantic states reduce shrimp trawl by catch of weakfish by 50% by 1994, and 5) implement mesh size restrictions for gill nets and finfish trawls to achieve a 75% escapement rate of undersized weakfish (Seagraves 1991). To comply with Amendment 1, North Carolina 1) required the use of BRDs beginning in 1992, 2) closed the ocean flynet fishery south of Cape Hatteras in 1994, 3) implemented minimum size limits for weakfish in 1992, and 4) implemented minimum mesh size requirements for gill nets and flynets in 1992. However, due to poor compliance from most states, Amendment 2 was adopted in 1994 (ASMFC 1994). The purpose of Amendment 2 was to allow full implementation of the management strategy in Amendment 1 under the newly passed Atlantic Coastal Fisheries Cooperative Management Act. The weakfish stock was assessed again in 1994 and found the stock was still overfished and overfishing was occurring (Gibson 1995). Amendment 3, adopted in 1996, required states to implement a 12-inch minimum size limit, set minimum mesh size requirements for gill nets and fish trawls that retained less than 25% of weakfish under 12 inches, and to strengthen BRD certification requirements. These measures were meant to reduce fishing mortality to $F=0.50$ by 2000 (Lockhart et al. 1996).

DRAFT – SUBJECT TO CHANGE

A new stock assessment for weakfish was completed in 2002 (Kahn 2002). The assessment showed that fishing mortality in 2000 was below the target of $F=0.50$ and that stock biomass had increased above the $SSB_{\text{threshold}}$ of 14,400 metric tons. The stock assessment was updated in 2006 (ASMFC 2006) and while the stock assessment was not formally accepted key points from the assessment were accepted for management use, they were 1) the stock is declining, 2) total mortality is increasing, 3) there was not much evidence for overfishing, 4) something other than fishing mortality was causing the decline in the stock, and 5) there is a strong chance that regulating the fishery would not, in itself, reverse stock decline.

In 2009 the stock was again assessed, and the results of the assessment indicated weakfish abundance had declined markedly, total mortality was high, non-fishing mortality had increased, and the stock was in a depleted state (NEFSC 2009). The weakfish stock was depleted and at an all-time low of 10.8 million pounds (4,899 metric tons). At that stock size, fishery removals (landings and dead discards combined) represented a significant proportion of the remaining biomass. While the decline in the stock primarily resulted from a change in the natural mortality of weakfish, it was further exacerbated by continued removals by the commercial and recreational fisheries. Natural mortality had risen substantially since 1995, with factors such as predation, competition, and changes in the environment having a stronger influence on recent weakfish stock dynamics than fishing mortality. Given the high natural mortality levels, stock projections indicated the stock was unlikely to recover rapidly, even under a harvest moratorium (NEFSC 2009).

A new stock assessment model was used in 2016 to assess the weakfish stock and found the stock was still depleted although there were some positive signs in SSB in the last few years of the assessment and that natural mortality had risen to levels that were preventing the stock from recovering (ASMFC 2016). With the advent of revised recreational landings estimates, the assessment was updated in 2019 (ASMFC 2019). The results differed little from the 2016 assessment, showing the stock was still depleted though there was a slight increase in SSB in the last few years.

Atlantic Croaker in the Gulf of Mexico and South and Mid-Atlantic Bights

Diamond et al. (2000) used matrix models to explore the population-level impacts of shrimp trawl bycatch on Atlantic croaker populations in the Gulf of Mexico and the South and Mid-Atlantic bights and explored tradeoffs between the directed adult fisheries and bycatch mortality in shrimp trawls. Based on a previous study (Diamond et al. 1999) their a priori assumptions were 1) both stocks were declining in abundance, 2) both populations were more sensitive to first-year survival than any adult year, 3) mortality in the late juvenile stage, which is primarily bycatch mortality, had a greater effect on population growth rates than mortality during any other first-year stage, and 4) Atlantic croaker in the Gulf were more affected by bycatch mortality than in the Atlantic because of higher bycatch levels in the Gulf.

Subsequent analysis showed both populations were more sensitive to adult survival than first-year survival. Bycatch mortality of late juveniles was not the most important factor affecting either population. Both populations were most sensitive to ocean larval mortality. In the Atlantic, this was followed by early juvenile and adult mortality. Although, bycatch mortality did have a

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negative impact on population growth rates they estimated that reducing late juvenile or adult mortality by 5% in the Atlantic would reverse the modest population decline seen in their model. They speculated that the BRDs currently being used in the fishery would achieve the 5% reduction in mortality.

South Carolina Trawl Net Closure

The inside waters of South Carolina's sounds and bays were consistently opened to trawling beginning in 1952. However, through time, conflict between large shrimping vessels and small shrimping vessels on whether the sounds and bays should remain open continued through the 1960s and 1970s. Small vessels preferred the sounds and bays remain open while the large vessels preferred them closed. Mid-sized vessels were evenly divided on the issue. By the 1980s, recreational fishermen and environmentalists became involved and asked for permanent closure of the sounds and bays to protect recreationally important finfish such as spotted sea trout (*Cynoscion nebulosus*) and red drum (*Sciaenops ocellatus*; Whitaker 1989). Bearden et al. (1985) examined all available information and provided a report concluding the policy of opening the sounds and bays had not increased or decreased the overall physical or economic yield of shrimp. It also indicated there was negligible impact of trawling on habitat, crabs, and fish in the sounds and bays.

However, at the request of shrimpers, recreational fishermen, and environmentalists, the South Carolina General Assembly closed the three sounds and one bay to commercial trawling for 1986 and 1987. The Crustacean Management section of the South Carolina Wildlife and Marine Resource Department (now the South Carolina Department of Natural Resources) set out to assess the closure through a fall trawl survey in the sounds and bays and a shrimp tagging program. Although it was pointed out that a two-year closure was too short to properly assess, it was concluded that:

1. Very few spotted seatrout and red drum were caught by trawling in the sounds and bays of South Carolina.
2. No evidence trawling in the sounds or along the ocean beaches caused any long-term decreases in finfish populations.
3. Loss of forage species was more difficult to assess but believe that serious impacts would have been realized long ago.
4. Shrimp were consistently larger in areas outside of the sounds compared to shrimp size inside the sounds. This may represent a greater economic yield but if there are greater losses from natural mortality before moving into the ocean, economic yield could decrease despite the increase in size.
5. It was concluded that shrimp and fish stocks had not been negatively affected from a biological standpoint by commercial shrimp trawling.

Gulf of Mexico Red Snapper

In the initial stock assessment (1995) for Gulf of Mexico red snapper, natural mortality of juveniles was thought to be low, and the assessment concluded approximately 80% of total juvenile

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mortality was from bycatch in the shrimp trawl fishery and was the reason for the stock decline (Goodyear 1995; Galloway et al. 2017). Management responded by requiring shrimp trawl bycatch mortality be reduced by 50% with no corresponding reductions from the directed fisheries (recreational and commercial). The reduction in shrimp trawl bycatch mortality was to be achieved by requiring the use of BRDs.

A new stock assessment conducted in 2005 determined the stock was still overfished because the BRDs did not meet the target reduction and harvest in the directed fisheries remained unchanged under the false assumption the bycatch reduction target was being met (SEDAR 2005; Galloway et al. 2017). The 2005 stock assessment also produced new estimates of juvenile mortality, attributing 33% of total juvenile mortality to shrimp trawls (much less than the initial stock assessment estimate of 80%) and natural mortality accounted for 67% of total juvenile mortality. Management again responded by not reducing harvest in the directed fisheries and instead opted to update BRD certification procedures (GMFMC 2006). A year later effort controls were established in the shrimp trawl fishery to reduce shrimp trawl effort in the western Gulf of Mexico by 74% in depths of 10-30 fathoms from 2001 to 2003 levels. In concert with this step, the quota for directed fisheries was reduced from 9.12 million pounds to 6.5 million pounds (GMFMC 2007) and was further reduced to 5 million pounds in 2008 and 2009. Only once harvest in directed fisheries was reduced did the stock begin to recover (Galloway et al. 2017). This should not be interpreted to mean that reducing bycatch mortality from shrimp trawls is unnecessary; however, it is likely not the only remedy needed to recover a depressed stock and, in some cases, reducing bycatch mortality may increase mortality from another source (natural mortality in the case of Gulf of Mexico red snapper). These types of counter-intuitive responses need to be considered and the effectiveness and impact of management measures need to be evaluated once implemented to ensure they result in the desired outcome (Pine III et al. 2009).

Summary

Below are a few summary points to consider:

- The CPUE method is preferred for calculating bycatch estimates because the ratio method is unreliable and prone to bias since it assumes a proportional relationship between the bycatch species and the target species.
- The level of observer coverage needed to attain reliable long-term estimates of shrimp trawl discards is likely high, as is the cost.
- In some instances, fishery-independent survey data may be used to provide guidance on potential bycatch reductions.
- Quantifying the impact of shrimp trawl bycatch on a species is difficult without an approved stock assessment for the species of interest.
- Reducing shrimp trawl bycatch alone is often not enough to recover an overfished stock.

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Tables

Table 1.1. Commercial shrimp bycatch estimation methods and corresponding data requirements (X) identified by the SEDAR Shrimp Workshop Panel (SEDAR 2014a).

Data Type	BYCATCH ESTIMATION METHODS		
	CPUE Method (King Mackerel; SEDAR 2014b)	CPUE Method (Sharks; SEDAR 2015)	Ratio Method (Atlantic Croaker Stock Assessment; ASMFC 2010)
Fishery Effort (Depth x Season x Strata x Gear Characteristics)	X	X	
Shrimp Catch	X (used to estimate effort)	X	X
Kept Bycatch/Fish			X (if available)
Discarded Bycatch/Fish	X (mortality estimate)	X	X
Fish age/length	X (Age-0 assumed)	X	X (Age-0 check assumption)
Fish BCPUE (observer CPUE)	X	X	
Fishery Independent CPUE)	X	X	
Minimum Data Requirement	Should be defined	Should be defined	Should be defined
BRD/TED-Type & Impact	X (need paired research)	X	X

X=Required

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Table 1.2. Summary of observer coverage percentages using trip days for the North Carolina shrimp trawl fishery from NCDMF bycatch characterization studies (Brown 2015, 2016, 2017, 2018). Fleet trip days data from the NCDMF Trip Ticket Program.
*Trip days includes shrimp trawl trips with durations of 1-6 days. Longer trips were excluded from the analysis and constituted 1.1% of the trips for 2012-2017.

Study Year	Study Months	Area	Gear	Observed Fishing Days	Total Trip Days (Sample Period)	Total Annual Trip Days	Percent Coverage (Sample Period)	Annual Percent Coverage
2012	Aug-Dec	Pamlico Sound	Otter Trawl	29	2,602	4,851	1.1	0.6
		Other Inshore	Otter Trawl	20	1,234	2,819	1.6	0.7
		Ocean	Otter Trawl	28	1,557	2,209	1.8	1.3
		<i>All</i>	<i>Otter Trawl</i>	77	5,393	9,879	1.4	0.8
	None	Pamlico Sound	Skimmer Trawl	0	3	6	0.0	0.0
		Other Inshore	Skimmer Trawl	0	957	1,092	0.0	0.0
		Ocean	Skimmer Trawl	0	0	0	0.0	0.0
		<i>All</i>	<i>Skimmer Trawl</i>	0	960	1,098	0.0	0.0
	Total	All Trawls		77	6,353	10,977	1.2	0.7
	2013	Jan-Dec	Pamlico Sound	Otter Trawl	39	4,856	4,856	0.8
Other Inshore			Otter Trawl	14	2,577	2,577	0.5	0.5
Ocean			Otter Trawl	43	2,091	2,091	2.1	2.1
<i>All</i>			<i>Otter Trawl</i>	96	9,524	9,524	1.0	1.0
None		Pamlico Sound	Skimmer Trawl	0	35	35	0.0	0.0
		Other Inshore	Skimmer Trawl	0	1,177	1,177	0.0	0.0
		Ocean	Skimmer Trawl	0	0	0	0.0	0.0
		<i>All</i>	<i>Skimmer Trawl</i>	0	1,212	1,212	0.0	0.0
Total		All Trawls		96	10,736	10,736	0.9	0.9
2014		Jan-Dec	Pamlico Sound	Otter Trawl	69	4,362	4,362	1.6
	Other Inshore		Otter Trawl	13	1,947	1,947	0.7	0.7
	Ocean		Otter Trawl	67	1,494	1,494	4.5	4.5
	<i>All</i>		<i>Otter Trawl</i>	149	7,803	7,803	1.9	1.9
	None	Pamlico Sound	Skimmer Trawl	0	23	23	0.0	0.0
		Other Inshore	Skimmer Trawl	0	705	705	0.0	0.0
		Ocean	Skimmer Trawl	0	0	0	0.0	0.0
		<i>All</i>	<i>Skimmer Trawl</i>	0	728	728	0.0	0.0
	Total	All Trawls		149	8,531	8,531	1.7	1.7
	2015	Jan-Aug	Pamlico Sound	Otter Trawl	23	3,520	5,794	0.7
Other Inshore			Otter Trawl	15	1,627	2,308	0.9	0.6
Ocean			Otter Trawl	28	621	2,358	4.5	1.2
<i>All</i>			<i>Otter Trawl</i>	66	5,768	10,460	1.1	0.6
Jan-Dec		Pamlico Sound	Skimmer Trawl	5	39	39	12.8	12.8
		Other Inshore	Skimmer Trawl	57	960	960	5.9	5.9
		Ocean	Skimmer Trawl	0	0	0	0.0	0.0
		<i>All</i>	<i>Skimmer Trawl</i>	62	999	999	6.2	6.2
Total		All Trawls		128	6,767	11,459	1.9	1.1
2016		Jan-Dec	Pamlico Sound	Otter Trawl	9	5,783	5,783	0.2
	Other Inshore		Otter Trawl	16	2,729	2,729	0.6	0.6
	Ocean		Otter Trawl	27	3,853	3,853	0.7	0.7
	<i>All</i>		<i>Otter Trawl</i>	52	12,365	12,365	0.4	0.4
	Jan-Dec	Pamlico Sound	Skimmer Trawl	0	119	119	0.0	0.0
		Other Inshore	Skimmer Trawl	20	1,217	1,217	1.6	1.6
		Ocean	Skimmer Trawl	0	0	0	0.0	0.0
		<i>All</i>	<i>Skimmer Trawl</i>	20	1,336	1,336	1.5	1.5
	Total	All Trawls		72	13,701	13,701	0.5	0.5
	2017	July-Dec	Pamlico Sound	Otter Trawl	8	6,259	6,440	0.1
Other Inshore			Otter Trawl	10	1,983	2,685	0.5	0.4
Ocean			Otter Trawl	2	2,576	4,353	0.1	0.0
<i>All</i>			<i>Otter Trawl</i>	20	10,818	13,478	0.2	0.1
July-Dec		Pamlico Sound	Skimmer Trawl	0	275	287	0.0	0.0
		Other Inshore	Skimmer Trawl	15	473	494	3.2	3.0
		Ocean	Skimmer Trawl	0	5	5	0.0	0.0
		<i>All</i>	<i>Skimmer Trawl</i>	15	753	786	2.0	1.9
Total		All Trawls		35	11,571	14,264	0.3	0.2

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Table 1.3. Estimated cost for implementing a commercial shrimp trawl observer program for the NC shrimp trawl fishery.

Category	Number of Staff	Unit Cost	Estimated Cost
Observer Field Supplies	28	\$2,000	\$56,000
Travel (Food, Lodging, Mileage)	28	\$17,808	\$498,624
Other	28	\$1,500	\$42,000
Staff			
Permanent Technician	13	\$36,000	\$468,000
6-month Temporary Technician	14	\$20,000	\$280,000
Biologist	1	\$45,000	\$45,000
Total			\$1,389,624

Table 1.4. Estimated number of trip days observed by position per month and year, number of trip days observed per year by position type, and total number of trip days observed per year for the NC shrimp trawl fishery.

Position Type	Number of Trip Days Observed / Person / Month	Total Number of Trip Days Observed / Person / Year	Total Number of Staff	Total Number of Trip Days Observed / Year / Position Type
Permanent Technician	7	84	13	1,092
6-month Temporary Technician	7	42	14	588
Permanent Biologist	4	48	1	48
Total Number of Trip Days Observed/Year				1,728

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Table 1.5. Estimated observer coverage for proposed level of observed trip days and number of trip day observations needed to attain 20% observer coverage for the NC shrimp trawl fishery, 2012-2017.

Year	Number of Trip Days	Proposed Observed Trip Days	Percent Observer Coverage	Observed Trip Days Needed for 20% Observer Coverage
2012	10,977	1,728	15.7	2,195
2013	10,736	1,728	16.1	2,147
2014	8,531	1,728	20.3	1,706
2015	11,459	1,728	15.1	2,292
2016	13,701	1,728	12.6	2,740
2017	14,264	1,728	12.1	2,853

Table 1.6. Estimated cost for implementing a commercial logbook program for the NC shrimp trawl fishery.

Category	Number of Staff	Unit Cost	Estimated Cost
Logbook Printing	-	-	\$11,250
Software Maintenance Contract	-	-	\$5,000
Software Configuration	-	-	\$60,000
Operational Cost	-	-	\$46,000
Staff			
Data Entry Clerk	1	\$25,000	\$25,000
Data Control Clerk	1	\$31,000	\$31,000
Port Agent	2	\$32,000	\$64,000
Biologist	1	\$41,000	\$41,000
Total			\$283,250

Figures

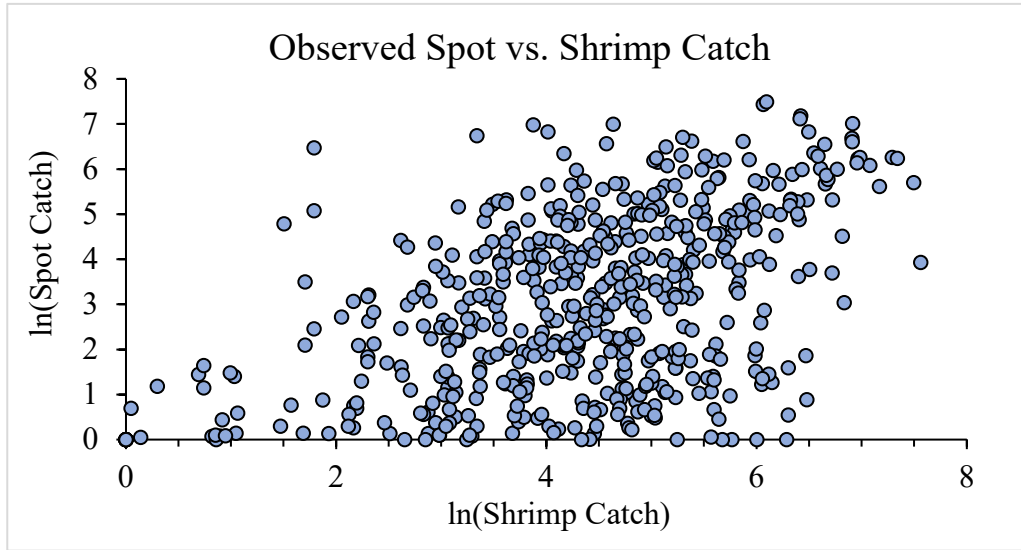


Figure 1.1. Plot of the natural log (ln) of spot (kg) versus the ln of shrimp (kg) in observed shrimp trawl catches, 2012-2017.

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APPENDIX 2. ISSUE PAPERS

APPENDIX 2.1. MANAGEMENT OF SHRIMP TRAWLING FOR PROTECTION OF CRITICAL SEA GRASS AND SHELL BOTTOM HABITATS

I. ISSUE

Providing additional protections for critical sea grass and shell bottom habitats through shrimp trawl area closures.

II. ORIGINATION

The North Carolina Division of Marine Fisheries (NCDMF) Shrimp Plan Development Team (PDT) and the public.

III. BACKGROUND

North Carolina’s estuarine system is the largest of any coastal state along the eastern Atlantic seaboard and encompasses a diverse aquatic system of estuarine rivers, creeks, large sounds, and inlets totaling over 2.2 million acres (Deaton et al. 2010; NCDMF unpublished data). Framed by a chain of low-lying barrier islands from Virginia to the Cape Fear River, these habitats include intertidal and subtidal oyster reefs and extensive submerged aquatic vegetation (SAV) beds which provide a litany of ecosystem services, including shoreline stabilization, storm water filtration, and critical habitat for a variety of juvenile finfish and shellfish species. Furthermore, this estuarine system provides North Carolina access to a variety of commercially and recreationally important fisheries, including shrimp, blue crab (*Callinectes sapidus*), oysters (*Crassostrea virginica*), southern flounder (*Paralichthys lethostigma*), spotted seatrout (*Cynoscion nebulosus*), and red drum (*Sciaenops ocellatus*). In addition, the estuarine waters of North Carolina provide important habitat for many interjurisdictional managed species including Atlantic croaker (*Micropogonias undulatus*), spot (*Leiostomus xanthurus*), and weakfish (*Cynoscion regalis*). Given these characteristics, it is clear the habitats which make up North Carolina’s estuarine system hold tremendous ecological, economic, and social value for the citizens of North Carolina and warrant management measures that guarantee their persistence.

While there are several major threats to the overall health of these habitats (i.e., pollution, coastal development, climate change, etc.), one of particular concern in North Carolina is the use of bottom disturbing fishing gears (i.e., trawls and dredges). Bottom trawls are conical nets pulled behind vessels along the benthos and are the primary fishing gear used to harvest shrimp (see *Description of the Fisheries* section of Amendment 2 for full description of gear). The potential environmental impact of using this gear has been extensively studied in a variety of habitat types ranging from flat sand and mud bottoms to structured habitats, including piled boulders, live bottom, seagrass, kelp beds, and coral reefs (Dorsey and Pederson 1998; Auster 1998; Hiddink et al. 2017; Sciberras et al. 2018). Findings from these studies suggest mobile fishing gear can significantly reduce habitat complexity by smoothing the bottom and removing structures that provide essential refuge and resources to a variety of benthic predator and prey species (Dorsey and Pederson 1998). Trawling also increases turbidity in many areas which can slow the growth of primary (algae and

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plants) and secondary producers (organisms that consume other organisms), limit nutrient regeneration, and disrupt the feeding relationships of all organisms within the ecosystem (the food web).

The magnitude of trawling disturbance is highly variable, ranging from no apparent effect to the complete elimination of some species, and can introduce long-term changes within the benthic community. The ecological effect of trawling depends upon site-specific characteristics of the ecosystem such as bottom type (sand, mud, shell, grass, reef, etc.), water depth, type of animal community (small vs. large sized species, short-lived vs. long-lived species, mobile vs. immobile species), type of trawl employed, and the intensity and duration of trawling and natural disturbances. The rate of recovery for benthic communities following bottom fishing disturbance events is also highly dependent on the habitat type. In other words, communities typically inhabited by sessile organisms with slow growth rates tend to also exhibit slow recovery rates (i.e., coral reefs, oyster reefs, etc.) following a disturbance. Conversely, habitats that experience consistent disturbance from storm events, wave action, and high tidal flow are commonly inhabited by fast growing, short-lived species which are generally capable of rapid recovery (NRC 2002).

Trawling Effects on Shell Bottom

For a complete review of habitat requirements, distribution, ecological role and functions, fish use, biological functions and status of shell bottom see the North Carolina Coastal Habitat Protection Plan (CHPP) Source Document (NCDEQ 2016).

Shell bottom is estuarine intertidal or subtidal bottom composed of surface shell concentrations including living or dead oysters (*Crassostrea virginica*), hard clams (*Mercenaria mercenaria*), or other shellfish (Street et al. 2005; NCDEQ 2016). Oyster rocks form a complex three-dimensional structure of accumulating shells and oysters over the course of many years and provide critical habitat for the settlement of larval oysters, sessile filter feeding organisms, and refuge for small fish and invertebrates. Shell bottom is widely recognized as essential fish habitat (EFH) for oysters and other reef-forming mollusks (ASMFC 2007). Shell bottom also provides ecosystem resilience by improving water quality through filtration (ASMFC 2007; Wall et al. 2008).

The more complex the habitat structure, the more susceptible the habitat is to disturbance by mobile bottom fishing gear (Auster 1998). Shell bottom is a complex habitat that is affected by both oyster dredges and otter trawls. Trawling over oyster reefs negatively impacts live shell bottom habitat by disturbing the structure of the reefs, reducing and scattering the upper layers of shell with the movement of trawl doors or chain as the gear is fished over the structure (NCDMF 2001; Street et al. 2005). In addition, trawling can significantly reduce epifaunal organisms in shell beds and recovery can take an extended period (Cook et al. 2013).

Shellfish rehabilitation and cultch planting has continuously occurred in North Carolina since the early 1900s. To date, millions of bushels of shell and fossil rock have been deposited into coastal estuaries from Dare to Brunswick counties. In most cases, cultch planting sites are not re-enhanced, rather new sites in new areas are built every year, resulting in thousands of sites in almost every suitable water body along the coast with reliable records for cultch planting dating back to 1981, detailing 1,648 reef sites (J. Peters, NCDMF, personal communication). For a complete review of

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the history of shellfish rehabilitation and cultch planting in North Carolina, see the North Carolina Oyster Fishery Management Plan (FMP; NCDMF 2001) and Amendment 4 of the North Carolina Oyster FMP (NCDMF 2017).

Oyster sanctuaries are protected under North Carolina Marine Fisheries Commission (NCMFC) Rule 15A NCAC 03K .0209 and delineated in NCMFC Rule 15A NCAC 03R .0117, which prohibits oyster harvest and use of trawls, long haul seines, and swipe nets therefore promoting growth and enhancing survivability of large oysters within the sanctuaries (Table 2.1.1). Oyster sanctuaries under construction but not yet incorporated into NCMFC Rule 15A NCAC 03R .0117 can be protected under NCMFC Rules 15A NCAC 03H .0103 and 15A NCAC 03K .0103 through proclamation authority.

Ongoing efforts to identify suitable areas for oyster restoration may include cultch planting and other oyster protections in areas where trawling currently occurs. State posted oyster plantings are protected from any type of trawling or seining when designated as shellfish management areas under NCMFC Rule 15A NCAC 03K .0103. NCMFC Rule 15A NCAC 03K .0103 gives the Fisheries Director proclamation authority to designate shellfish management areas in areas with suitable environmental conditions necessary for shellfish growth or areas that have shellfish populations or shellfish enhancement projects. Within shellfish management areas, it is unlawful to use trawl nets, long haul seines or swipe nets. These areas must be marked with signs or buoys.

Posting of natural oyster beds has never been attempted because of the large number of areas and lack of sufficient resources for enforcement. Some areas where enhancement activities are conducted, and shell fishing activities are restricted or prohibited, except by proclamation, are designated as shellfish management areas.

Seed oyster management areas are open harvest areas that, by reason of poor growth characteristics, predation rates, overcrowding or other factors, experience poor use of oyster populations for direct harvest and sale to licensed dealers and are designated by the NCMFC as a source of seed for public and private oyster culture. Seed oyster management areas are designated in NCMFC Rule 15A NCAC 03R .0116 and trawl nets, long haul seines, and swipe nets are unlawful to use in designated seed oyster management areas.

Trawl Effects on Submerged Aquatic Vegetation (SAV)

For a complete review of habitat requirements, distribution, ecological role and functions, fish use, biological functions and status of SAV habitat see the North Carolina CHPP Source Document (NCDEQ 2016).

SAV is fish habitat dominated by one or more species of underwater vascular plants. The NCMFC defines SAV habitat as submerged lands that (NCMFC Rule 15A NCAC 03I .0101 (4)(i); NCDEQ 2016):

- i. Are vegetated with one or more species of submerged aquatic vegetation including bushy pondweed or southern naiad (*Najas guadalupensis*), coontail (*Ceratophyllum demersum*), eelgrass (*Zostera marina*), horned pondweed (*Zannichellia palustris*),

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naiads (*Najas* spp.), redhead grass (*Potamogeton perfoliatus*), sago pondweed (*Stuckenia pectinata*, formerly *Potamogeton pectinatus*), shoalgrass (*Halodule wrightii*), slender pondweed (*Potamogeton pusillus*), water stargrass (*Heteranthera dubia*), water starwort (*Callitriche heterophylla*), waterweeds (*Elodea* spp.), widgeon grass (*Ruppia maritima*) and wild celery (*Vallisneria americana*). These areas may be identified by the presence of above-ground leaves, below-ground rhizomes, or reproductive structures associated with one or more SAV species and include the sediment within these areas;

Or

- ii. have been vegetated by one or more of the species identified in Sub-item (4)(i)(i) of this rule within the past 10 annual growing seasons and that meet the average physical requirements of water depth (six feet or less), average light availability (Secchi depth of one foot or more), and limited wave exposure that characterize the environment suitable for growth of SAV. The past presence of SAV may be demonstrated by aerial photography, SAV survey, map, or other documentation. An extension of the past 10 annual growing season's criteria may be considered when average environmental conditions are altered by drought, rainfall, or storm force winds.

SAV is included as fish habitat under NCMFC rules defined above, modified to include low salinity species and to address difficulties in identification of SAV habitat in 2009. The previous definition required the presence of leaves, shoots, or rhizomes. However, because the presence of SAV varies seasonally and inter-annually, a single inspection could result in improper habitat determination. The modified rule defines habitat to include areas where SAV is present, or areas where there is documentation of professional knowledge of its presence within the past ten growing seasons.

SAV occurs in subtidal and intertidal zones and provides refuge, forage, spawning and nursery areas for many organisms including red drum, spotted seatrout, snapper/grouper, bay scallops (*Argopecten irradians*), and penaeid shrimp. SAV provides important ecosystem functions such as structural complexity, sediment and shoreline stabilization, primary productivity, and nutrient cycling.

There are two distinct groups of SAV ecosystems in NC distributed according to estuarine salinity. One group, referred to as low salinity SAV, thrives in fresh and low salinity riverine waters (<10 ppt). The second group, referred to as high salinity SAV or seagrass, occurs in moderate to high (>10 ppt) salinity estuarine waters of the bays, sounds, and tidal creeks. These groups are distinguished by different species composition and living requirements, and have characteristics similar to SAV communities found in many other estuaries in the U.S. While most SAV is found in water depths less than six feet, Costa (1988) noted in Buzzards Bay Massachusetts in poorly flushed areas where water transparency is poor, eelgrass was only present in shallower depths (2.0-5.9 feet) while in well flushed offshore waters eelgrass was found in deeper depths (9.8-19.7 feet). It is difficult to gauge the historic extent of SAV distribution in North Carolina because of inadequate records. However, journal accounts from fishermen describe SAV beds in coves along mainland Pamlico Sound during the 1800s where it was absent in the late 1990s (NCDEQ 2016).

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In addition, historic accounts have documented the presence of SAV in the upper portions of the Neuse and Pamlico rivers and in areas of Albemarle Sound.

Natural events, human activities, and climate change influence the distribution and quality of SAV habitat. Natural events include shifts in salinity due to drought and excessive rainfall, animal foraging, storm events, temperature, and disease. SAV is vulnerable to water quality degradation, in particular suspended sediment and pollutant runoff (NCDEQ 2016). The majority of SAV loss can be attributed to large-scale eutrophication (nutrient enrichment) and sedimentation, which reduces light penetration to the plants (Costello and Kenworthy 2011). It should be noted in North Carolina, even in areas where shrimp trawling is prohibited, like Albemarle Sound, Currituck Sound, upper Neuse River, upper Pamlico River, Pungo River, and most primary and secondary nursery areas (Figures 2.1.1a), SAV is either absent or limited to depths less than six feet suggesting factors other than shrimp trawling limit the extent of SAV distribution.

Bottom disturbing fishing gears can damage SAV by shearing blades, seeds and/or flowers, uprooting or burying entire areas of habitat, or increasing turbidity causing a reduction in light required for critical metabolic processes like photosynthesis. Impacts from trawling over SAV may occur from the sweep of the net or the digging of the trawl doors into the sediment (ASMFC 2000). Estimates of maximum cutting depth for otter trawl doors range from an inch to a foot (2.54-30.48 cm) when used in depths over 100 feet (30.48 m; ASMFC 2000), although such deep water does not occur in North Carolina's estuaries. Variation in cutting depth is the result of differences in gear weight, bottom hardness and towing warp to depth ratios (a measure of the force of the gear). Little information exists on the direct impact of trawling over SAV; however, impacts can be intuitively applied based on knowledge of trawl design and mechanics and the effects of trawling in other habitats.

SAV beds on the eastern side of Pamlico, Core and Back sounds are directly protected from the impacts of trawl nets via a trawl net prohibited area (NCMFC Rule 15A NCAC 03R .0106) and SAV beds north of the Intracoastal Waterway (IWW) and on the western end of Bogue Sound and in New River are protected via proclamation (NCDMF 2007). Additionally, mechanical clam harvest areas (MCHA) in Core Sound and North River have been modified and the MCHA in Bogue Sound was eliminated by proclamation to avoid overlap with SAV habitat (Proclamation SF-7-2020). SAV beds are indirectly protected from trawls via designation of primary, secondary, and special secondary nursery areas.

Trawl Effects on Soft Bottom

Most bottom trawling in North Carolina occurs over soft bottom habitat. For a comprehensive review of the impact of trawling on sediment and productivity in North Carolina waters see NCDMF (1999), NCDMF (2014a), and NCDEQ (2016).

Soft bottom covers approximately 1.9 million acres, or 90% of the 2.1 million acres of estuaries and coastal rivers in North Carolina (Riggs 2001). Soft bottom is unconsolidated, unvegetated sediment that occurs in freshwater, estuarine, and marine systems. It is found in both subtidal and intertidal zones and can be characterized by geomorphology (the shape and size of the system), sediment type, water depth, hydrography, and salinity (Street et al. 2005). As with other habitats,

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damage from bottom-disturbing fishing gear varies with gear type and habitat complexity. Because of a lack of structure and complexity, soft bottom habitats are considered the habitat which may be most resilient to damage by bottom-disturbing gear.

Trawling in sandy and muddy areas causes resuspension of bottom sediments resulting in increased turbidity and alteration of grain sizes. Besides the resulting turbidity, grain size of the sediment as it settles back to the bottom can be altered. Tidal transport of fine-grained sediments can alter the sediment composition by increasing average grain size of the trawled bottom (NCDMF 1999). Sandy substrate located in shallow high energy areas are regularly disturbed by natural physical processes and recover quickly (Posey et al. 1996; Kaiser 1998). Deeper (greater than 40 feet), high energy areas may also experience significant sediment disturbance from storm events, wave action and currents (Posey et al. 1996; van Denderen et al. 2015; Lambert et al. 2017). These areas would be expected to recover quickly from trawling disturbances, while areas that are deep and muddy with little natural disturbances are slow to recover from physical processes or trawling disturbances (DeAlteris et al. 1999).

Multiple studies have examined the effect of trawling on sediment in estuaries (Barnette 2001). Generally, resuspension of sediment is caused by trawl doors penetrating the sediment with depth of penetration being influenced by sediment composition and type of trawl (Delapenna et al. 2006). However, the depth of penetration by any part of the gear is always greater in muddy substrate compared to sandy substrate (NCDMF 1999). In a metanalysis of global bottom trawl studies otter trawl doors (2.44 cm on average) were found to penetrate the sediment less than other trawl types including beam trawls (2.72 cm), towed scallop dredges (5.47 cm), and hydraulic dredges (16.11 cm; Hiddink et al. 2017).

In South Creek, a tributary of the Pamlico River in NC, bottom trawling increased total suspended solid (TSS) concentrations one to three times more than pre-trawl levels, with concentrations returning to pre-trawl levels by the next day (Corbett et al. 2004). Under high wind and current conditions TSS dispersed throughout the water column but redeposited relatively quickly when wind and current were low. In Hillsborough Bay, a shallow microtidal estuary on the Gulf coast of Florida, suspended sediment concentrations had similar increases from trawling and large vessel wakes with plumes persisting for eight hours and sediment transport dependent on currents and sediment type (Schoellhamer 1996). Generally, in shallow waters, like Pamlico Sound with an average depth of 16 feet, wind has been shown to cause as much resuspension of sediment as trawling (Cahoon et al. 2002; Corbett et al. 2004). Recovery from bottom trawl disturbance is dependent on sediment type, depth, currents and bioturbation (Barnette 2001).

Globally, marine sediments are an important carbon sink (Atwood et al. 2020), and shallow coastal waters, like North Carolina estuaries, can serve as carbon sinks (Crosswell et al. 2014). Under certain conditions, bottom disturbance, including bottom trawling, can re-mineralize sedimentary carbon to CO₂. At a global scale, estimates of the amount of aqueous CO₂ emissions from disturbed marine sediments are comparable to estimates of carbon loss from soil during terrestrial farming, though global estimates of CO₂ released from bottom trawling are preliminary and represent a best estimate based on available data that require further research to verify (Sala et al. 2021). Carbon stocks in marine sediments vary across depths and regions with almost four times as much carbon in deep sea sediment (>1,000 meters; >3,281 feet) than in shallow seas (Atwood et al. 2020),

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though this largely due to the extreme difference in total area. While generally functioning as carbon sinks, shallow estuarine areas, like Pamlico Sound, can also become carbon sources during periods of high winds (Crosswell et al. 2014). The extent to which disturbance from bottom trawling releases carbon from sediments in Pamlico Sound compared to carbon released from natural events is unknown and requires further work.

Bottom disturbance can also resuspend pollutants like heavy metals, polycyclic hydrocarbons (PAHs), petroleum hydrocarbons, polychlorinated biphenyls (PCBs), and pesticides bound to sediment particles. Toxins can affect benthic invertebrates by inhibiting or altering reproduction or growth, and in some cases causing mortality (Weis and Weis 1989). Because low concentrations of heavy metals in the water column can be easily incorporated into fine grained sediment, particularly organic rich muds which is a common bottom type in North Carolina estuaries, chemicals can accumulate in the sediment to toxic levels and be resuspended into the water column (Riggs et al. 1991). In Hancock and Slocum creeks, Corbett et al. (2009) found higher rates of sedimentation and contamination in sediment than in the higher energy Neuse River mainstem. Resuspension of sediments where heavy metals and other contaminants are found could have serious consequences with more significant effects where contaminants are found in higher concentrations (i.e., near areas affected by major industrialization; Barnette 2001), though the extent to which contaminants may be resuspended by natural processes compared bottom disturbance by trawls is unknown.

General Impacts of Trawling

For a comprehensive review of the impact of trawling on sediment and productivity in North Carolina waters, see NCDMF (1999), NCDMF (2014a), and NCDEQ (2016).

The effects of trawling on benthic habitat have been well documented (NCDMF 1999; Barnette 2001; NCDEQ 2016; Hiddink et al. 2017; Sciberras et al. 2018). Impacts from mobile bottom-disturbing fishing gear, like shrimp trawls, range from changes in community composition from removal of species to physical disruption of the habitat (Barnette 2001).

Bottom trawling is generally more damaging when occurring over structurally complex biotic habitat like oyster reefs, or SAV (Althaus et al. 2009; Cook et al. 2013) when compared to effects on sandy shallow soft bottom that is lacking structure but can also be damaging to these habitats depending on composition of sediment and type of trawl (Brown 1989; Engel and Kvitek 1998; Collie et al. 2000; Hiddink et al. 2017; Sciberras et al. 2018). However, in many areas, including deep sea habitats, bottom disturbance from natural processes is similar to bottom disturbance from trawls depending on many factors including depth and sediment type (Diesing et al. 2013; van Denderen et al. 2015; Lambert et al. 2017). In areas of high natural disturbance, the benthic community is more resilient to bottom trawl impacts and recovers quickly from disturbance (van Denderen et al. 2015). Bottom trawling can reduce small scale habitat complexity (Auster and Langton 1999) and reduce epifauna abundance and diversity (Kaiser and Spencer 1996; Hinz et al. 2008). Primary productivity can be reduced due to increased turbidity, disruption of the benthic microalgae, and secondary effects on the food chain (West et al. 1994). Increased turbidity reduces light penetration and consequently, the primary productivity of benthic microflora on the seafloor, as well as phytoplankton in the water column (Auster and Langton 1999). The sediment

DRAFT – SUBJECT TO CHANGE

composition of the bottom can also change with frequent trawling. Given the close relationship between sediment size and benthic community structure, this sediment shift will alter the benthic community (Thrush and Dayton 2002).

Shrimp trawling can reduce or degrade structure and habitat complexity by disturbing epifauna, smoothing bedforms, and removing organisms but the magnitude of trawling disturbance is highly variable depending on habitat type, gear type, intensity, and duration of trawling and natural disturbances (Barnette 2001).

Critical Habitat Areas

The 1996 amendment to the federal Magnuson-Stevens Act recognized the loss of marine and estuarine habitat as a long-term threat to the viability of U.S. fisheries and emphasized habitat conservation as an important component of fisheries conservation and management. The amendment defined essential fish habitat (EFH) as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity.” (Magnuson-Stevens Act 16 U.S.C. 1802 §3(10)) and designated habitat areas of particular concern (HAPC) as a subset of EFH. Designations do not confer any specific habitat protections but can focus habitat conservation efforts. The federal councils have taken a range of approaches to designating HAPCs. The South Atlantic Fishery Management Council (SAFMC) designates specific habitat types (i.e., SAV) and discrete sites with known boundaries (e.g., the “Point” and “Ten Fathom Ledge”) as HAPCs while the Gulf and Caribbean Councils designate discrete areas (MAFMC 2016). The Mid-Atlantic Fishery Management Council (MAFMC) and the Atlantic States Marine Fisheries Commission (ASMFC) use the more general and broad application of the HAPC terminology by designating habitat types and not discrete sites. The National Marine Fisheries Service (NMFS) has encouraged the councils to shift HAPC designations from broad habitat types to discrete, geographically defined sites for more effective management (SAFMC 2016).

Shallow habitats with structure, such as SAV and oyster reefs, provide more predator protection and food than soft bottom habitat, enhancing growth and survival of juvenile fish (Lehnert and Allen 2002; Ross 2003; Grabowski et al. 2005). Multiple studies have documented that abundance of penaeid shrimp, sciaenids (fish in the drum family including Atlantic croaker, spot, red drum, spotted seatrout, etc.), and other estuarine dependent species is significantly greater in SAV, and oyster reef habitat than in soft bottom habitat (NCDEQ 2016). Shell bottom is widely recognized as EFH for oysters and other reef-forming mollusks (ASMFC 2007). In addition to its role as EFH for oysters, shell bottom provides critical fisheries habitat for ecologically and economically important finfish, mollusks, and crustaceans. The SAFMC considers shell bottom to be EFH for black drum (*Pogonias cromis*), striped bass (*Morone saxatilis*), weakfish, spotted seatrout, summer flounder (*P. dentatus*), and southern flounder and SAV is considered EFH for shrimp, red drum, snapper and grouper species, and spiny lobster (*Palinuridae* spp.).

IV. AUTHORITY

North Carolina General Statutes

§ 113-134 RULES

§ 113-173 RECREATIONAL COMMERCIAL GEAR LICENSE

DRAFT – SUBJECT TO CHANGE

§ 113-182 REGULATION OF FISHING AND FISHERIES

§ 113-182.1 FISHERY MANAGEMENT PLANS

§ 113-221.1 PROCLAMATIONS; EMERGENCY REVIEW

§ 143B-289.52 MARINE FISHERIES COMMISSION – POWERS AND DUTIES

North Carolina Marine Fisheries Commission Rules

15A NCAC 03H .0103 Proclamations, General

15A NCAC 03J .0104 Trawl Nets

15A NCAC 03K .0103 Shellfish Management Areas

15A NCAC 03K .0208 Seed Oyster Management Areas

15A NCAC 03K .0209 Oyster Sanctuaries

15A NCAC 03L .0101 Shrimp Harvest Restrictions

15A NCAC 03L .0103 Prohibited Nets, Mesh Lengths and Areas

V. DISCUSSION

- Section focuses on habitat protections in areas from Core Sound and South
- Management options in *Appendix 2.2: Shrimp Management in Special Secondary Nursery Areas* and *Appendix 2.3: Reducing Shrimp Trawl Bycatch Through Area Closures that Increase Connectivity Between Closed Areas* may also provide additional habitat protections and should be considered in conjunction with this issue paper
- Goal of this paper is protecting SAV and shell bottom habitat from damage by shrimp trawls

The focus of this issue paper is areas from Core Sound and South because of the higher frequency of critical shell bottom and SAV habitat. However, depending on the management approach taken in the *Shrimp Management in Special Secondary Nursery Areas* and *Reducing Shrimp Trawl Bycatch Through Area Closures that Increase Connectivity Between Closed Areas* issue papers additional critical habitat protections in other areas may need to be considered. Examples of where and how those protections could occur are discussed in this paper.

There are approximately 2.2 million acres of coastal estuarine waters (excluding the ocean) in North Carolina, of which 242,642 acres are joint waters. The NCMFC has designated 161,830 acres as either Primary Nursery Areas (PNA), Permanent Secondary Nursery Areas (SNA), or Special Secondary Nursery Areas (SSNA), which represent 7% of the total estuarine waters (Table 2.1.1, Appendix 3 Maps 3.1-3.12). Additionally, the North Carolina Wildlife Resources Commission (NCWRC) has designated 30,384 acres of inland waters under its jurisdiction as inland nursery areas. PNAs and SNAs are permanently closed to certain fishing gears, while SSNAs are conditionally opened to certain fishing gears (see *Appendix 2.2: Shrimp Management in Special Secondary Nursery Areas*).

In the 1980s, the NCDMF formed an internal Critical Habitat Committee to work with the North Carolina Marine Fisheries Commission (NCMFC) Habitat Advisory Committee to discuss the concept of expanding habitat protections. The committee recommended expanding fish sampling to identify anadromous spawning and nursery areas, estuarine areas important to juvenile reef fish like gag grouper (*Mycteroperca microlepis*), black sea bass (*Centropristis striata*), and sheepshead

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(*Archosargus probatocephalus*), and mapping of shellfish and SAV resources due to their importance as nursery area (Noble and Monroe 1991). The Estuarine Benthic Mapping Program was implemented in 1990 and Critical habitat definitions were put into rule in 1994 (15A NCAC 03I .0101 (4)).

The CHPP initiated a process to identify SHAs for key species (NCDEQ 2016). The CHPP recommended identification, nomination, and designation of SHAs as a tool to focus habitat and water quality protection efforts. However, before SHAs can influence regulatory management strategies, sampling of indicators is needed to verify ecosystem function and identify site-specific management needs (NCDEQ 2016). While the SHA verification process is underway, it may be years before statewide verification of SHA nominations are complete. Because the historic extent of SAV habitat since 1981 and known shell bottom areas have been mapped (Figure 2.1.1a-g), additional habitat protections should be considered prior to SHA verification.

Specific critical habitat protections, including protections for SAV and shell bottom have been implemented as part of FMPs for shrimp (NCDMF 2006; 2015), oysters (NCDMF 2001), bay scallop (NCDMF 2007), and blue crab (NCDMF 1998; 2020). In addition, the 2006 Shrimp FMP included consideration of a strategy to expand areas where dredging and trawling is prohibited to allow some recovery of SAV and shell bottom where those habitats historically occurred (NCDMF 2006). Trawling and dredging is prohibited in SAV beds on the eastern side of Pamlico, Core and Back sounds through a no trawl area designation (NCMFC Rule 15A NCAC 03R .0106). SAV beds north of the IWW and on the western end of Bogue Sound are protected via proclamation (NCDMF 2007). SAV in New River is also protected within no trawl areas. Trawling was prohibited in Albemarle and Currituck sounds due to user conflicts, but the prohibition also provided ancillary protections for habitat (NCMFC Rule 15A NCAC 03J .0104). Trawl nets, long haul seines, and swipe nets are prohibited in any designated oyster sanctuary (355.80 acres); shellfish (25.57 acres) or seed management areas (2,590.26 acres; NCMFC Rule 15A NCAC 03K .0103). Crab spawning sanctuaries (NCMFC Rule 15A NCAC 03L .0205) and inlet trawling restrictions (NCMFC Rule 15A NCAC 03J .0401) provide a “no trawl corridor” around inlets that protect crabs and allows migration of sub-adult fish to the ocean.

The NCDMF Director, through proclamation authority, may designate cultch planting sites as shellfish management areas thereby protecting them from bottom disturbing gears. Currently, 2,971.63 acres have been designated as oyster sanctuary, shellfish or seed management areas which are required, by rule, to be marked with signs or buoys (Table 2.1.2; Figure 2.1.1a-g). While cultch planting has occurred at thousands of sites throughout the state, very few have been designated as shellfish management areas primarily because they have been managed as open harvest areas. In addition, marking sites can be difficult and prior to 2002, cultch planting locations are uncertain because of Loran to GPS coordinate conversion errors (J. Peters, NCDMF, personal communication). When adequately marked, smaller trawlers will usually avoid cultch planting sites due to the damage cultch material causes to nets. Public meetings are held prior to the annual cultch planting season to solicit input from the public on locations for cultch planting sites. While input from shrimp trawlers would be useful in reducing impact of cultch locations to the shrimp trawl fishery, the meetings are generally poorly attended with minimal input on locations and no feedback from shrimp trawlers (C. Luck and C. Stewart, NCDMF, personal communication). Generally, there seems to be little overlap or conflict between cultch planting locations and the

DRAFT – SUBJECT TO CHANGE

shrimp trawl fishery because cultch planting sites are in shallow water where minimal shrimp trawling occurs. Cultch material has been planted on 634.44 acres in North Carolina's estuarine waters, of which, 64.4% (408.36 acres) occurs in areas already closed to trawling.

Beds of SAV occur in North Carolina in subtidal, and occasionally intertidal, areas of sheltered estuarine and riverine waters where there is suitable sediment, adequate light reaching the bottom, and moderate to negligible current velocities of turbulence (Ferguson and Wood 1994; Thayer et al. 1984). SAV habitat is primarily located in shallow water (< 6 feet) where minimal trawling occurs. Of the 191,155 acres of historical SAV distribution in North Carolina's estuarine waters, 77.2% (222,769.68 acres) occurs in areas closed to shrimp trawling (Figure 2.1.1a-g).

Because most SAV and shell bottom habitat occurs in shallow water one method for protecting these habitats could be to prohibit trawling within certain depth contours. A similar strategy is used to define designated pot areas where shrimp trawling is prohibited in the Pamlico, Bay and Neuse rivers from June 1 to November 30 in less than six feet of water. Prohibiting shrimp trawling in less than six feet of water, or in less than 12 feet of water in specific areas or statewide would provide protection for a majority, or all shell bottom and SAV habitat. However, this type of restriction is difficult to enforce and could be difficult to comply with depending on the capability of individual shrimp trawl boats. Depending on the depth contour used, areas where critical habitat does not occur might be closed to shrimp trawling which could be detrimental to the shrimp trawl fishery.

Additional protections for some or all SAV and shell bottom habitat occurring outside of currently closed areas should be considered and may be necessary as SAV and shell bottom habitat naturally expands, or new cultch planting locations are added. The management framework by which shrimp trawling can be restricted in SAV and shell bottom habitats already exists. Existing no shrimp trawl areas could be expanded, or new no shrimp trawl areas could be designated to create more extensive areas of habitat protection. No shrimp trawl areas are used to protect SAV habitat in New River, Bogue, eastern Pamlico, and Core sounds and these areas could be expanded to encompass additional SAV habitat. Including cultch planting locations in no shrimp trawl areas would eliminate the need to designate and mark individual sites as shellfish management areas and creating more clearly identified no shrimp trawl lines may be more effective than marking several smaller areas individually.

In the New River, shrimp trawl areas occur in the same area as the MCHA, which were adjusted to protect SAV in 2017 (Figure 2.1.2). Additionally, MCHAs in Core Sound and North River have been modified and the MCHA in Bogue Sound was eliminated by proclamation to avoid overlap with SAV habitat (Proclamation SF-7-2020). Where possible, in areas south of Pamlico Sound, allowing shrimp trawling to only occur within MCHAs would accomplish the objective of protecting SAV habitat and create common boundaries for enforcement. Applying this strategy in Core Sound (Figure 2.1.3) and North River (Figure 2.1.4) would provide protection for SAV habitat in these waterbodies, streamline enforcement, and minimally impact shrimp trawling because most of the closed area would be locations that are not trawled because of shallow water or other obstructions. Adjacent to Core Sound, consideration could also be given to allowing shrimp trawling to continue in the marked navigable channel in the Straits area (Figure 2.1.5). This channel is an area where shrimp trawling occurs and SAV is not present.

DRAFT – SUBJECT TO CHANGE

Historic SAV mapping indicates the presence of SAV habitat near the southern shore of Bogue Sound, though SAV may not be present in these locations every year (Figure 2.1.6). While this area is open to shrimp trawling, shallow water, and the presence of SAV minimizes effort in this area, though some shrimp trawling occurs in the IWW and deeper water areas near Salter Path. The MCHA in Bogue Sound was eliminated in 2020 (Proclamation SF-7-2020) so matching the shrimp trawl area with the MCHA is not possible. Because of the patchy distribution of SAV south of the IWW in Bogue Sound, a no shrimp trawl area would need to be large enough to encompass the entire SAV area. Bogue Sound could be closed to shrimp trawling except for in the IWW and within 100 yards on the south side of the IWW and in Banks Channel from Wood Island to Dog Island. The IWW and Banks Channel represent areas where shrimp trawling currently occurs where no SAV is present so this option would protect SAV habitat while continuing to allow shrimp trawling (Figure 2.1.7).

MCHA's are designated in Newport and White Oak rivers and shrimp trawling does occur in these rivers, though effort is generally low. However, SAV is less extensive in these waterbodies (Figure 2.1.1e-f) and likely does not require additional shrimp trawl protections. Most shrimp trawling in Newport River occurs along the Penn Point shrimp line which protects shell bottom habitat, leases, and cultch planting sites above the line. Shrimp trawling also occurs around Core Creek. Similarly, the MCHA in White Oak River does not encompass the extent of trawlable area in the river which occurs around Cahoon's slough, the Turnstake, Hills Bay, and the mouth of Pettiford Creek.

In locations with no MCHA, shrimp trawl lines could be adjusted to encompass additional SAV and shell bottom habitat. Because current understanding of SAV distribution is based on historic mapping efforts (1981-2015), maps may not represent the actual extent of SAV in any given year but does represent potential SAV habitat. Therefore, any shrimp trawl closures implemented to protect SAV must be broad enough to capture potential SAV habitat distribution and could limit the use of shrimp trawls in potentially productive areas with no SAV present. However, shrimp trawl closures that are broader provide buffer between open areas and SAV and should be considered when delineating closure areas. Shrimp trawl closures to protect shell bottom habitat, particularly cultch planting areas, could be implemented to protect these areas from damage by shrimp trawls. In addition, defining areas of shell bottom as no shrimp trawl areas may prevent damage to shrimp trawl gear. However, since oyster dredges are allowed in cultch planting areas in the north, the ecological benefit of restricting shrimp trawls in these areas would be limited.

Modification of no shrimp trawl lines could be accomplished via revision of existing proclamations or suspending rules via proclamation. This method of implementation may be most effective in locations where no trawl areas already exist and are near SAV and shell bottom habitat. Creating no shrimp trawl areas around SAV and shell bottom habitat would be effective in areas where existing closures do not exist or where modification of existing no shrimp trawl areas is not realistic. For example, West Bay is closed to trawling early in the season but can be opened to shrimp trawling (Figure 2.1.8). There are no existing no shrimp trawl areas near West Bay, so creating a no shrimp trawl area in West Bay encompassing SAV and shell bottom habitat would define an area as open to trawling (Figure 2.1.9). For either implementation method, creating lines that use existing landmarks and are clear would be important for promoting compliance and simplifying enforcement. Another option would be to prohibit shrimp trawling within a certain

DRAFT – SUBJECT TO CHANGE

depth contour within West Bay that would encompass critical habitat areas. Similar options could be considered in Croatan and Roanoke sounds where critical habitats are present but no specific management options were discussed in this issue paper. Management options in *Appendix 2.2: Shrimp Management in Special Secondary Nursery Areas* and *Appendix 2.3: Reducing Shrimp Trawl Bycatch Through Area Closures that Increase Connectivity Between Closed Areas* may also provide additional habitat protections and should be considered in conjunction with this issue paper.

The management options discussed in this issue paper represent immediate, direct action that can be taken through review of the shrimp FMP to protect critical shell bottom and SAV habitat. Direct protections of SAV and shell bottom habitat aligns with the strategy from the 2006 Shrimp FMP to expand areas where dredging and trawling is prohibited to allow some recovery of SAV and shell bottom where those habitats historically occurred (NCDMF 2006) and the priority that has been put on SAV in the current CHPP review. A long-term, more effective strategy to protect critical habitat, including SAV and shell bottom, is needed to focus future protections in areas designated as SHAs. SHA nominations have been completed for areas throughout the state (NCDMF 2009; 2011; 2014b; 2018), but cannot influence regulatory management strategies until designation, based on verification of ecosystem function and identification of site-specific management needs (NCDEQ 2016). SHAs identified in the CHPP represent a subset of priority habitat areas for protection due to their exceptional condition or imminent threat to their ecological functions supporting finfish and shellfish species (Deaton et al. 2006). The SHAs have been nominated on scientific understanding of relationships between habitats, connectivity, and fish production. Because of the rigorous scientific process in which SHAs are identified and designated, additional habitat protections or modification of existing habitat protections should be considered upon completion of SHA designations.

While closing areas of critical SAV and shell bottom habitat allows for calculation of how much additional habitat will be protected, additional benefits are difficult to quantify because physical disturbance by shrimp trawls is not the primary threat to these habitats, particularly SAV. In the absence of shrimp trawls, shell bottom habitat may still be covered by sediment and SAV growth may be impaired by poor water quality, climate change, disease, or other natural disturbances.

VI. PROPOSED RULE(S)

This action will result in no immediate rulemaking, rather existing proclamation authority pertaining to use of trawls may be used.

VII. MANAGEMENT OPTIONS AND IMPACTS

(+ Potential positive impact of action)

(- Potential negative impact of action)

1. *Status quo* – Maintain the areas open to shrimp trawling as identified in current rules and proclamation.
 - + Continued access to resources by shrimpers
 - + Will not create shifts in effort to other areas

DRAFT – SUBJECT TO CHANGE

- + Area closures to address bycatch considered in Amendment II may provide additional habitat protections
 - + Most cultch planting areas are open to oyster harvest so prohibiting shrimp trawling has limited ecological benefit
 - + Most SAV and shell bottom habitat already occurs in areas closed to shrimp trawling
 - SAV and shell bottom habitat may be damaged by continued trawling
 - Could have negative impacts on important fish stocks
 - Could negatively affect historic and future cultch planting efforts
 - Lack of clear boundaries could lead to damages to trawl gear
2. Modify existing or create new shrimp trawl closure lines to protect additional SAV habitat.
- + Decrease damage to SAV from shrimp trawls
 - + Minimal impact to fishermen since areas are not used extensively
 - + Modification of closure lines would occur by proclamation allowing for flexibility
 - + Identifying clear boundaries could prevent damage to gear and habitat
 - + Bycatch reduction
 - May decrease some traditional shrimp trawling areas
 - Could shift effort to other areas
 - SAV mapping reflects historic distribution, so creation of broad no shrimp trawl areas may prevent shrimp trawling in productive areas with no SAV
 - Modification of existing closure lines could cause confusion
3. Modify existing or create new shrimp trawl closure lines to protect additional shell bottom habitat.
- + Decrease damage to shell bottom habitat from shrimp trawls
 - + Minimal impact to fishermen since areas are not used extensively
 - + Closure lines would occur by proclamation allowing for flexibility
 - + Identifying clear boundaries could prevent damage to gear and habitat
 - + Bycatch reduction
 - May decrease some traditional shrimp trawling areas
 - Could shift effort to other areas
 - Shellfish management areas are already closed to trawling
 - Most cultch planting areas are open to mechanical oyster harvest so prohibiting shrimp trawling has limited ecological benefit
 - Modification of existing closure lines could cause confusion

VIII. RECOMMENDATIONS

Division of Marine Fisheries

- Prohibit shrimp trawling east and north of a line from Pea Island marshes to the southwestern shore of Wanchese (close all of Roanoke Sound and area around Oregon Inlet)
- Prohibit shrimp trawling in Core Sound and its tributaries except within the Mechanical Clam Harvest Area (MCHA)
- Prohibit shrimp trawling in North River, Back Sound, and their tributaries except within the MCHA in North River

DRAFT – SUBJECT TO CHANGE

- Prohibit shrimp trawling in Bogue Sound and its tributaries except within the Intracoastal Waterway (IWW)

Northern Advisory Committee

- In regard to Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats remain at status quo.

Southern Advisory Committee

- No motion passed.

Finfish Advisory Committee

- No motion or recommendation.

Shellfish and Crustacean Advisory Committee

- No motion passed.

Habitat and Water Quality Advisory Committee

- Align shrimp trawling areas with Mechanical clam harvest areas in Core Sound and North River and allow trawling in Straits Channel of Core Sound.
- Supports management strategies for protection of SAV and Shell bottom habitat from trawling impacts.
- Amend the current document to include a formal decision analysis for the options presented in the FMP and other options discussed during the Habitat and Water Quality Advisory Committee meeting. The analysis will be presented to the MFC for review at a future date.

NCMFC Selected Management Strategy

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Tables

Table 2.1.1. Existing areas closed to the use of trawls in coastal and estuarine waters of North Carolina.

Type of Closure	Location	Restriction	Purpose	Reference
Primary Nursery Area	Statewide/Internal Coastal Waters	Unlawful to use trawl nets or other bottom disturbing gear	Protect habitat for juvenile fish and shrimp	15A NCAC 03N .0104 15A NCAC 03R .0103
Secondary Nursery Area	Statewide/Internal Coastal Waters	Unlawful to use trawl nets	Protect habitat for juvenile fish and shrimp	15A NCAC 03N .0105(a) 15A NCAC 03R .0104
Special Secondary Nursery Area	Statewide/Internal Coastal Waters	Can be opened to the use of trawl nets by proclamation from August 16 to May 14	Protect habitat for juvenile fish and shrimp while allowing taking of shrimp after they have grown or when juvenile fish have left area	15A NCAC 03N .0105 15A NCAC 03R .0105
Trawl Net Prohibited Areas	Statewide/Coastal and Internal Coastal Waters	Unlawful to use trawl nets; parts of Pamlico, Core and Back sounds can be opened to peeler crab trawling by proclamation	Protect sensitive habitat or reduce bycatch	15A NCAC 03J .0104(b)(3)(4) 15A NCAC 03R .0106
Military Danger Zones	Statewide/Coastal and Internal Coastal Waters	No public access	Public safety	15A NCAC 03R .0102
Crab Spawning Sanctuaries	All coastal inlets	From Barden Inlet north unlawful to use trawls in spawning sanctuaries from March 1 to August 31; From Beaufort inlet south unlawful to use trawls in spawning	Provide protection for spawning blue crabs	15A NCAC 03L .0205 15A NCAC 03R .0110 Proclamation M-7-2020

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Type of Closure	Location	Restriction	Purpose	Reference
		sanctuaries from March 1 to October 31		
Designated Pot Areas	Pamlico, Bay, Neuse rivers and their tributaries	Unlawful to use trawl nets in designated pot areas from June 1 to November 30	Reduce gear conflicts between trawls and crab pots	NCAC 03J .0104(b)(6) 15A NCAC 03J .0301(a)(2) 15A NCAC 03R .0107 Proclamation (i.e., SH-1-2020)
Seed Oyster Management Areas	Statewide/Internal Coastal Waters	Unlawful to use trawl nets in seed oyster management areas	Protect oyster habitat	15A NCAC 03K .0208 15A NCAC 03R .0116
Oyster Sanctuaries	Croatan Sound, Pamlico Sound, Neuse River	Unlawful to use trawl nets in oyster sanctuaries	Protect oyster habitat	15A NCAC 03k .0209 15A NCAC 03R .0117
Shrimp Trawl Prohibited Areas	Pungo, Pamlico, Neuse, Shalotte, Calabash rivers; Eastern Channel; Sunset Beach	Unlawful to use shrimp trawls	Protect habitat, reduce bycatch, reduce gear conflicts	15A NCAC 03L .0103(e) 15A NCAC 03R .0114
Other Trawl Closures				
Miscellaneous	Atlantic Ocean	Unlawful to use trawls in specified areas during specified times	Protect habitat, reduce bycatch, reduce gear conflicts	15A NCAC 03J .0202 (1)(2) 15A NCAC 03J .0202 (8)
Miscellaneous	Albemarle Sound and Tributaries	Unlawful to use trawls	Protect habitat, reduce bycatch, reduce gear conflicts	15A NCAC 03J .0104 (b) (3)
Miscellaneous	Southport Boat Harbor	Unlawful to use any commercial fishing gear	Reduce user group conflict, public safety	15A NCAC 03J .0206
Miscellaneous	Duke Energy Progress Brunswick Nuclear Plant Intake Canal Closure	Unlawful to use any commercial fishing gear	Public safety	15A NCAC 03J .0207

DRAFT – SUBJECT TO CHANGE

Type of Closure	Location	Restriction	Purpose	Reference
Miscellaneous	Dare County	Unlawful to use commercial fishing gear within 750 feet of licensed fishing piers when open to the public	Reduce user group conflict	15A NCAC 03J .0402(a)(1)(ii)
Miscellaneous	Onslow and Pender counties	Unlawful to use commercial fishing gear during specified times and distances from fishing piers	Reduce user group conflict	15A NCAC 03J .0402(a)(2)(A)(B)(i)(ii)
Miscellaneous	New Hanover County	Unlawful to use commercial fishing gear during specified times and distances from fishing piers	Reduce user group conflict	15A NCAC 03J 0402(a)(3)(A)(B)(i)(iii)

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Table 2.1.2. Total acreage of shellfish management areas, oyster sanctuary, designated seed oyster management area, cultch planting sites and SAV habitat (1981-2015) and total acreage of estuarine waters closed to trawling.

Designation	Total Acreage
Shellfish Management Area*	26
Oyster Sanctuary*	395
Designated Seed Oyster Management Area*	2,590
SAV	191,155
Cultch Planting Sites ⁺	634
Closed Estuarine Waters	1,003,634

* Closed to trawling

⁺ Estimated acreage

Figures

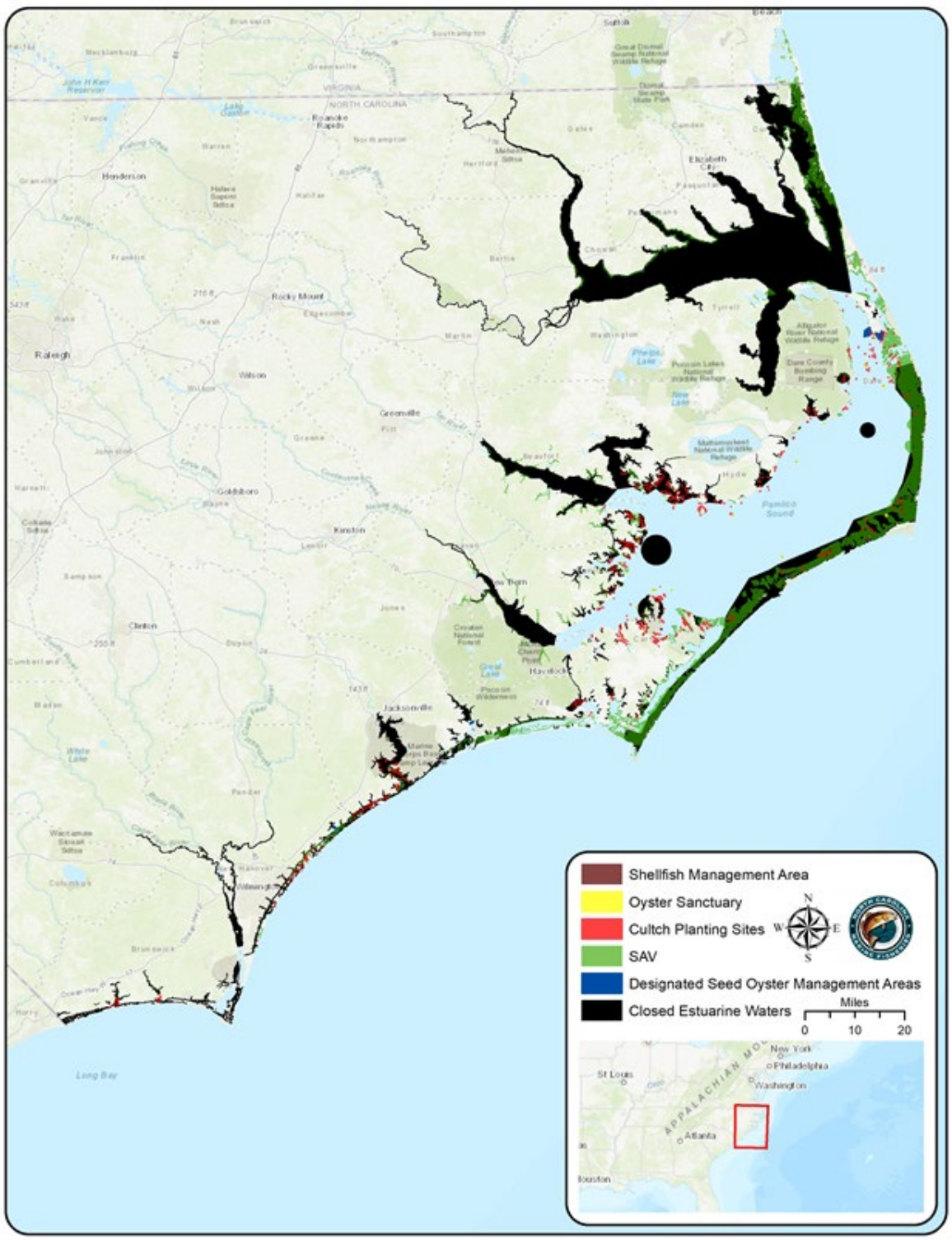


Figure 2.1.1a. Designated oyster sanctuary, shellfish, and seed oyster management areas and historical SAV locations (since 1981) and cultch planting locations in North Carolina Estuarine waters.

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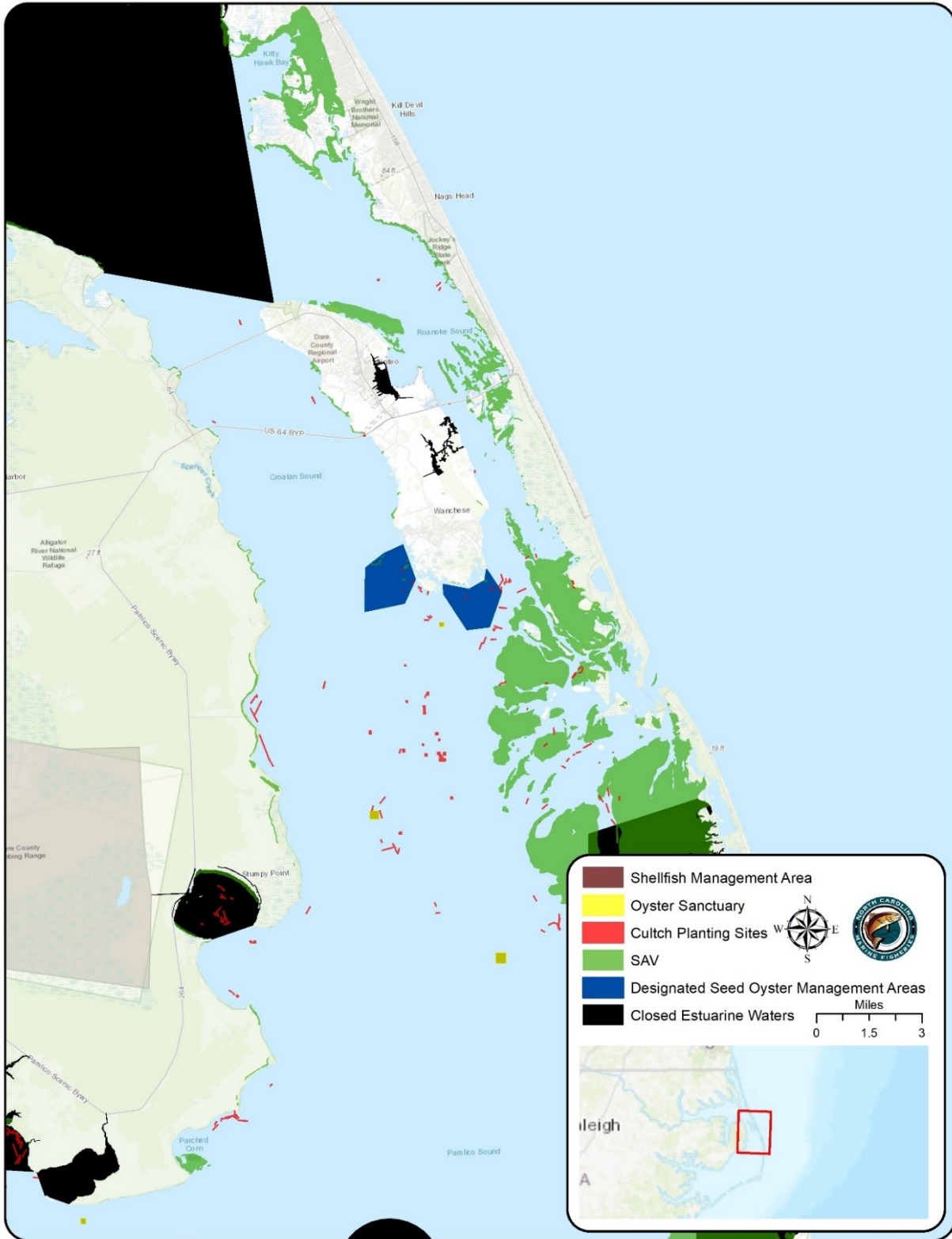


Figure 2.1.1b. Designated oyster sanctuary, shellfish, and seed oyster management areas and historical SAV locations (since 1981) and cultch planting locations in Croatan and Roanoke sounds.

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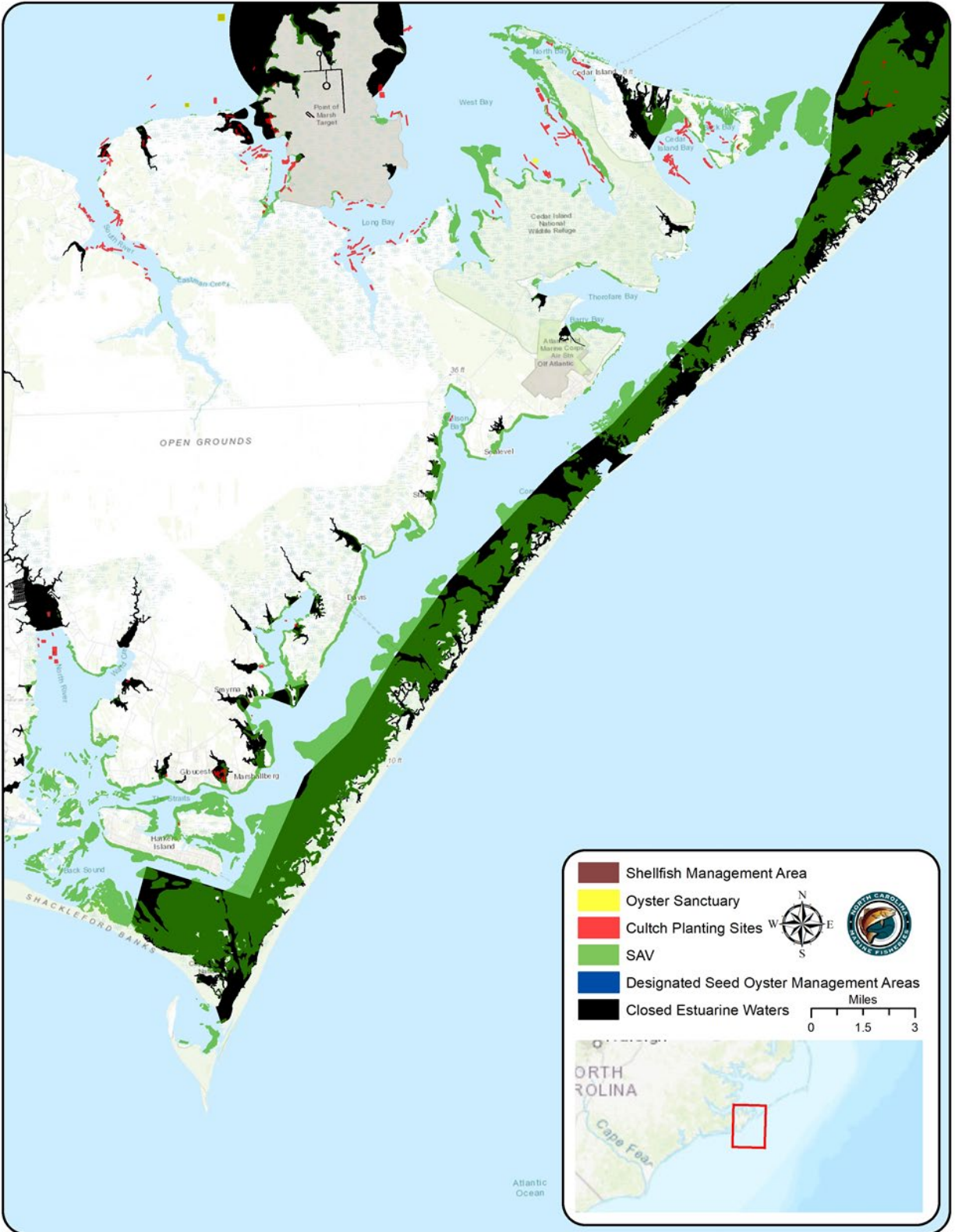


Figure 2.1.1c. Designated oyster sanctuary, shellfish, and seed oyster management areas and historical SAV locations (since 1981) and cultch planting locations in Core Sound.

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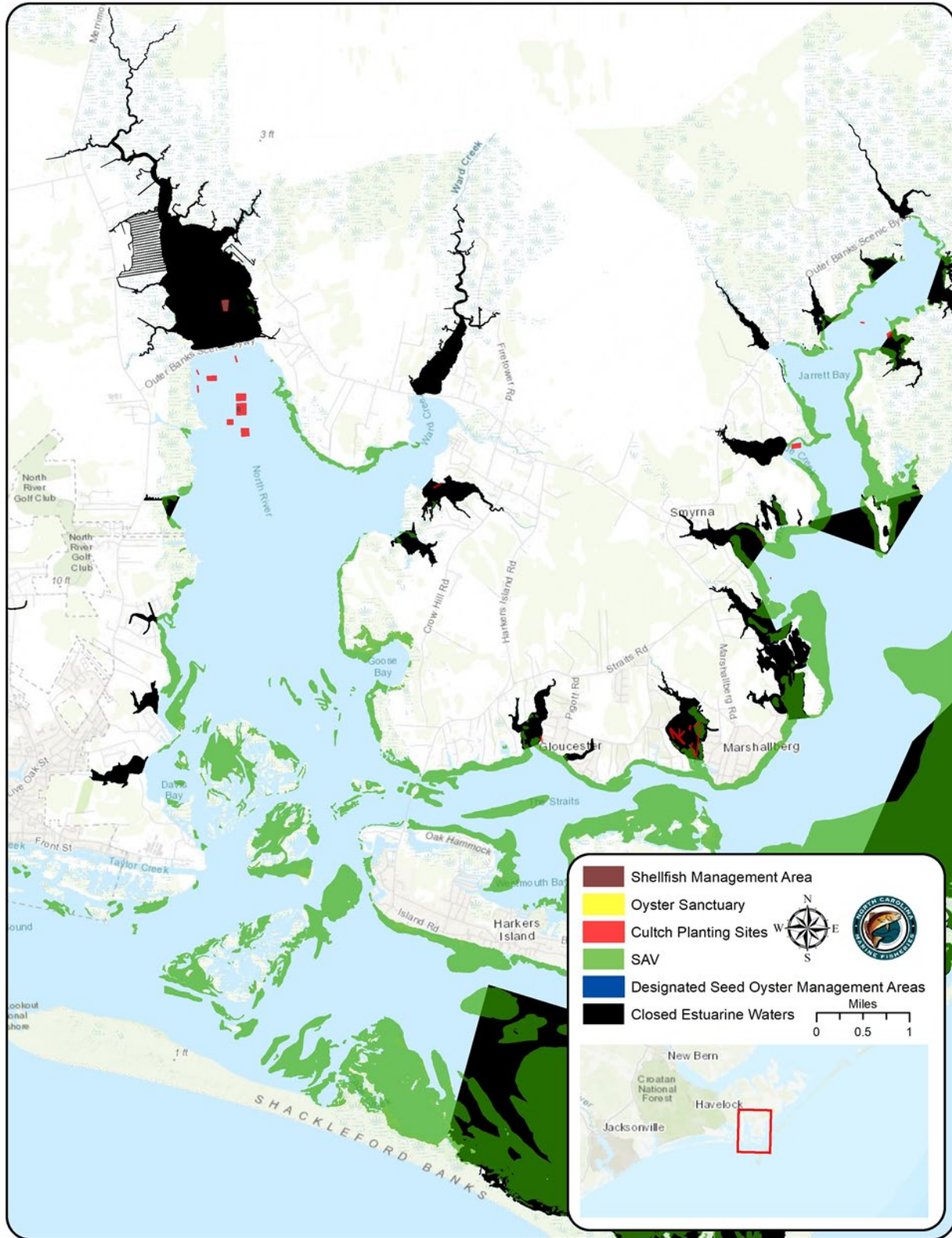


Figure 2.1.1d. Designated oyster sanctuary, shellfish, and seed oyster management areas and historical SAV locations (since 1981) and cultch planting locations in North River.

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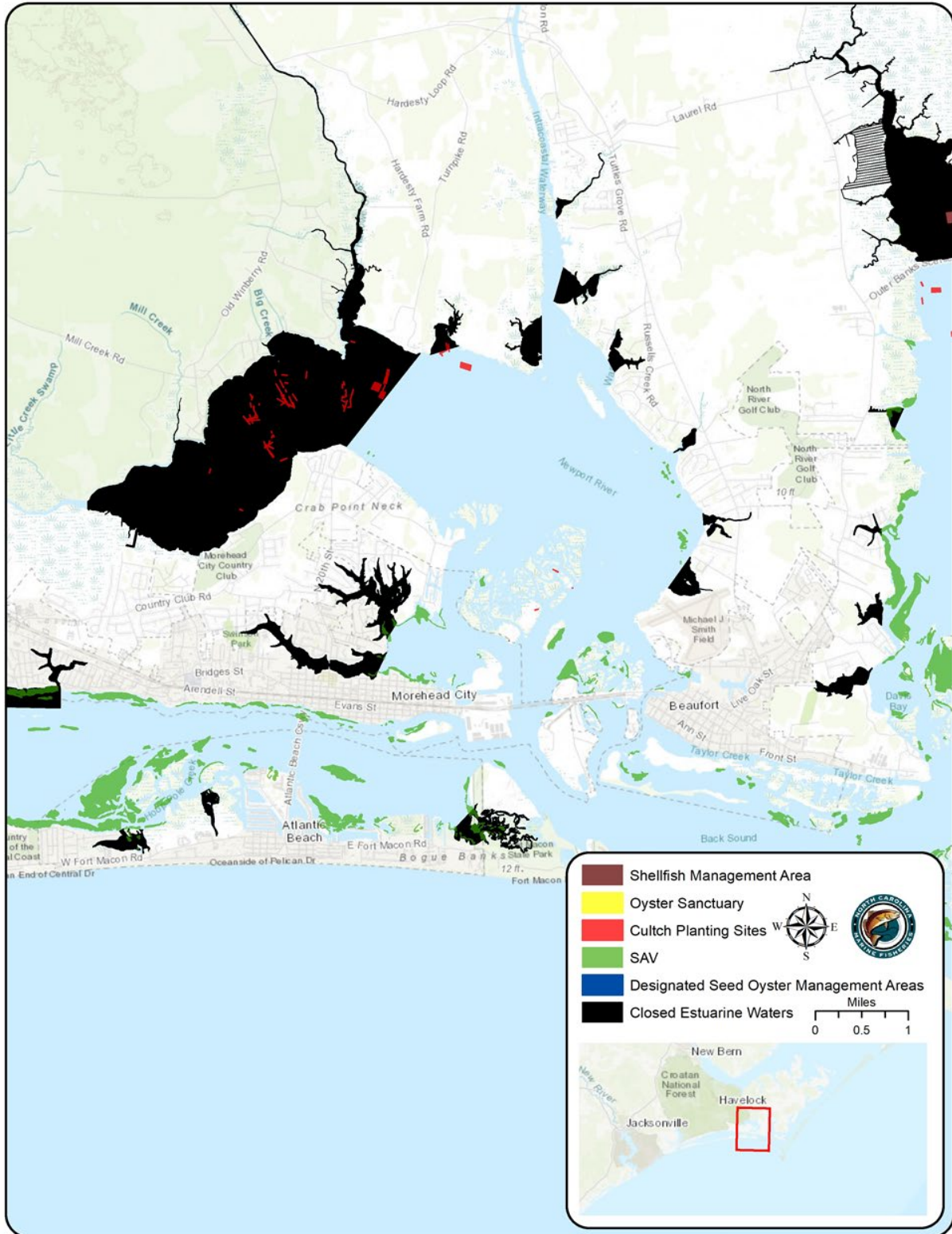


Figure 2.1.1e. Designated oyster sanctuary, shellfish, and seed oyster management areas and historical SAV locations (since 1981) and cultch planting locations in Newport River.

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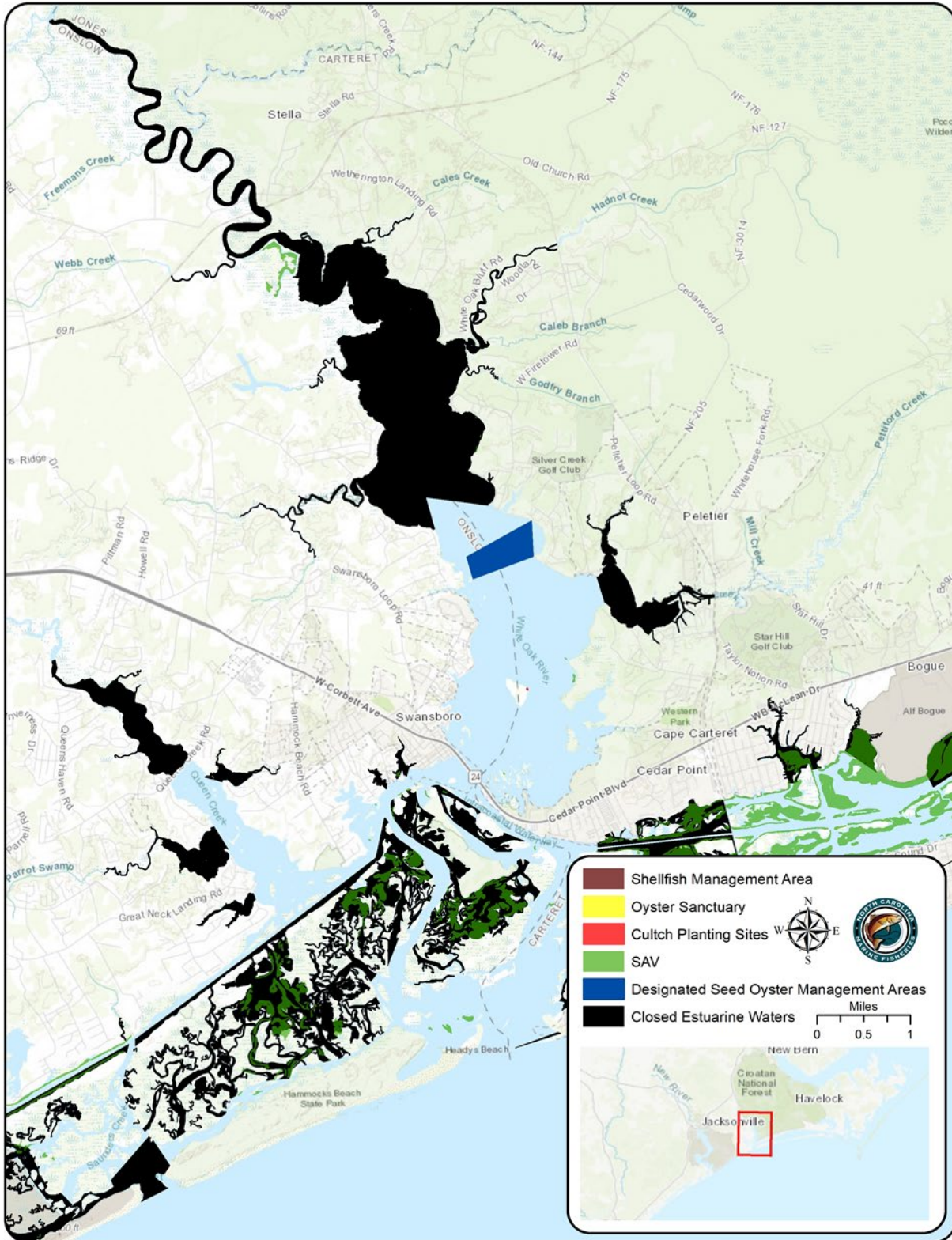


Figure 2.1.1f. Designated oyster sanctuary, shellfish, and seed oyster management areas and historical SAV locations (since 1981) and cultch planting locations in White Oak River.

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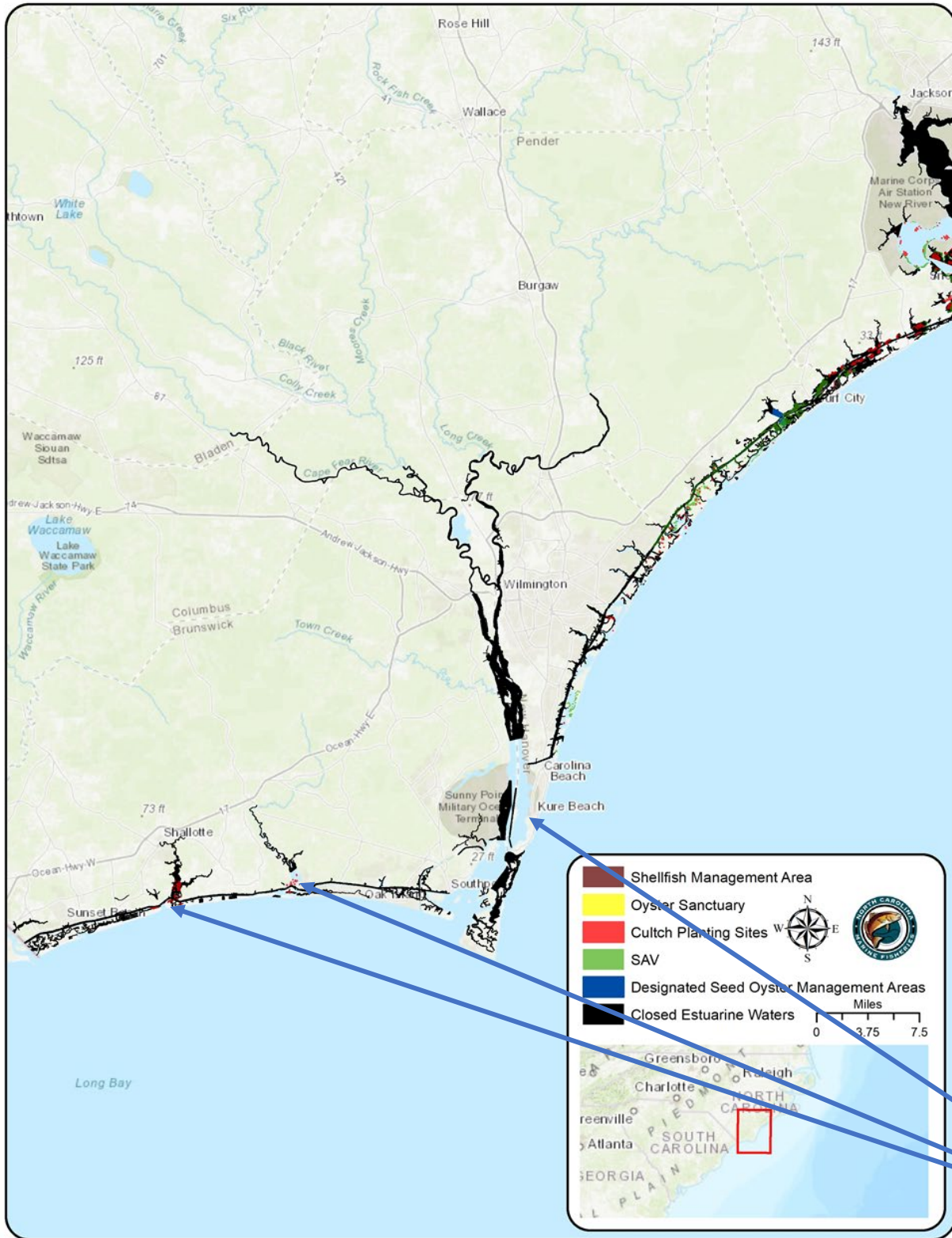


Figure 2.1.1g. Designated oyster sanctuary, shellfish, and seed oyster management areas and historical SAV locations (since 1981) and cultch planting locations south of New River.

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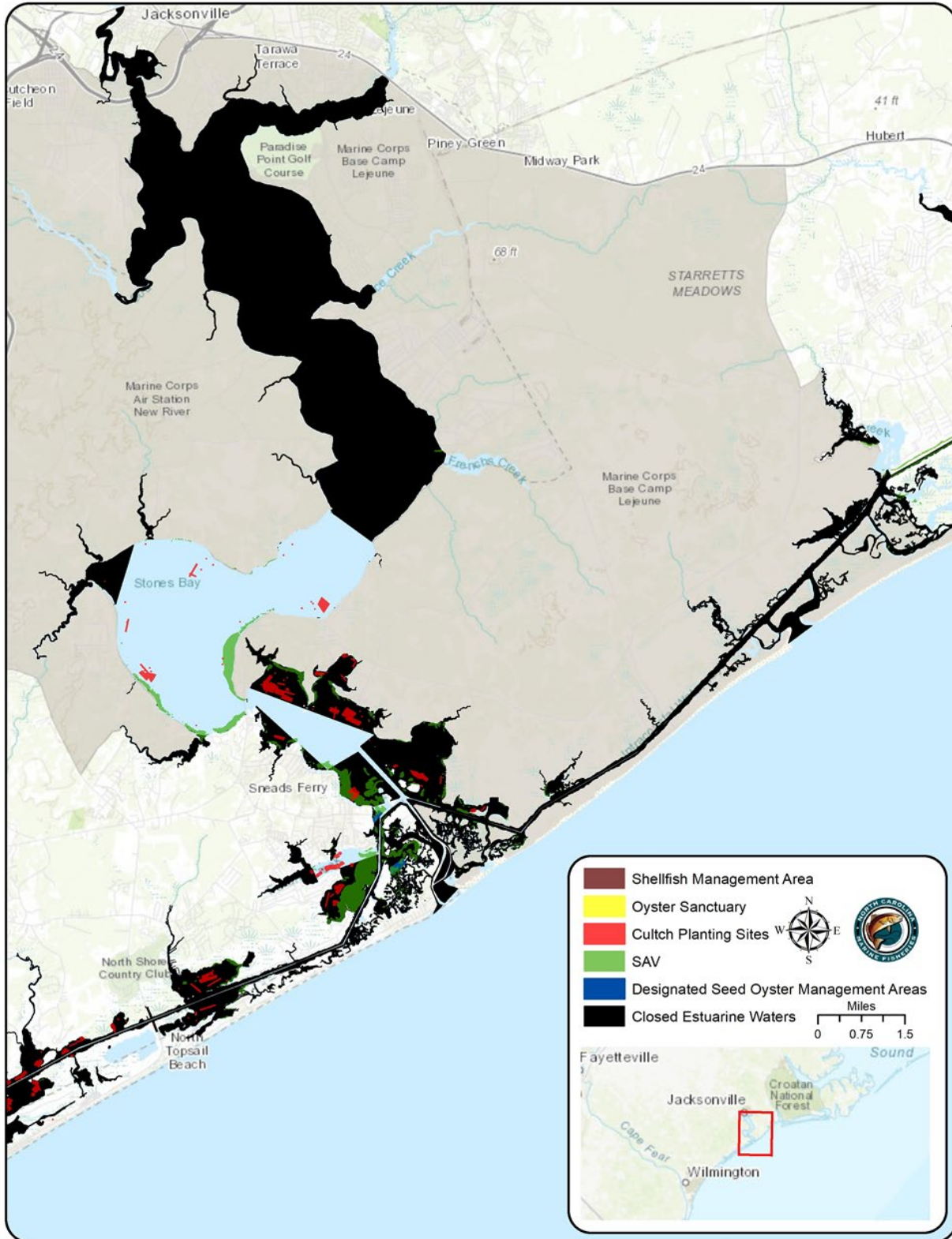


Figure 2.1.2. Designated oyster sanctuary, shellfish, and seed oyster management areas and historical SAV locations (since 1981) and cultch planting locations in New River.

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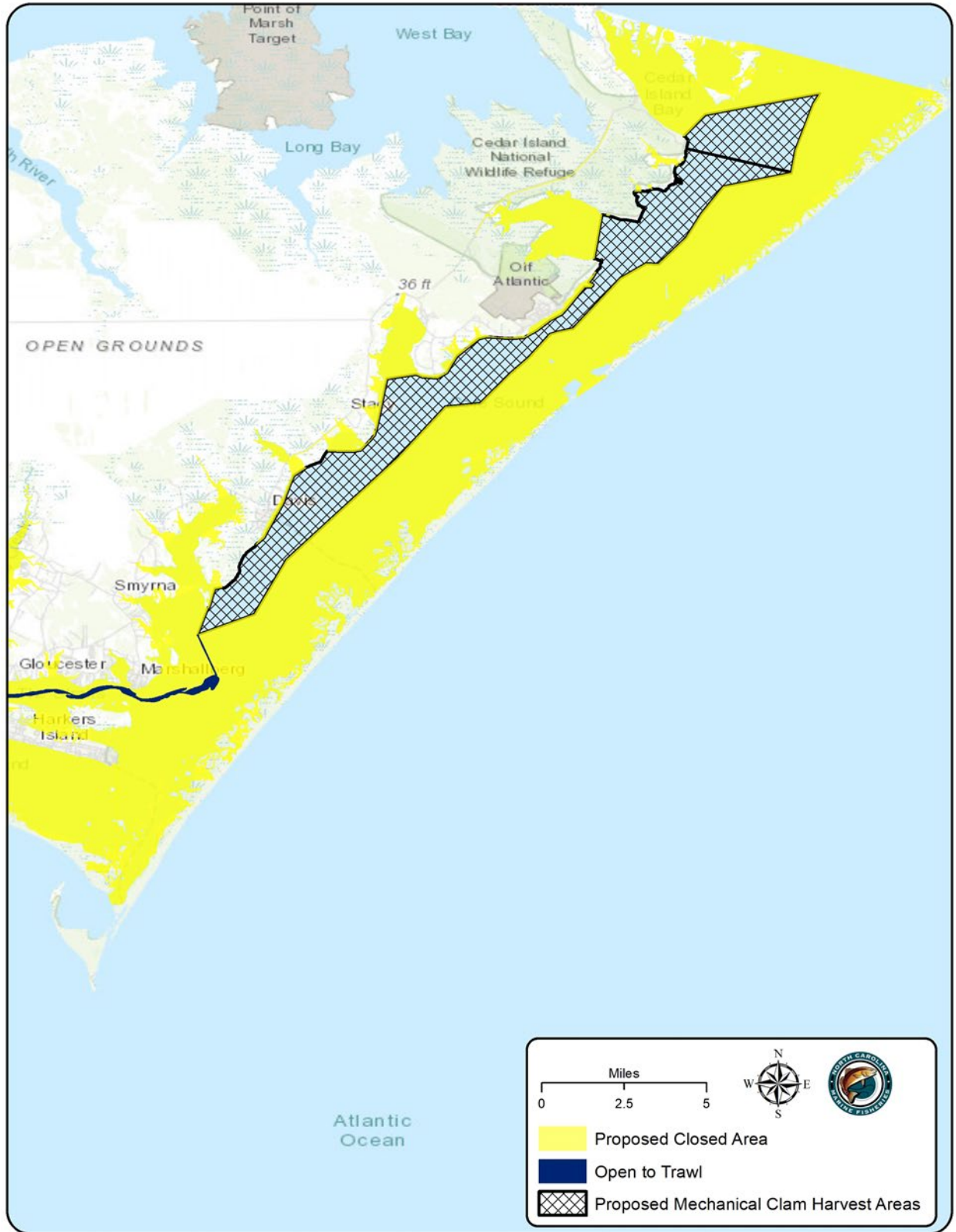


Figure 2.1.3. Location of mechanical clam harvest area in Core Sound.

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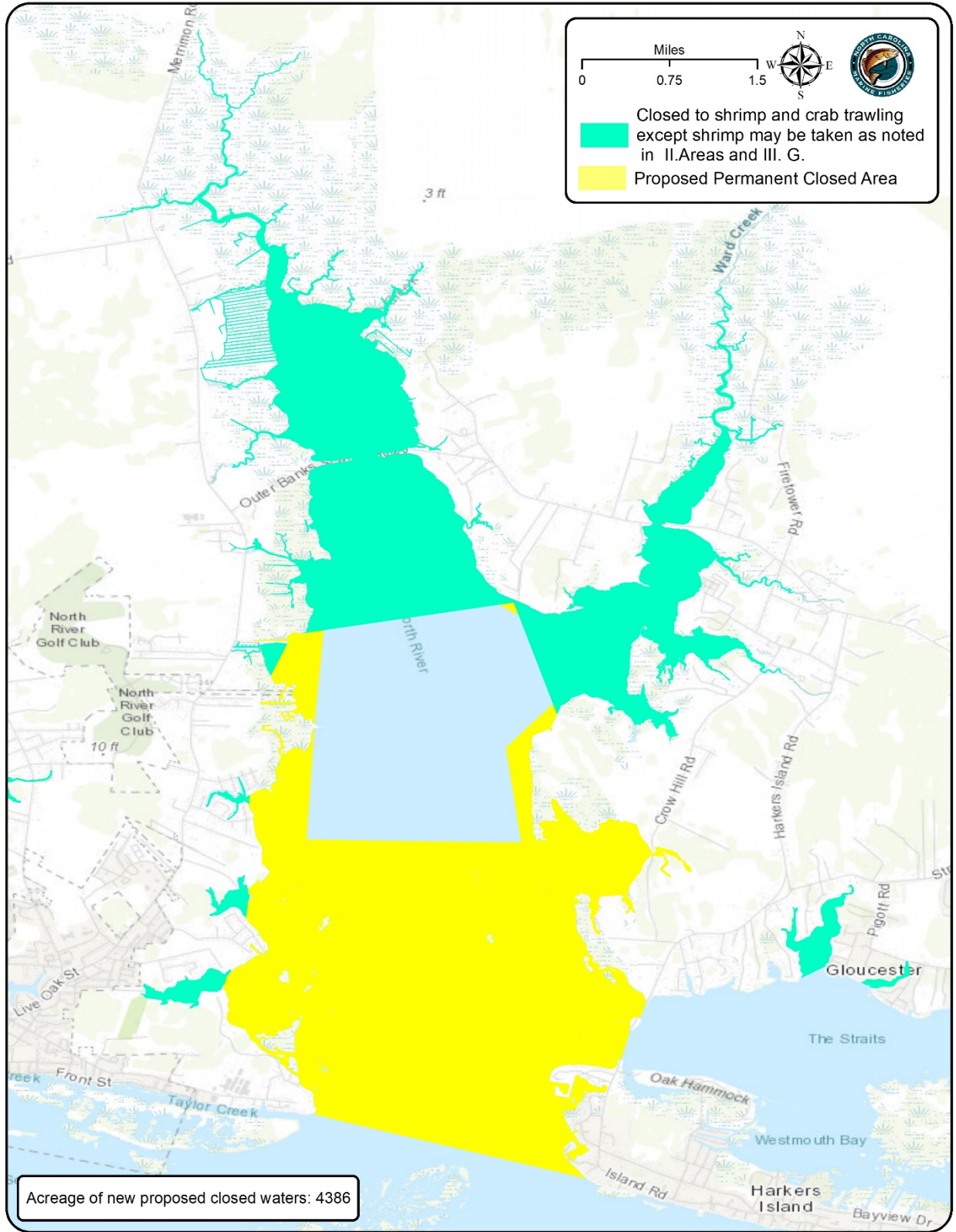


Figure 2.1.4. Location of mechanical clam harvest area in North River.

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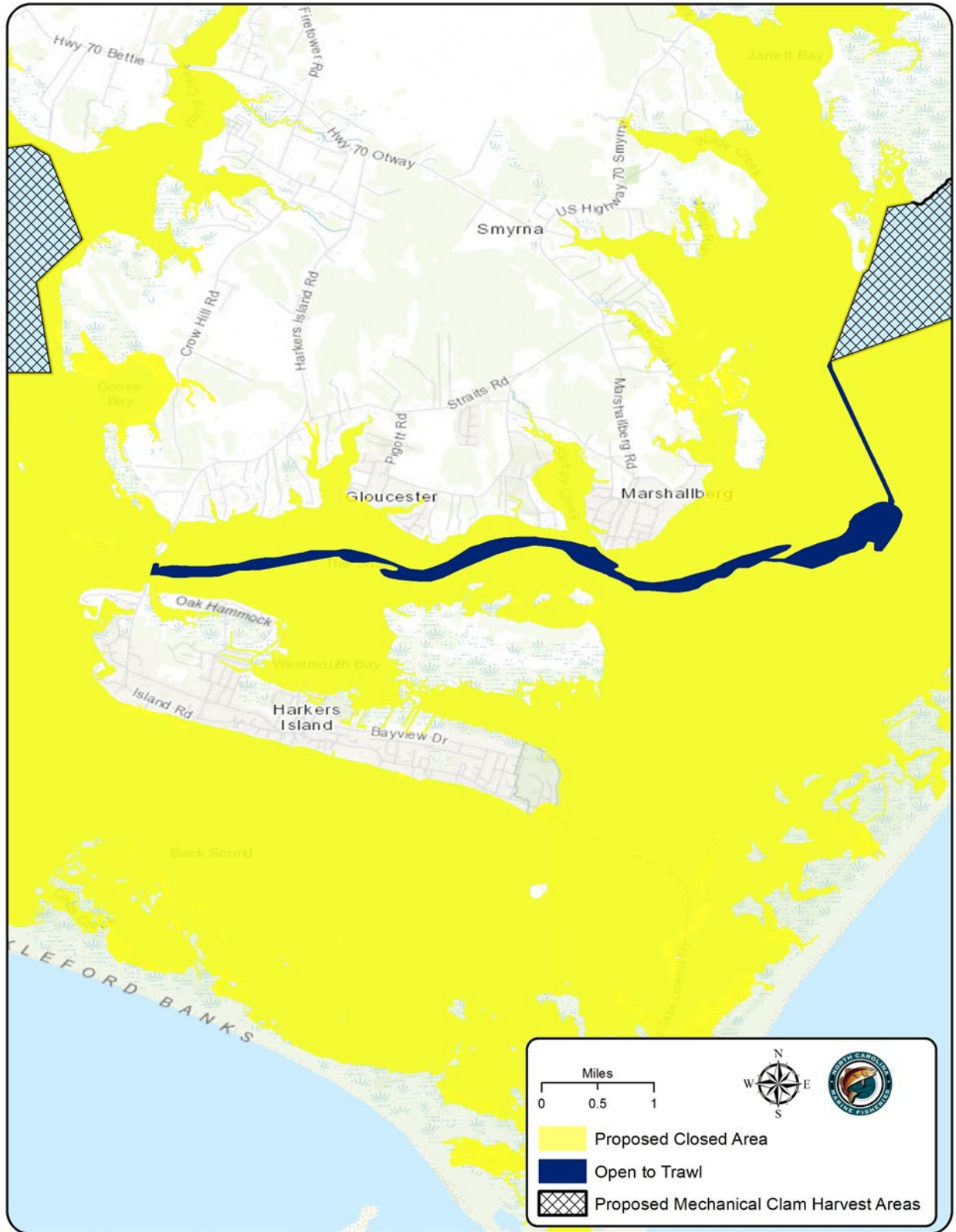


Figure 2.1.5. Location of marked channel in the “Straits”.

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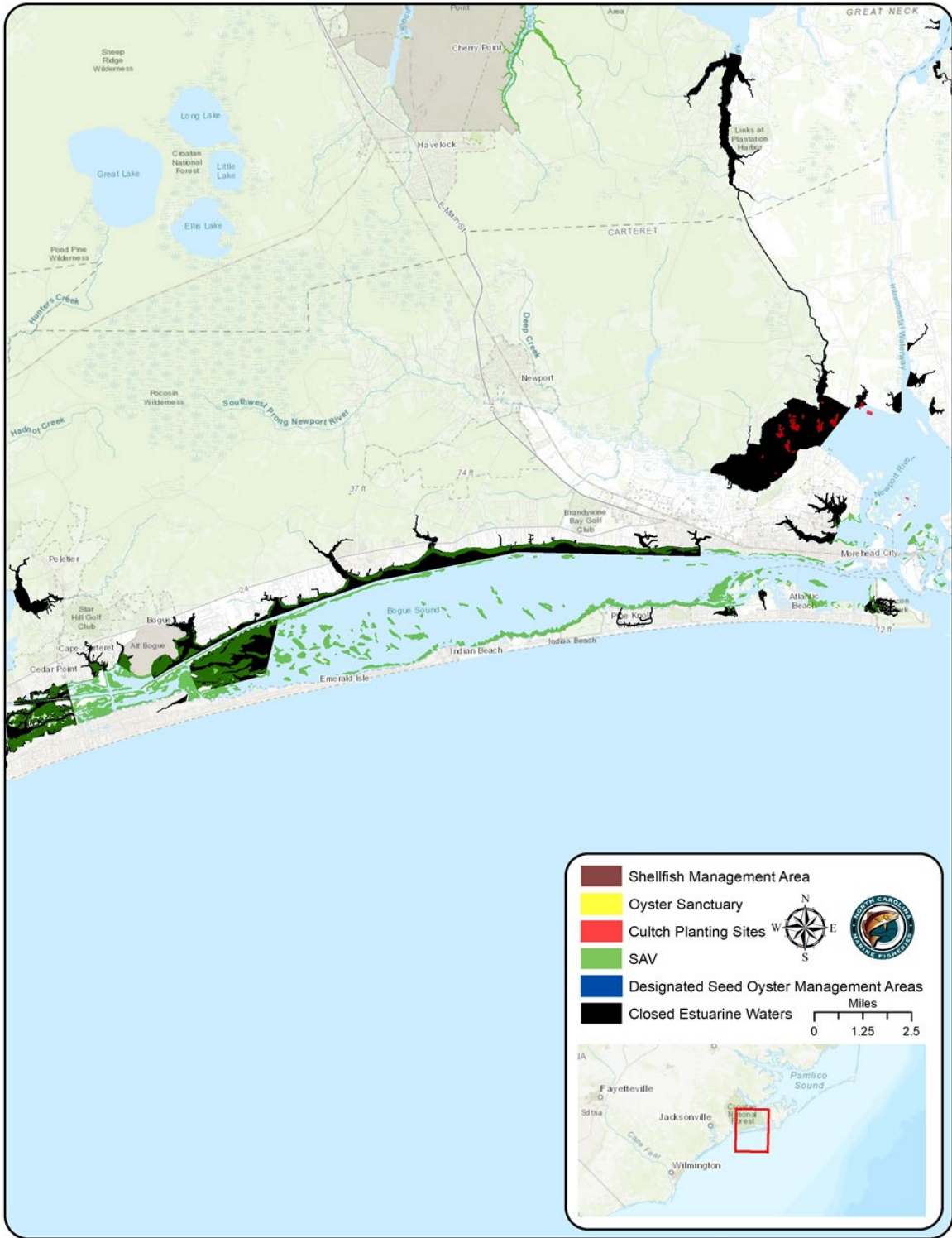


Figure 2.1.6. Designated oyster sanctuary, shellfish and seed oyster management areas and historical SAV locations (since 1981) and cultch planting locations in Bogue Sound.

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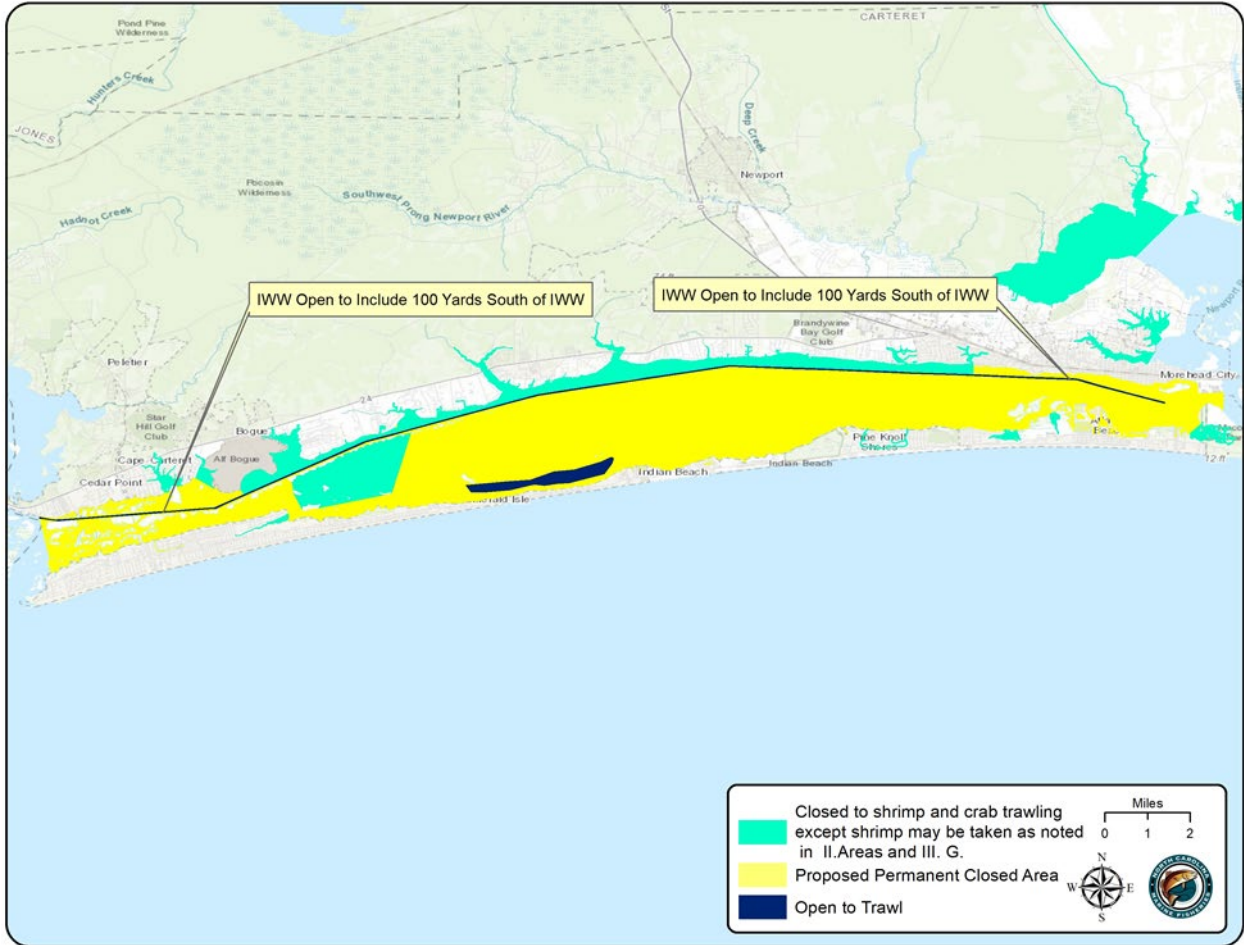


Figure 2.1.7. Proposed shrimp trawl area in Bogue Sound, allowing trawling in the IWW and within 100 yards on the south side of the IWW and in Banks Channel.

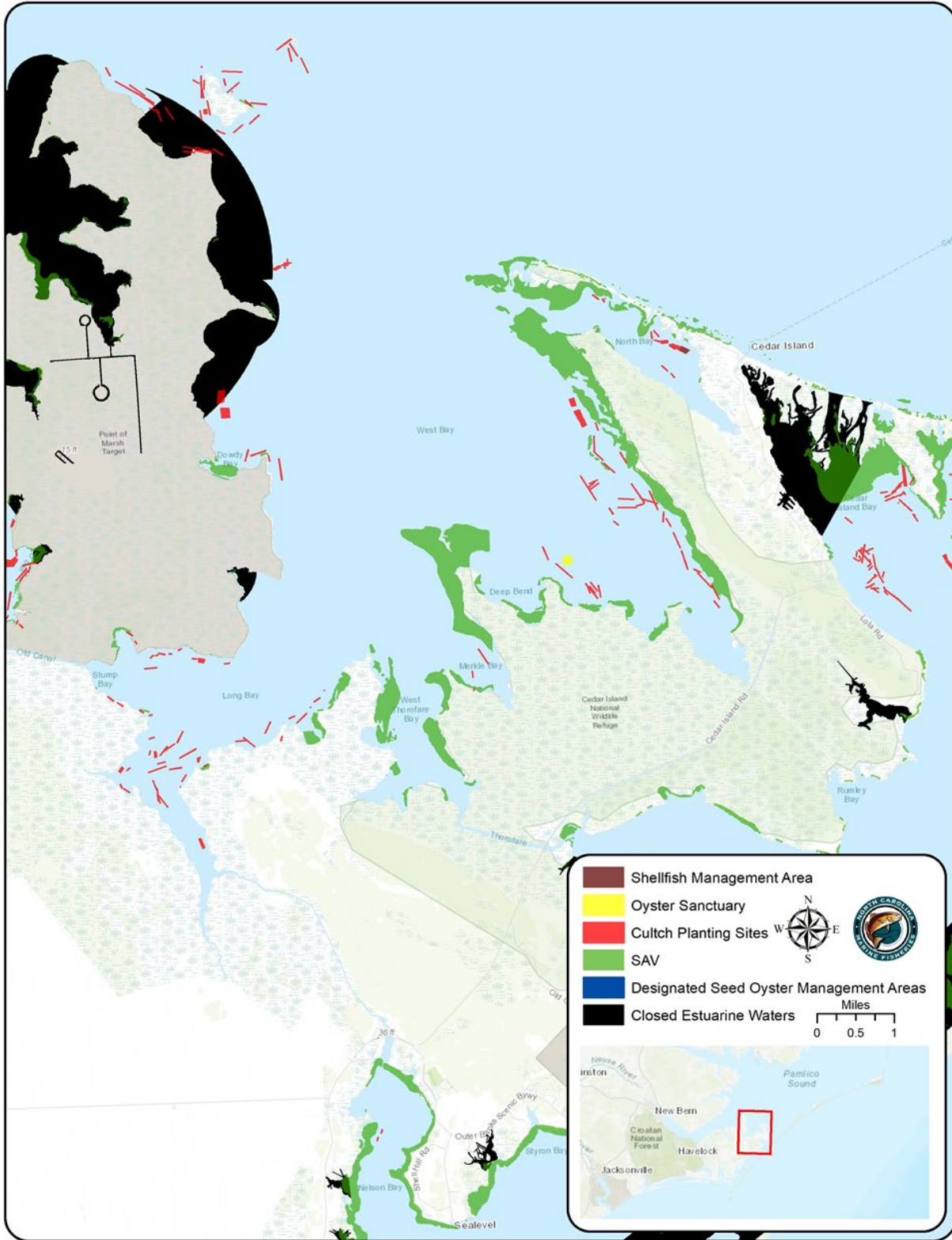


Figure 2.1.8. Designated oyster sanctuary, shellfish and seed oyster management areas and historical SAV locations (since 1981) and cultch planting locations in West Bay.

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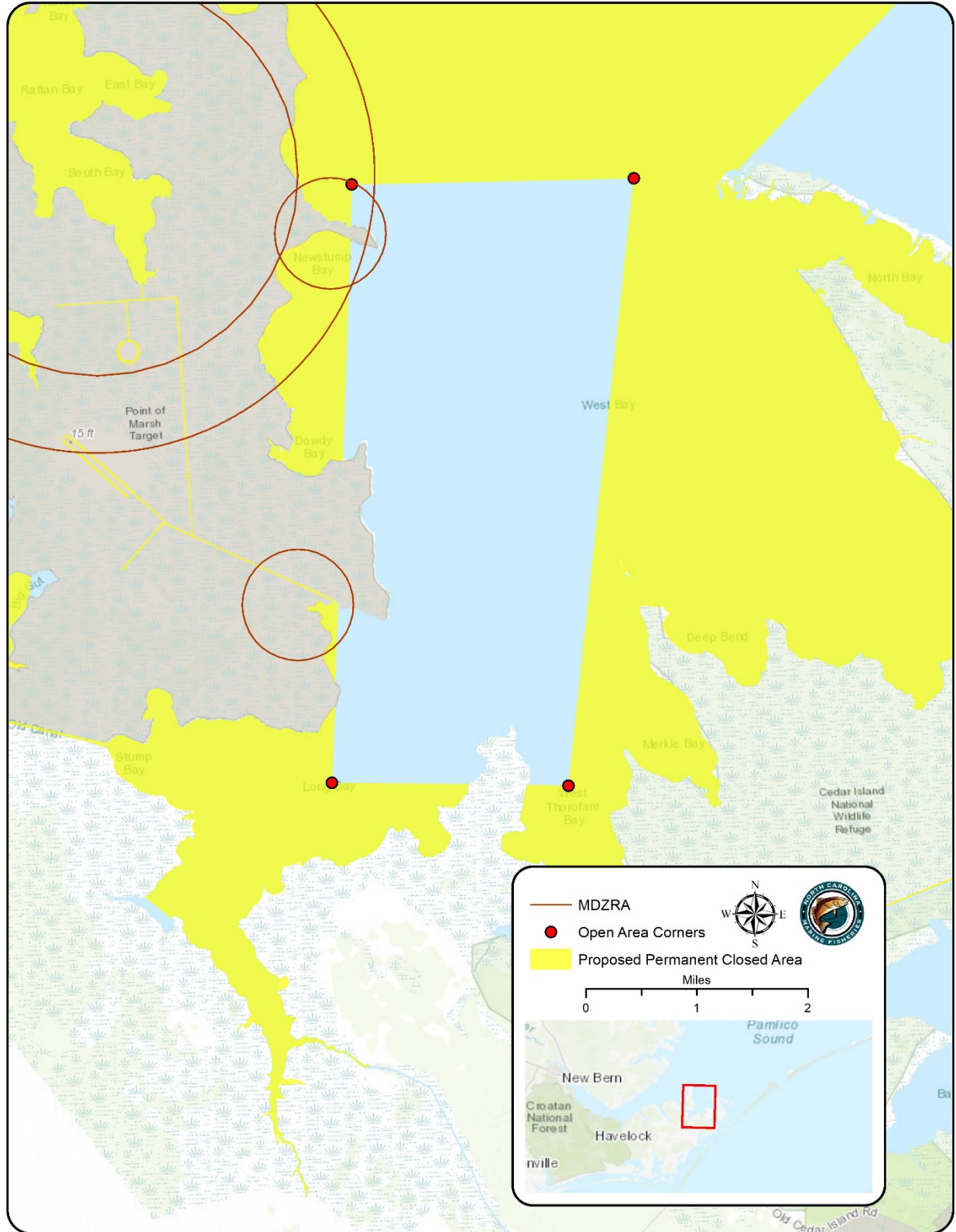


Figure 2.1.9. Example area closure in West Bay to protect SAV and shell bottom habitat.

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APPENDIX 2.2. SHRIMP MANGAEMENT IN SPECIAL SECONDARY NURSERY AREAS

I. ISSUE

Evaluate current shrimp management in Special Secondary Nursery Areas (SSNA)

II. ORIGINATION

The North Carolina Division of Marine Fisheries (NCDMF) Shrimp Plan Development Team (PDT)

III. BACKGROUND

Primary nursery areas (PNA), Secondary Nursery Areas (SNA) and Special Secondary Nursery Areas (SSNA) are defined in NCMFC Rule 15A NCAC 03I .0101 and designated in 15A NCAC 03R .0103, .0104, and .0105. It is unlawful to use any trawl net, long haul seine, swipe net, dredge, or mechanical method for clams or oysters for the purpose of taking any marine fishes in PNAs. In SNAs, it is unlawful to use trawl nets for any purpose. However, in SSNAs the Fisheries Director, may, by proclamation, open any or all SSNAs, or any portion thereof to shrimp or crab trawling from August 16 through May 14.

The SNA and SSNA designations are based primarily on the life histories of the same suite of species used in the PNA designations. As these species grow, they begin to move out of PNAs and toward the middle portion of the estuarine bays and sounds (secondary), then into the lower portions of the system (originally called temporary nursery or transport areas), and eventually the ocean (NCDMF 1978; Ross and Epperly 1985). SSNAs were designated to allow shrimping to occur once substantial out-migration of fish had occurred, so as to provide access to the marketable shrimp resource that might otherwise be lost due to out-migration (NCDMF 1978). Areas considered for SSNA designation were those where the shrimp populations would empty into unfishable bottom and where no substantial oyster habitats would be damaged by trawling.

At their February 2020 business meeting the North Carolina Marine Fisheries Commission (NCMFC) changed the designation of 10 SSNAs that had not been opened to trawling in many years to permanent SNAs. The 2021 Revision to Amendment 1 to the N.C. Shrimp Fishery Management Plan (FMP) documents the rationale and provides supporting data for changing the designations of these SSNAs (NCDMF 2021). A total of 28,741 acres of SSNAs remain (Table 2.2.1, Figures 2.2.1-2.2.3). This issue paper for Amendment 2 of the shrimp FMP further evaluates the opening of SSNAs to shrimp trawling.

Prior to the 2006 Shrimp FMP, shrimp management strategies focused on maximizing the economic value of the shrimp fishery. With implementation of the 2006 Shrimp FMP, shrimp management by size was developed to address economic conditions in the shrimp fishery and other strategies were implemented to minimize waste though gear modifications [trawl mesh size, bycatch reduction devices (BRD), area closures], culling practices, and harvest restrictions (NCDMF 2006). While size management was carried forward in Amendment 1, the emphasis of

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the amendment was to address bycatch in the commercial and recreational shrimp fisheries and development of a live bait shrimp fishery (NCDMF 2015).

The criteria for managing opening and closing of SSNAs also shifted with the adoption of Amendment 1, concentrating on minimizing bycatch while also meeting target shrimp sizes (count of shrimp per pound heads-on). Thus, SSNA openings based on division sampling have occurred later in the season (mid-September and October) to address bycatch concerns, particularly in Core and Stump sounds as well as the New River (Table 2.2.2, Figure 2.2.4). While determining openings and closures through the use of count size may be an appropriate management strategy in terms of economics – maximizing the number and size of shrimp caught, is not necessarily an appropriate measure to reduce bycatch because this measure may not reduce the length of a shrimping season. The intent of the rule which established the August 16 through May 14 SSNA opening window was to allow for the migration of juvenile finfish out of the area balanced against shrimp availability and size. Under existing procedures, a warm winter with favorable environmental conditions may lead to an early season opening, while harsh environmental conditions may lead to a later season opening or no opening at all.

Overall, larger shrimp (lower count size) are landed in the northern and central regions of the state (Roanoke, Croatan, Pamlico and Core sounds) with minimal loss of shrimp due to out-migration. However, in the southern region south of New River, shrimp tend to be smaller in size due to the lack of extensive bays and sounds and out-migration can occur over a shorter period of time. Shrimp size also fluctuates more in the southern region in response to environmental conditions. Large volumes of juvenile shrimp are often pushed out of PNAs following excessive rainfall. When this occurs, the event is often over before a closure in an open SSNA can take effect. In other instances, the size of shrimp brought to market may be notably smaller than those observed during NCDMF sampling, prompting requests from fishermen and dealers to close an area shortly after it has opened. In the southern portion of the state, some dealers have reported that smaller shrimp can at times demand a higher price earlier in the season than larger shrimp due to availability. Live shrimp sold for bait, are often smaller, and have higher value than shrimp harvested for consumption (Figure 2.2.5). While delayed openings may allow larger shrimp to be caught later in the season, supply and demand largely determines shrimp prices; therefore, shrimp management by size is not an effective tool for enhancing the value of the shrimp fishery, nor reducing bycatch.

In order to evaluate current shrimp management in SSNAs, it is important to understand that SSNAs are ecologically equivalent to permanent SNAs with similar habitat characteristics and patterns of species diversity and seasonality; only being differentiated by SSNA allowance to be opened seasonally to trawling. Both SSNAs and permanent SNAs are typically located in the middle portion of the estuarine system and are primarily composed of developing sub-adults of similar size that have migrated from an upstream PNA. Ross and Epperly (1985) noted monthly abundances of winter-spawned species such as spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), southern flounder (*Paralichthys lethostigma*), and blue crab (*Callinectes sapidus*) were similar among trawl stations in the shallow creeks and bays adjacent to Pamlico Sound (Stumpy Point Bay to northern Core Sound), many of which are classified as SSNA and permanent SNAs. Overall, species diversity and seasonality were also found to be similar across all stations. Using cluster analysis to examine the classification of nursery areas in Pamlico

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and Core sounds as well as portions of the Albemarle Sound, Noble and Monroe (1991) also found that relative species abundance and diversity overlapped at stations with similar abiotic profiles and habitat characteristics (bottom composition, sediment size, depth).

Data from NCDMF Estuarine Trawl Survey (Program 120) was paired into two categories (SSNA and PNA) based on their proximity (< 1 mile) to the SSNAs listed in Table 2.2.1 to evaluate the community structure of finfish and invertebrates at eight stations (4 SSNAs and 4 PNAs) in Core Sound from 1978 to 1981 and Roanoke Sound from 2006 to 2019. Community indices were calculated using methods described by Kwak and Peterson (2007). Data were limited to time periods where sampling was conducted both before and after August 16th. Prior to 1989, sampling was conducted year-around, but was later limited to 104 core stations with sampling only occurring in May and June. However, in the Roanoke Sound temporal coverage was expanded beyond May and June to provide more information on within-year changes in growth, mortality, and abundance of blue crab. A paired t-test was also used to compare the relative abundance (number per sample) and mean lengths of penaeid shrimp (brown, pink, white), Atlantic croaker, southern flounder, spot, summer flounder, and weakfish between nursery types.

A total of 95 species of finfish and crustaceans were collected in SSNAs and 65 species in PNAs. The Margalef Index, a weighted measure of species richness (number of different species) that compensates for differences in sample size (Margalef 1958; Kwak and Peterson 2007), was also higher for SSNAs, indicating a greater species richness (Table 2.2.3). Species diversity (Shannon Diversity Index H'), which accounts for species richness and abundance (Hamilton 2005; Kwak and Peterson 2007) was also higher in SSNAs. Species evenness (Shannon's Index J'), an expression of how evenly individuals are distributed among different species (Kwak and Peterson 2007) was higher in SSNAs. Overall, the species composition of both nursery types was similar; however, more unique species were observed in SSNAs. These findings are similar to those of Ross and Epperly (1985) which found that species richness, diversity, and evenness were lower in the uppermost portions of the estuary (i.e., PNAs). The nursery-role of a habitat can vary for species with different life history strategies, degree of estuarine dependency, and use on varying geographic, ontogenetic (physical and psychological), annual and cohort-specific scales (Able 2005). Therefore, SSNAs may not only serve as important migration corridors for winter spawned species, but also as nursery areas for spring and summer spawned species.

Based on the results of the paired t-tests, the relative abundance of Atlantic croaker, southern flounder, summer flounder, and weakfish was not significantly different between SSNAs and PNAs (Table 2.2.4). In SSNAs, relative abundance of southern flounder, spot, summer flounder, and weakfish peaked in May and June; however, Atlantic croaker peaked in October (Figure 2.2.6). The relative abundance of brown and white shrimp in SSNAs peaked in June and July, respectively, declining rapidly after August and September. The mean length of southern flounder as well as brown, pink, and white shrimp was not significantly different between nursery types (Table 2.2.4). Length frequency distribution of target species was similar for target species in both nursery types (Figure 2.2.7). These results further support the ecological similarity between SSNAs and PNAs and demonstrates the importance of both habitats as essential habitat for many developing sub-adult finfish and invertebrates at their various life stages throughout the year.

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The presence of juvenile fish is not the only factor that is considered when identifying nursery areas. In addition to species abundance, size composition, and species diversity, several abiotic factors (bottom type, sediment size, salinity, temperature, and depth) must be evaluated for an area to be designated a PNA. As ecosystem science advances, it has been found that in addition to these factors, other things such as growth, predator protection, and movement out of the nursery into the adult habitat influence determination of nursery areas. Based on Beck et al. (2001), Dahlgren et al. (2006), and Peterson (2003), nursery areas are a subset of juvenile habitat that contributes disproportionately more to the production of juveniles that recruit into a population than another area of similar size. Once a waterbody has been identified by NCDMF as a potential nursery area, a sampling station is established and is sampled a minimum of three years prior to designation to account for annual variability. This process also includes comparisons to other nursery areas to ensure consistent application of the methodology (NCDMF 2013). Since SSNAs are a subset of SNAs, no further sampling or analysis is needed to change the remaining SSNAs to permanent SNAs. Additionally, SNAs do not have additional protections from other agencies' rules, except for a North Carolina Coastal Resources Commission (CRC) rule that restricts impacts to secondary nursery areas (among several other natural resources areas) in the siting of energy facilities [7M .0403 (f)(10)(A)].

Changing the designation of SSNAs to PNAs or expanding nursery area designations is outside of the scope of the Shrimp FMP. The Coastal Habitat Protection Plan (CHPP) provides the proper framework to assist the Marine Fisheries, Environmental Management, and Coastal Resources commissions in managing fish habitat for continued protection and restoration. In addition, an objective of this amendment is to develop a strategy through the CHPP to review current nursery areas and to identify and evaluate potential areas suitable for designation. Efforts are currently underway to create a multi-metric index that will describe the ecological condition of Strategic Habitat Areas (SHAs). SHAs are a subset of high quality or rare, relatively unaltered habitats or systems of habitats that support estuarine and coastal fish and shellfish species. The multi-metric index will evaluate several variables including community diversity, species richness, and feeding guilds (species that share similar niches or ecological roles). A similar process will also be used describe the ecological condition of PNAs, SNAs, and non-nursery areas. Additional work will focus on evaluating current nursery area designations and better aligning the current approach of designating nursery areas in North Carolina with the most current science.

See the CHPP for additional information on protection of critical habitats as well as the identification of SHAs. Current and previous versions of the CHPP and the CHPP Source Document can be viewed and downloaded from: <http://portal.ncdenr.org/web/mf/habitat/chpp/downloads>.

IV. AUTHORITY

North Carolina General Statutes

§ 113-134 RULES

§ 113-173 RECREATIONAL COMMERCIAL GEAR LICENSE

§ 113-182 REGULATION OF FISHING AND FISHERIES

§ 113-182.1 FISHERY MANAGEMENT PLANS

§ 113-221.1 PROCLAMATIONS; EMERGENCY REVIEW

DRAFT – SUBJECT TO CHANGE

§ 143B-289.52 MARINE FISHERIES COMMISSION – POWERS AND DUTIES

North Carolina Marine Fisheries Commission Rules

15A NCAC 03H .0103 PROCLAMATIONS, GENERAL

15A NCAC 03L .0101 SHRIMP HARVET RESTRICTIONS

15A NCAC 03J .0103 GILL NETS, SEINES, IDENTIFICATION, RESTRICTIONS

15A NCAC 03N .0105 PROHIBITED GEAR, SECONDARY NURSERY AREAS

V. DISCUSSION

- Section discusses potential management measures to reduce bycatch in SSNAs
- Establishing static seasons with delayed openings could reduce bycatch and allow access to larger more marketable shrimp later in the season
- Changing the designation of all SSNAs to permanent SNAs would eliminate bycatch by making it unlawful to use any trawl (beam, crab, skimmer, otter, etc.)
- The amount of bycatch reduction is non-quantifiable (see *Appendix 1: Shrimp Trawl Bycatch Assessment*)
- Changing the designation of all SSNAs to permanent SNAs would require gill net (<5-inch stretch mesh) attendance in all waters from May 1 through November 30

By allowing limited trawling in SSNAs, fishermen may catch shrimp late in the season that have not migrated out into the larger estuaries. The division conducts regular sampling in the central and southern regions of the state to monitor abundance of bycatch and shrimp size and abundance if the area is being considered for opening. Target sizes (count of shrimp per pound heads-on) differ by waterbody within the state to account for variability in size preference of user groups, geographic differences in shrimp size at migration, weather events, vessel sizes, and socioeconomic conditions (NCDMF 2006). Timing of SSNA openings can be highly influenced by environmental conditions, proximity to major inlets and rivers, and input from stakeholders, and vary by area. In smaller waterbodies of the state, shrimp tend to migrate earlier due to lack of extensive bays and sounds. Management by target size has been controversial because of bycatch, variability in shrimp abundance and size from year to year, timing of opening, user conflicts, and pressure from fishermen to access the resource.

Using the NCTTP landings data, the monthly percentage of shrimp harvested in all estuarine waters that were a 31/35 count or lower (average target opening size for SSNAs listed in Table 2.2.1) was calculated from 1994 to 2019 (Table 2.2.5). While landings data for each SSNA could not be identified, count sizes were used as a proxy for shrimp sizes in SSNAs. On average, 69% of the shrimp landed from August 1 to May 31 were a 31/35 count or lower (Table 2.2.5). If a September 1 to November 30 season was in place, approximately 81% of the shrimp landed would be a 31/35 count or lower. Approximately 85% of the shrimp landed would be a 31/35 count or lower if the season was delayed to October 1 to December 31. In the southern portion of the state, marketable shrimp typically migrate out of the estuaries earlier in the year; thus, seasons could be established regionally to account for differences in migration timing.

While many SSNAs have periodically opened from 2000 to 2019, several have not opened to shrimp trawling in many years (Tables 2.2.1 and 2.2.2). The North River and Ward Creek SSNAs

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have only opened once since 2000. The Chadwick Bay SSNA has only opened twice since being designated a SSNA in 2011; last opening in 2012. The Kitty Hawk/Buzzards Bay SSNA has never opened since being designated as nursery area in 2004. In the Stump Sound SSNA, the area from the Highway 210 Bridge to Marker #49 has opened twice from 2015-2019; the opening in 2018 was to allow access to shrimp prior to Hurricane Florence. The presence of small shrimp and high levels of bycatch, as well as limited stakeholder demand have minimized the need to open most SSNAs. Changing these particular SSNA designations to permanent SNAs would have little to no impact on commercial shrimp and crab trawling since these areas have not been opened to trawling in many years. Not allowing trawling in these areas would also provide further protection to critical habitats used by numerous economically important species of fish and invertebrates as well as other prey species. Furthermore, eliminating bottom disturbing gear such as crab and shrimp trawling in these areas would provide additional protection to significant portions of NCMFC nominated SHAs.

Re-designating all SSNAs to permanent SNAs, making it unlawful to use all trawl nets for any purpose, would further reduce bycatch and protect developing sub-adult finfish and invertebrates that have migrated from PNAs and critical fish habitats. Re-designating all SSNAs to permanent SNAs would also provide further protection to species such as Atlantic Croaker that migrate through SSNAs into PNAs in September (Figure 2.2.6). However, changing the designation of all SSNAs to permanent SNAs would impact commercial shrimp trawling; most notably in SSNAs located in Core and Stump sounds, and the New River. Overall, SSNAs make up a small percentage of the total acreage of North Carolina's estuarine waters open to trawling (Table 2.2.1). Closing these areas to trawling leaves a considerable amount of water open to trawling and potentially allows more marketable shrimp to be harvested downstream of the current SSNA boundaries. Currently, only skimmer trawls are allowed in the New River SSNA; prohibiting the use of all trawls could elevate conflicts between otter and skimmer trawlers downstream.

Changing the designation of all SSNAs to permanent SNAs would eliminate crab trawling in some areas. However, effort in the crab trawl fishery has been low in recent years with most effort occurring in the central region of the state (Core and Bogue sounds; Table 2.2.6). Statewide, blue crab landings from crab and shrimp trawls account for 0.05% and 0.1%, respectively of the total blue crab harvest in recent years (NCDMF 2020). Since 2009, there have been no landings from crab trawling in the New River, Chadwick Bay, and Stump Sound, though it is allowed. With the adoption of Amendment 3 to the Blue Crab FMP in 2020, the use of crab trawls was prohibited north of the shrimp trawl lines in the Pamlico, Pungo, and Neuse rivers (NCDMF 2020). This action was taken to improve habitat conditions for blue crabs as well as other economically important species and provide additional protection of SHAs. Trawling has also been further limited to November through February in fourteen inlets from Beaufort Inlet south to the NC/SC line with the inception of new crab spawning sanctuaries on May 1, 2020.

Attendance requirements for gill nets would also change if SSNAs were reclassified to permanent SNAs (Table 2.2.7). Current gill net attendance requirements for each SSNA are shown in Figures 2.2.8-2.2.10. NCMFC Rules 15A NCAC 03J .0103 and 03R .0112 require attendance of small mesh gill nets (<5 inch stretch mesh) in all permanent SNAs. The 2001 Red Drum FMP implemented small mesh gill net attendance from May 1 through October 31 (later extended through November) in areas where juvenile red drum (*Sciaenops ocellatus*) typically occur, in

DRAFT – SUBJECT TO CHANGE

shallow bays and creeks, shorelines, and over shallow submerged aquatic vegetation (NCDMF 2001). Additionally, the South Atlantic Fishery Management Council (SAFMC) designated specific inshore areas in the south Atlantic region as Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) in their Habitat Plan for red drum (SAFMC 1998). In North Carolina, these federal areas included all state-designated nursery habitats of particular importance for red drum (i.e., all PNAs and all SNAs). When the gill net attendance rule language was adopted, it covered areas listed as PNAs and SNAs, but not SSNAs. The stated rationale for red drum bycatch reduction would apply to any SNA (past or future).

VI. PROPOSED RULE(S)

Completed after recommendations are brought forward.

VII. MANAGEMENT OPTIONS AND IMPACTS

(+ Potential positive impact of action)

(- Potential negative impact of action)

1. *Status quo* - Continue to manage special secondary nursery concentrating on minimizing bycatch while also meeting target shrimp sizes with sampling.
 - + No rule changes are needed
 - + No impact to commercial fishermen
 - + Flexibility in dealing with dynamic conditions
 - Does not minimize bycatch from shrimp trawls in SSNAs
 - Does not address the needs of all user groups (bait vs. consumption)
 - Does not protect habitat from bottom disturbing gear
 - Labor intensive and expensive sampling
 - Shrimp abundance and size vary widely in the same geographic area
 - Bycatch abundance variable due to environmental conditions and locations in the estuary
2. Establish static seasons for shrimp trawling in all or some special secondary nursery areas.
 - + Potential to reduce bycatch from shrimp trawls in SSNAs
 - + Potential to increase harvest size and economic value of shrimp
 - + Opening and closing dates predetermined
 - + Satisfy fishermen who disagree with flexible openings.
 - + Minimizes confusion of openings
 - Does not protect habitat from bottom disturbing gear
 - No flexibility in dealing with dynamic conditions
 - Potential for excessive harvest of small shrimp or shrimp gone when opened
 - May adversely impact some fishermen more than others
3. Change the designation of all or some special secondary nursery areas to permanent secondary nursery areas which would prohibit all trawling. Under NCMFC Rule 15A NCAC 03R .0112(b)(1), gill net attendance is required in all waters of permanent secondary nursery areas from May 1 through November 30.

DRAFT – SUBJECT TO CHANGE

- + Eliminate bycatch from shrimp trawls in all SSNAs
- + Protects habitat from bottom disturbing gear
- +/- Gill net attendance required in all waters from May 1 through November 30
- + Nursery rule changes are needed
 - Eliminates crab trawling when the areas are open
 - Loss of income to commercial fishermen and dealers
 - Cannot assess benefit of bycatch reduction on fish stocks with current data
 - Loss of recreational shrimp source
 - May concentrate participants into open areas and result in greater effort impacts overall
 - May adversely impact some fishermen more than others

VIII. RECOMMENDATIONS

Division of Marine Fisheries

- Change the designation of all SSNAs to SNAs.

Northern Advisory Committee

- No recommendation.

Southern Advisory Committee

- Change the designation of “all SSNA listed to SNA[s]”.

Finfish Advisory Committee

- No motion or recommendation.

Shellfish and Crustacean Advisory Committee

- No motion passed.

Habitat and Water Quality Advisory Committee

- No motion or recommendation.

NCMFC Selected Management Strategy

IX. LITERATURE CITED

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Tables

Table 2.2.1. Total acreage, year designated, percent (%) acreage of estuarine waters open to trawling, year designated, last year opened, and target opening sizes (count of shrimp per pound heads-on) of special secondary nursery areas.

Current Rule ID 03R .0105	Description	Acreage	Percent Acreage of Estuarine Waters Open to Trawling	Year Designated (reclassified)	Latest Year Opened	Proclamation Reference	Target Count size
1 (a)	Shallowbag Bay	468	0.04	2004	2017	SH-5-2017	27-35
1 (b)	Kitty Hawk Bay-Buzzard Bay	1,996	0.18	2004			27-35
3 (a)	West Thorofare Bay	776	0.07	1986	2018	SH-6-2018	27-35
3 (b)	Long Bay-Ditch Bay	1,140	0.10	1986	2018	SH-6-2018	27-35
3 (c)	Turnagain Bay	963	0.09	1995	2018	SH-6-2018	27-35
4 (a)	Cedar Island Bay	1,794	0.16	1986	2018	SH-6-2018	27-35
4 (b)	Thorofare Bay-Barry Bay	2,156	0.19	1986	2018	SH-6-2018	27-35
4 (c)	Nelson Bay	1,077	0.10	1986	2018	SH-6-2018	27-35
4 (d)	Brett Bay	251	0.02	1986	2018	SH-6-2018	27-35
4 (e)	Jarrett Bay	1,431	0.13	1986	2018	SH-6-2018	27-35
5 (a)	North River	978	0.09	1986	2000	SH-4-2000	27-35
5 (b)	Ward Creek	625	0.06	1986	2000	SH-4-2000	27-35
7	New River (above HWY 172 Bridge)**	14,669	1.31	1995	2019	SH-7-2019	20-30
8	Chadwick Bay	167	0.01	2011	2012	SH-8-2012	30-40
9	Intracoastal Waterway (Stump Sound)	252	0.02	1995	2019	SH-7-2019	20-30

* Not opened after SSNA designation

**Only 5,406 acres is open to trawling or 0.48% of estuarine waters open to trawling

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Table 2.2.2. Special secondary nursery (SSNA) openings by waterbody, 2000-2019. Re-openings are bolded.

	Total Openings	Not Opened	Opened Aug. 16	Openings							
				Aug. 1-16	Aug. 17-31	Sept. 1-16	Sept. 17-30	Oct. 1-16	Oct. 17-31	Nov. 1-16	Nov. 17-30
<u>Roanoke Sound Area</u>											
Shallowbag Bay	13	2	8	8	5						
Kitty Hawk Bay-Buzzard Bay	0	20	0								
<u>Core Sound Area</u>											
West Thorofare Bay ⁴	17	3	0				2	6	7	1	
Long Bay-Ditch Bay ⁴	17	3	0				2	6	7	1	
Turnagain Bay ⁴	17	3	0				2	6	7	1	
Cedar Island Bay ⁴	17	3	0				2	6	7	1	
Thorofare Bay-Barry Bay ⁴	17	3	0				2	6	7	1	
Nelson Bay ⁴	17	4	0				2	6	7	1	
Brett Bay ⁴	17	3	0				2	6	7	1	
Jarrett Bay ⁴	17	3	0				2	6	7	1	
<u>North River Area</u>											
North River	1	19	1	1							
Ward Creek	1	19	1	1							
<u>New River Area</u>											
New River (above HWY 172 Bridge) ¹	21	0	0		10	5	2	2(1)	1		
New River (Hine to Lowe Point) ²	1	19	0			1					
Chadwick Bay	2	7	0		2						
<u>Stump Sound (IWW)</u>											
Marker 17 to HWY 50 Bridge (total)	3	17	0		3						
Marker 17 to HWY 50 Bridge (total in parts)	8	12	0			1		1		1	2
Marker 17 to Marker 49 (upper, middle) ³	1	19	0			1					3
Marker 17 to HWY 210 Bridge (upper)	20	0	2	2	9	5	1	1	2		
HWY 210 Bridge to Marker 45 (middle) ¹	13	9	0		3	1		1		1(1)	2(1)
HWY 210 Bridge to Marker 49 (middle)	11	9	0		3	1		1		1	2
Marker 45 to HWY 50 Bridge (lower) ¹	16	5	1	1	7	3		1	1		2(1)
Marker 49 to HWY 50 Bridge (lower)	15	5	1	1	6	3		1		1	2

¹ Closed and reopened within year due to small shrimp and bycatch concerns

² Partial opening of SSNA on 9/3/2004, full opening on 9/14/2004

³ Opened on 9/5/18 for Hurricane Florence

⁴ Opened on 9/12/18 for Hurricane Florence

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Table 2.2.3. Total number of samples collected, total species abundances, species richness, species diversity, and species evenness of Special Secondary Nursery Areas (SSNA) and Primary Nursery Areas (PNA) located in Core (1978-1981) and Roanoke sounds (2006-2019).

	SSNA	PNA
Total Samples	251	250
<u>Abundance</u>		
Total Number of Individuals	31,013	18,410
<u>Species Richness</u>		
Total Species	95	65
Margalef Index	9.09	6.52
<u>Species Diversity</u>		
Shannon Diversity Index (H')	2.83	1.77
<u>Species Evenness</u>		
Shannon's Index (J')	0.62	0.42

Table 2.2.4. Relative abundance (number per sample), standard error (SE), percent standard error (PSE), total number collected (N), number measured, modal length (mm), mean length (mm), size range (mm) for economically important species collected in NCDMF Program 120 in Core (1978-1981) and Roanoke sounds (2006-2019). Bolded relative abundance and mean length values are statistically significant ($p < 0.05$).

Common Name	Relative Abundance	SE	PSE	Number Collected	Sample Size	Number Measured	Mode (mm)	Mean Length (mm)	Size Range (mm)
SSNA									
Brown Shrimp	7.2	1.2	16	1,813	251	1,574	25	66.8	5-138
Pink Shrimp	1.0	0.2	17	245	251	244	35	57.9	15-145
White Shrimp	1.9	0.6	33	470	251	366	24	50.7	15-162
Atlantic Croaker	7.3	1.3	18	1,833	251	1,302	25	60.3	10-265
Southern Flounder	0.4	0.1	26	99	251	99	59	83.8	37-380
Spot	17.0	2.7	16	4,259	251	2,381	55	63.6	12-215
Summer Flounder	0.1	0.0	37	17	251	17	43	91.1	53-197
Weakfish	0.2	0.1	50	50	251	50	45	54.1	25-209
PNA									
Brown Shrimp	4.6	0.6	14	1,152	250	1,150	65	67.3	13-155
Pink Shrimp	0.3	0.1	23	77	250	77	35	56.1	25-168
White Shrimp	0.4	0.1	26	107	250	35	37	53.1	24-99
Atlantic Croaker	6.6	1.0	16	1,639	250	1,379	22	70.3	7-245
Southern Flounder	0.1	0.0	17	35	250	107	75	86.1	29-453
Spot	26.7	3.9	15	6,666	250	3,673	55	69.4	16-200
Summer Flounder	0.1	0.0	35	13	250	13	66	68.8	38-116
Weakfish	0.1	0.0	33	20	250	20	45	89.7	22-188

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Table 2.2.5. Total estuarine shrimp landings and count size (number of shrimp per pound, heads-on), 1994-2019. NUM/DOZ=dozens of shrimp sold as live bait converted to pounds.

Size	Month											
	1		2		3		4		5		6	
	lb.	%	lb.	%	lb.	%	lb.	%	lb.	%	lb.	%
0/15	47,154	19.1	10,449	32.8	12,066	7.7	38,009	6.4	26,575	1.4	101,545	1.3
16/20	102,216	41.5	7,053	22.1	18,122	11.6	50,517	8.5	79,783	4.2	322,792	4.2
21/25	55,956	22.7	6,733	21.1	10,708	6.8	25,072	4.2	106,788	5.7	638,028	8.3
26/30	4,344	1.8	1,380	4.3	8,175	5.2	18,739	3.1	176,800	9.4	1,043,711	13.5
31/35	21,563	8.8	1,152	3.6	4,937	3.2	36,465	6.1	251,733	13.4	961,695	12.5
36/40	4,639	1.9	636	2.0	12,625	8.1	89,913	15.0	345,570	18.4	1,050,185	13.6
41/45	4,954	2.0	514	1.6	19,586	12.5	94,863	15.9	299,495	16.0	839,595	10.9
46/50	1,986	0.8	489	1.5	17,906	11.4	129,512	21.7	327,509	17.4	975,897	12.6
51/55	916	0.4	1,913	6.0	17,891	11.4	25,754	4.3	57,731	3.1	336,663	4.4
56/60	90	0.0	711	2.2	11,585	7.4	21,059	3.5	34,873	1.9	562,452	7.3
60/70	101	0.0	281	0.9	3,773	2.4	2,854	0.5	17,307	0.9	397,094	5.1
70/80		0.0	4	0.0	230	0.1	197	0.0	5,483	0.3	136,455	1.8
80+		0.0		0.0	147	0.1	2,466	0.4	3,623	0.2	45,663	0.6
MIXED	1,962	0.8	475	1.5	18,675	11.9	61,568	10.3	142,888	7.6	304,045	3.9
NUM/DOZ	409	0.2	63	0.2	224	0.1	604	0.1	1,224	0.1	4,051	0.1
Total	246,289	100	31,852	100	156,648	100	597,592	100	1,877,381	100	7,719,869	100
Size < 31/35	231,231	93.9	26,767	84.0	54,008	34.5	168,802	28.2	641,678	34.2	3,067,770	39.7

Size	Month											
	7		8		9		10		11		12	
	lb.	%	lb.	%	lb.	%	lb.	%	lb.	%	lb.	%
0/15	3,637,516	8.7	8,771,235	24.1	4,999,151	21.7	7,869,400	39.6	4,118,059	48.3	451,226	31.3
16/20	9,708,484	23.2	11,291,889	31.0	4,927,747	21.4	3,634,021	18.3	1,162,558	13.6	360,609	25.0
21/25	11,433,320	27.3	6,191,082	17.0	3,906,628	16.9	2,633,966	13.2	923,615	10.8	308,675	21.4
26/30	8,233,091	19.7	3,216,202	8.8	2,030,047	8.8	974,281	4.9	292,217	3.4	44,749	3.1
31/35	2,700,684	6.4	1,118,548	3.1	1,677,016	7.3	1,486,633	7.5	643,622	7.6	76,541	5.3
36/40	2,444,248	5.8	1,234,049	3.4	1,467,136	6.4	1,174,098	5.9	431,511	5.1	57,786	4.0
41/45	653,750	1.6	642,456	1.8	892,771	3.9	577,994	2.9	244,930	2.9	33,582	2.3
46/50	885,838	2.1	779,181	2.1	730,163	3.2	426,681	2.1	128,316	1.5	20,138	1.4
51/55	183,318	0.4	360,530	1.0	387,263	1.7	138,488	0.7	90,234	1.1	20,223	1.4
56/60	341,249	0.8	519,438	1.4	420,795	1.8	215,100	1.1	106,857	1.3	19,317	1.3
60/70	174,122	0.4	475,245	1.3	467,507	2.0	182,927	0.9	95,971	1.1	15,087	1.0
70/80	49,647	0.1	228,867	0.6	234,544	1.0	56,322	0.3	53,564	0.6	2,891	0.2
80+	41,897	0.1	173,485	0.5	235,186	1.0	38,224	0.2	38,691	0.5	2,236	0.2
MIXED	1,385,882	3.3	1,403,106	3.9	672,985	2.9	475,262	2.4	181,996	2.1	24,372	1.7
NUM/DOZ	3,543	0.0	3,063	0.0	2,534	0.0	5,478	0.0	9,050	0.1	3,096	0.2
Total	41,876,591	100	36,408,376	100	23,051,472	100	19,888,875	100	8,521,190	100	1,440,528	100
Size < 31/35	35,713,095	85.3	30,588,955	84.0	17,540,588	76.1	16,598,302	83.5	7,140,071	83.8	1,241,800	86.2

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Table 2.2.6. Annual crab and peeler trawl landings by region, 2009-2019.

Year	ASMA ¹		Pamlico Sound Region ²		Core/Bogue Sound to New River ³		New River to SC State line ⁴	
	Participants	Trips	Participants	Trips	Participants	Trips	Participants	Trips
2009	4	17	57	430	3	37	0	0
2010	3	11	29	143	25	150	0	0
2011	2	3	20	123	20	143	0	0
2012	3	3	9	17	5	25	0	0
2013	1	2	12	42	9	70	0	0
2014	0	0	23	58	17	165	0	0
2015	1	1	28	109	25	380	0	0
2016	2	2	20	84	23	391	0	0
2017	0	0	19	71	21	297	0	0
2018	1	1	8	10	20	168	0	0
2019	6	27	17	74	19	222	0	0

¹ All the waters north of Pamlico Sound

² Pamlico Sound, Pamlico River, Pungo River, Neuse River, and Bay River

³ Core Sound, Bogue Sound, Newport River, North River, White Oak River, New River, Inland Waterway-Onslow

⁴ Masonboro Sound, Topsail Sound, Cape Fear River, Shallotte River, Lockwood Folly River, Stump Sound (IWW), and Brunswick County (IWW)

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Table 2.2.7. Current and potential gill net attendance requirement changes (<5 inch stretch mesh) for each special secondary nursery area (SSNA) under consideration for reclassification by management option.

Management Options	Shallowbag Bay	Kitty Hawk Bay-Buzzard Bay	West Thorofare Bay	Long Bay-Ditch Bay	Turnagain Bay	Cedar Island Bay	Thorofare Bay-Barry Bay	Nelson Bay
Current gill net attendance requirements	Attendance not required	Attendance not required	Attendance within 50 yards of shore from May 1 - November 30	Attendance within 50 yards of shore from May 1 - November 30	Attendance within 200 yards from shore in all waters year round	Attendance within 50 yards of shore from May 1 - September 30	Attendance within 50 yards of shore from May 1 - September 30	Attendance within 50 yards of shore from May 1 - September 30
Options 1 & 2: Remain as SSNAs*	No change	No change	No change	No change	No change	No change	No change	No change
Option 3: Reclassify as SNAs [†] with gill net attendance	Gill net attendance period in all waters from May 1 - November 30	Gill net attendance period in all waters from May 1 - November 30	Extends gill net attendance period in all waters from May 1 - November 30	Extends gill net attendance period in all waters from May 1 - November 30	No change	Extends gill net attendance period in all waters from May 1 - November 30	Extends gill net attendance period in all waters from May 1 - November 30	Extends gill net attendance period in all waters from May 1 - November 30

Management Options	Brett Bay	Jarrett Bay	North River	Ward Creek	New River (above HWY 172 Bridge)	Chadwick Bay	Intracoastal Waterway (Stump Sound)
Current gill net attendance requirements	Attendance within 50 yards of shore from May 1 - September 30	Attendance within 50 yards of shore from May 1 - September 30	Attendance within 50 yards of shore from May 1 - September 30	Attendance within 50 yards of shore from May 1 - September 30	Attendance within 50 yards of shore from May 1 - September 30	Attendance within 50 yards of shore from May 1 - September 30	Attendance within 50 yards of shore from May 1 - September 30
Options 1 & 2: Remain as SSNAs*	No change	No change	No change	No change	No change	No change	No change
Option 3: Reclassify as SNAs [†] with gill net attendance	Extends gill net attendance period in all waters from May 1 - November 30	Extends gill net attendance period in all waters from May 1 - November 30	Extends gill net attendance period in all waters from May 1 - November 30	Extends gill net attendance period in all waters from May 1 - November 30	Extends gill net attendance period in all waters from May 1 - November 30	Extends gill net attendance period in all waters from May 1 - November 30	Extends gill net attendance period in all waters from May 1 - November 30

* Special Secondary Nursery Area

† Secondary Nursery Area

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Figures

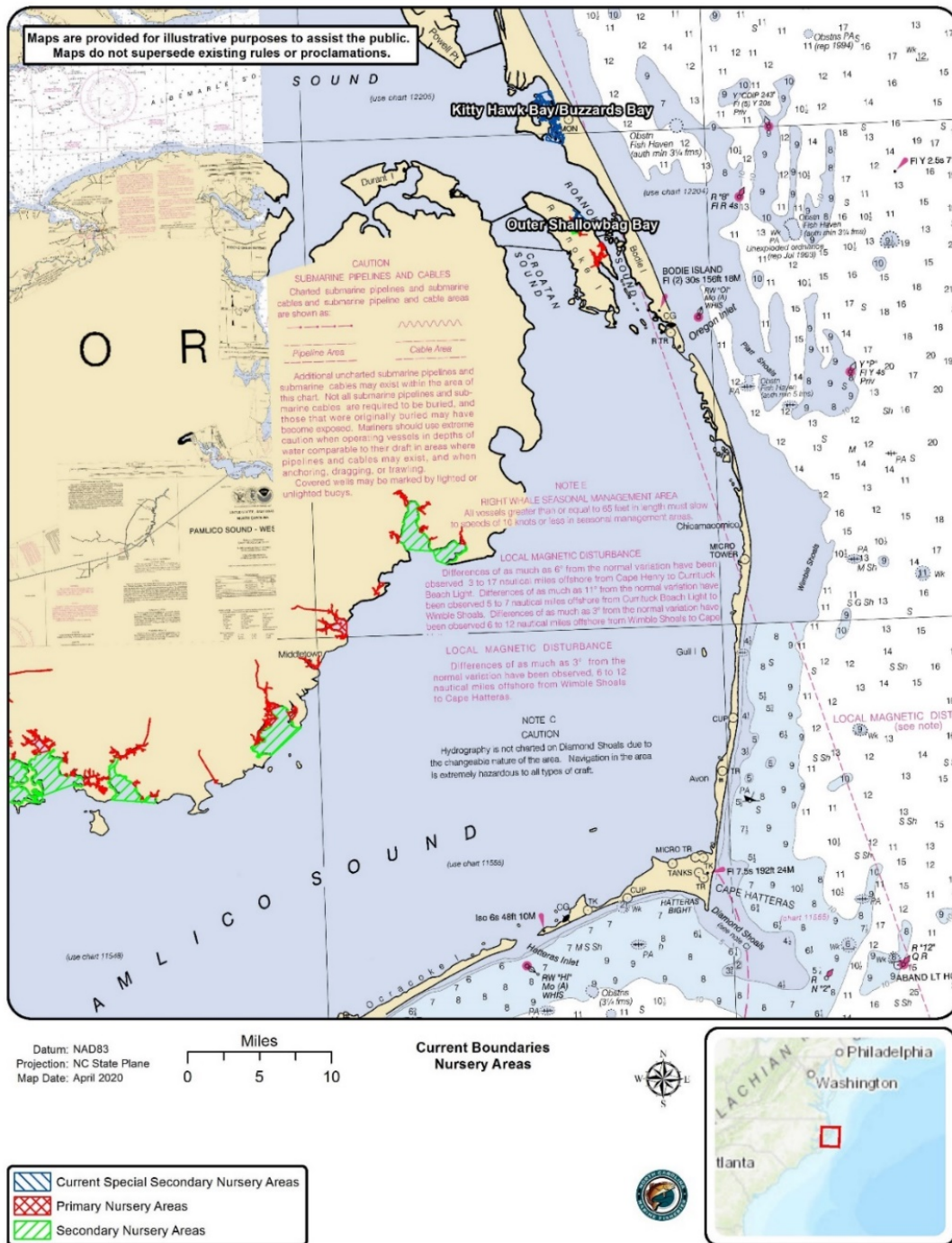


Figure 2.2.1. Map of the shrimp management and nursery areas in the Roanoke Sound that are subject to gill net attendance rules (<5-inch stretch mesh). Gill net attendance will be required in all areas marked as special secondary nursery areas (SSNAs) from May 1 through November 30 if their designation is changed to permanent secondary nursery areas (SNAs). Year-round attendance (<5-inch stretch mesh) is already required in Scranton Creek.

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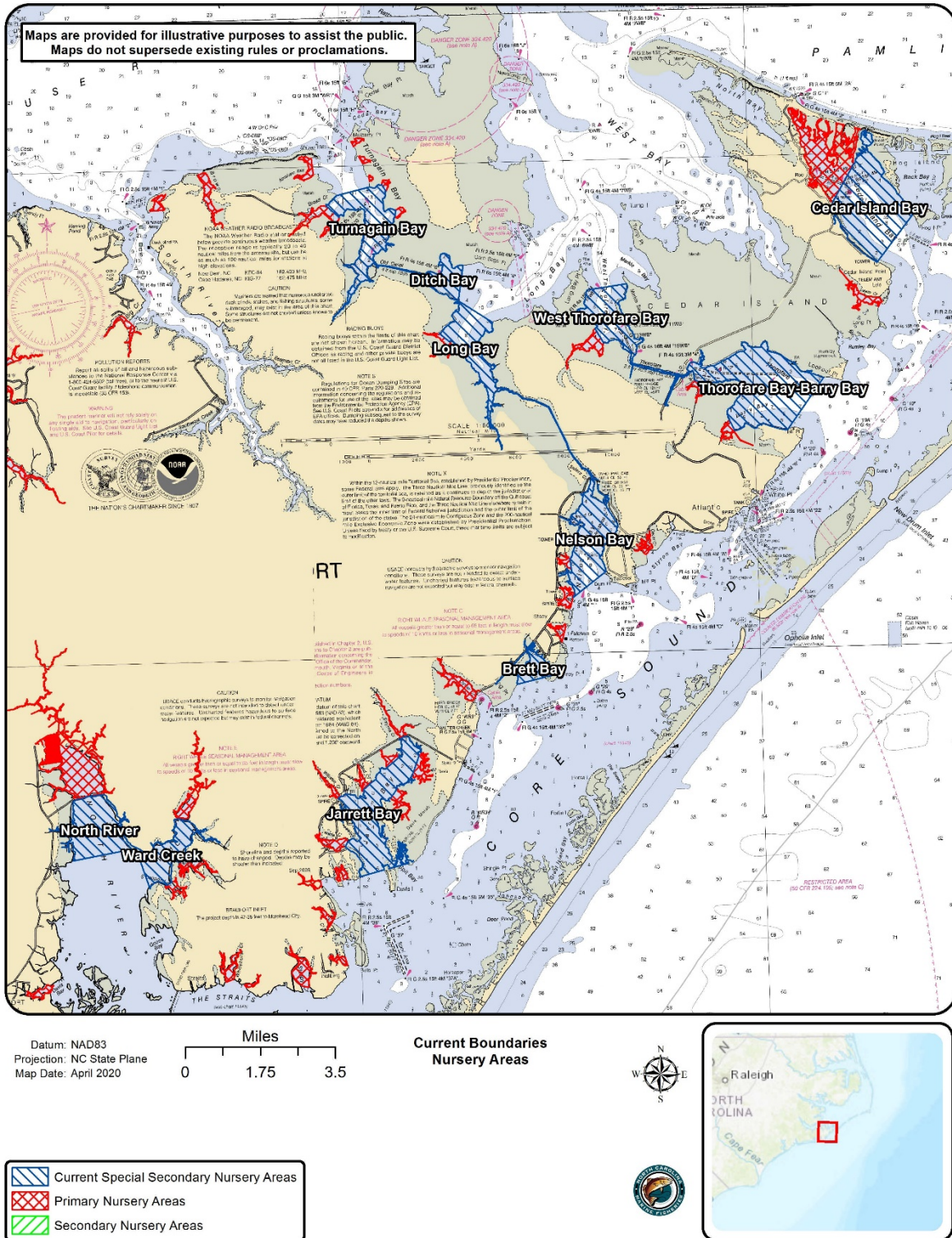


Figure 2.2.2. Map of the shrimp management and nursery areas in the Core Sound Region. Gill net attendance (<5-inch stretch mesh) will be required in all areas marked as special secondary nursery areas (SSNAs) from May 1 through November 30 if their designation is changed to permanent secondary nursery areas (SNAs).

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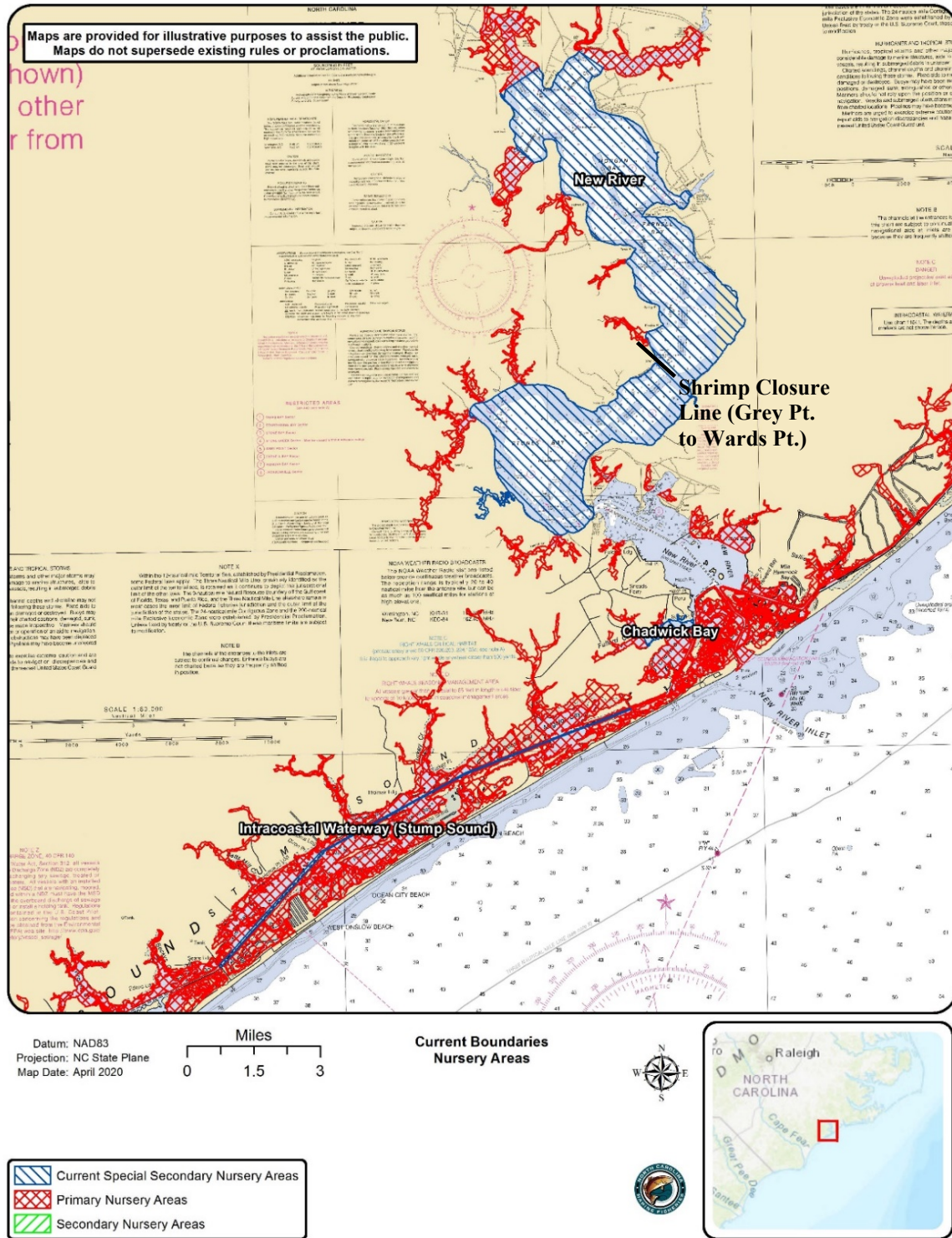


Figure 2.2.3. Map of the shrimp management and nursery areas in the New River, Chadwick Bay, and Stump Sound (IWW). Gill net attendance (<5-inch stretch mesh) will be required in all areas marked as special secondary nursery areas (SSNAs) from May 1 through November 30 if their designation is changed to permanent secondary nursery areas (SNAs).

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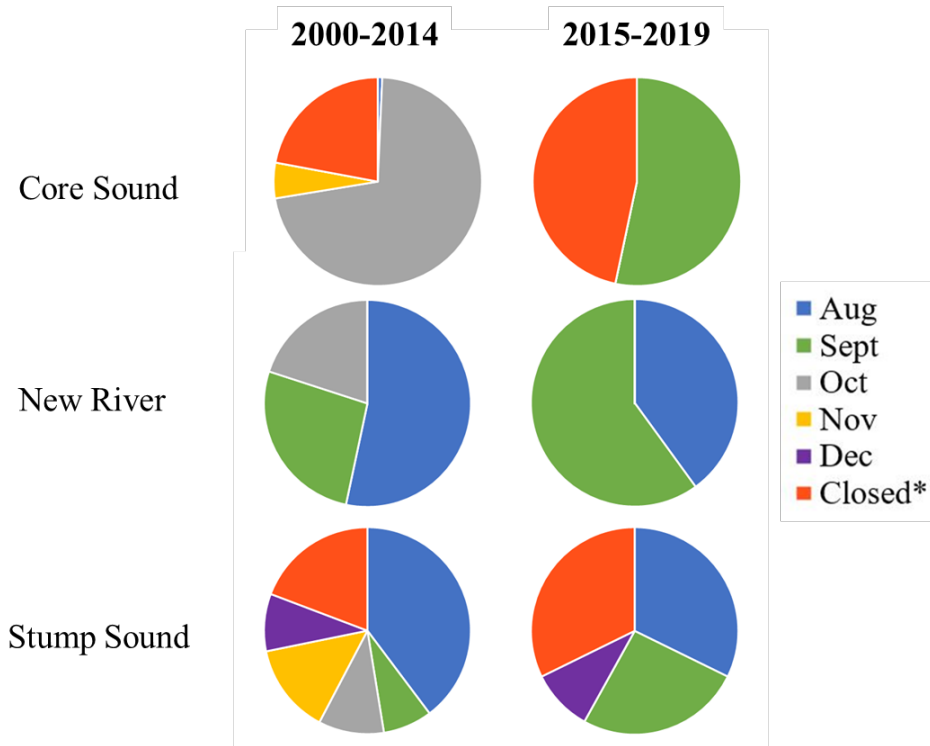


Figure 2.2.4. Special secondary nursery (SSNA) openings (percent of total) in Core Sound, New River, and Stump Sound shown by month and waterbody from 2000-2014 and 2015-2019. *Closures in Stump Sound may be partial closures.

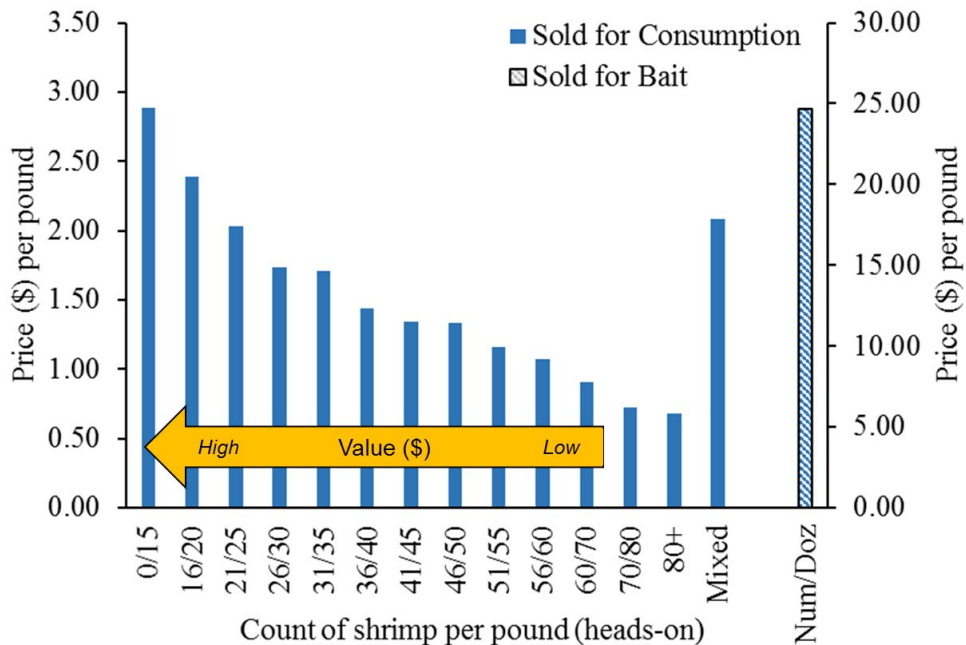


Figure 2.2.5. Value of estuarine shrimp by count size (heads-on), 1994-2019.

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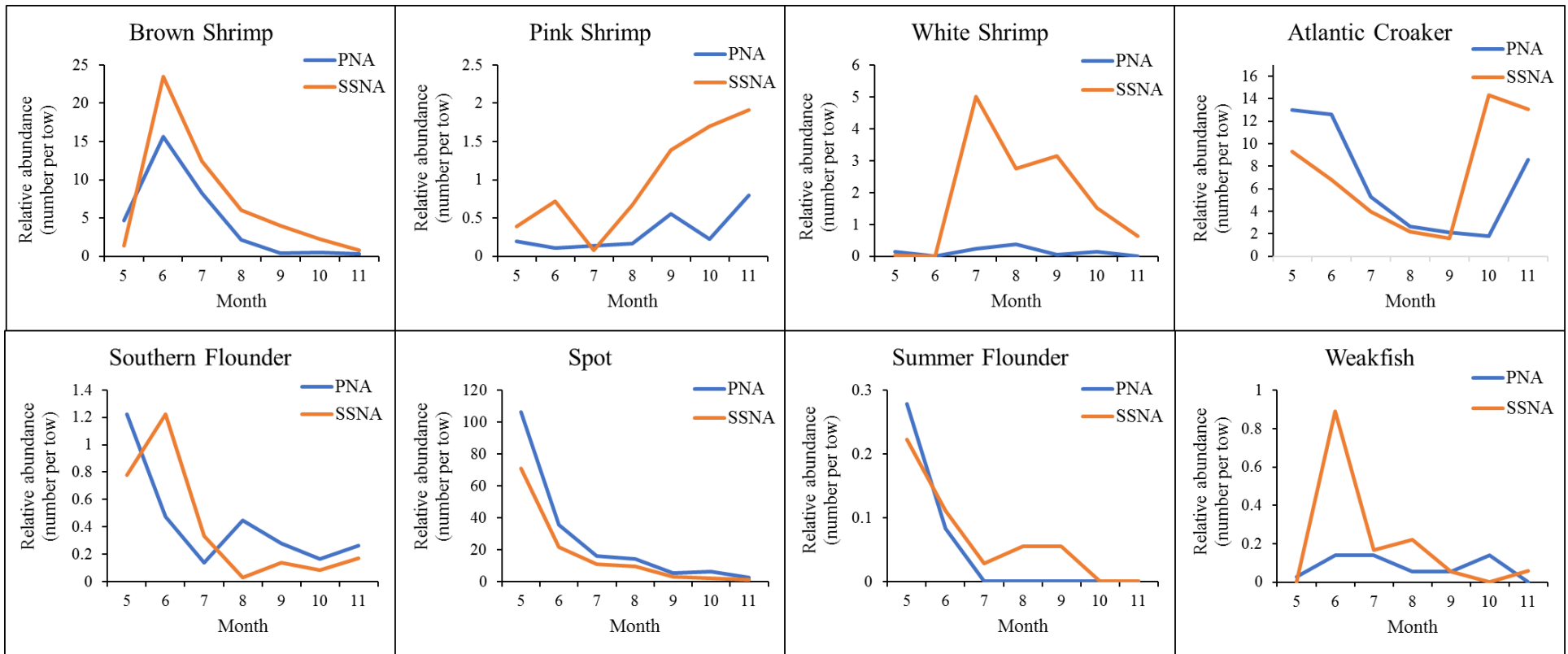


Figure 2.2.6. Relative abundance (number per sample) of target species collected in NCDMF Program 120 in Core (1978-1981) and Roanoke sounds (2006-2019) by nursery type (primary nursery - PNA, special secondary nursery - SSNA).

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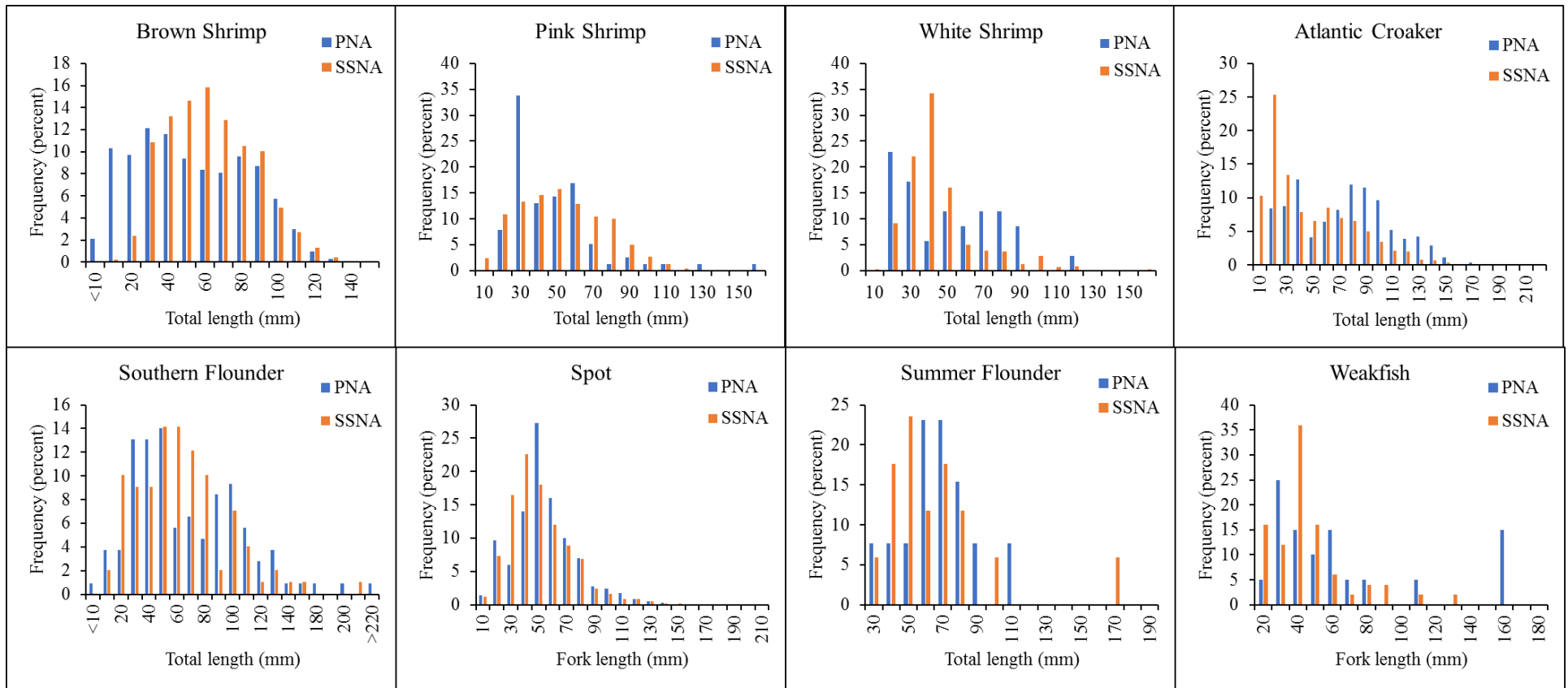


Figure 2.2.7. Expanded length frequency distribution of target species collected in NCDMF Program 120 in Core (1978-1981) and Roanoke sounds (2006-2019).

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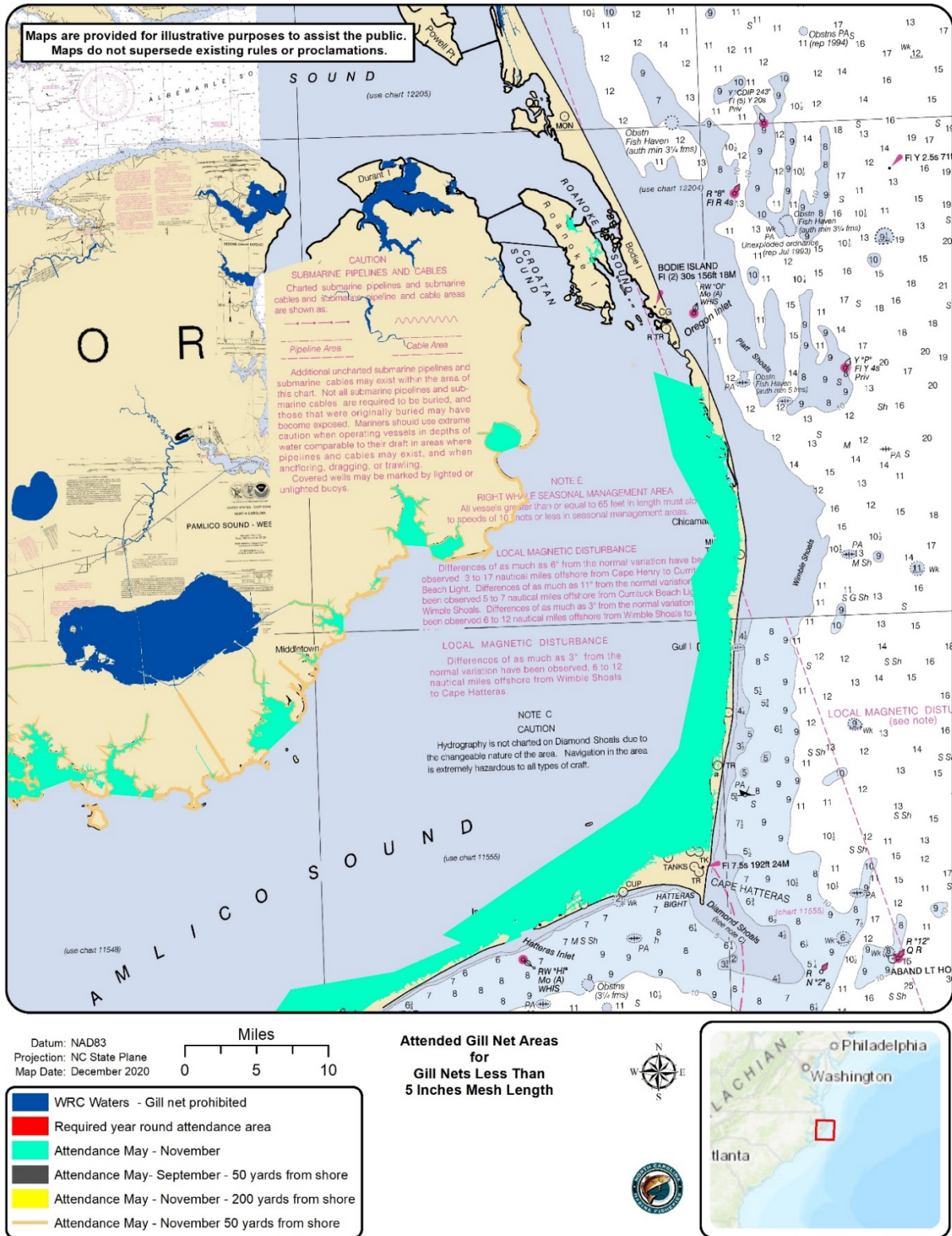


Figure 2.2.8. Map of current gill net attendance (<5-inch stretch mesh) and primary and permanent secondary nursery areas in Shallowbag, Kitty Hawk, and Buzzard bays.

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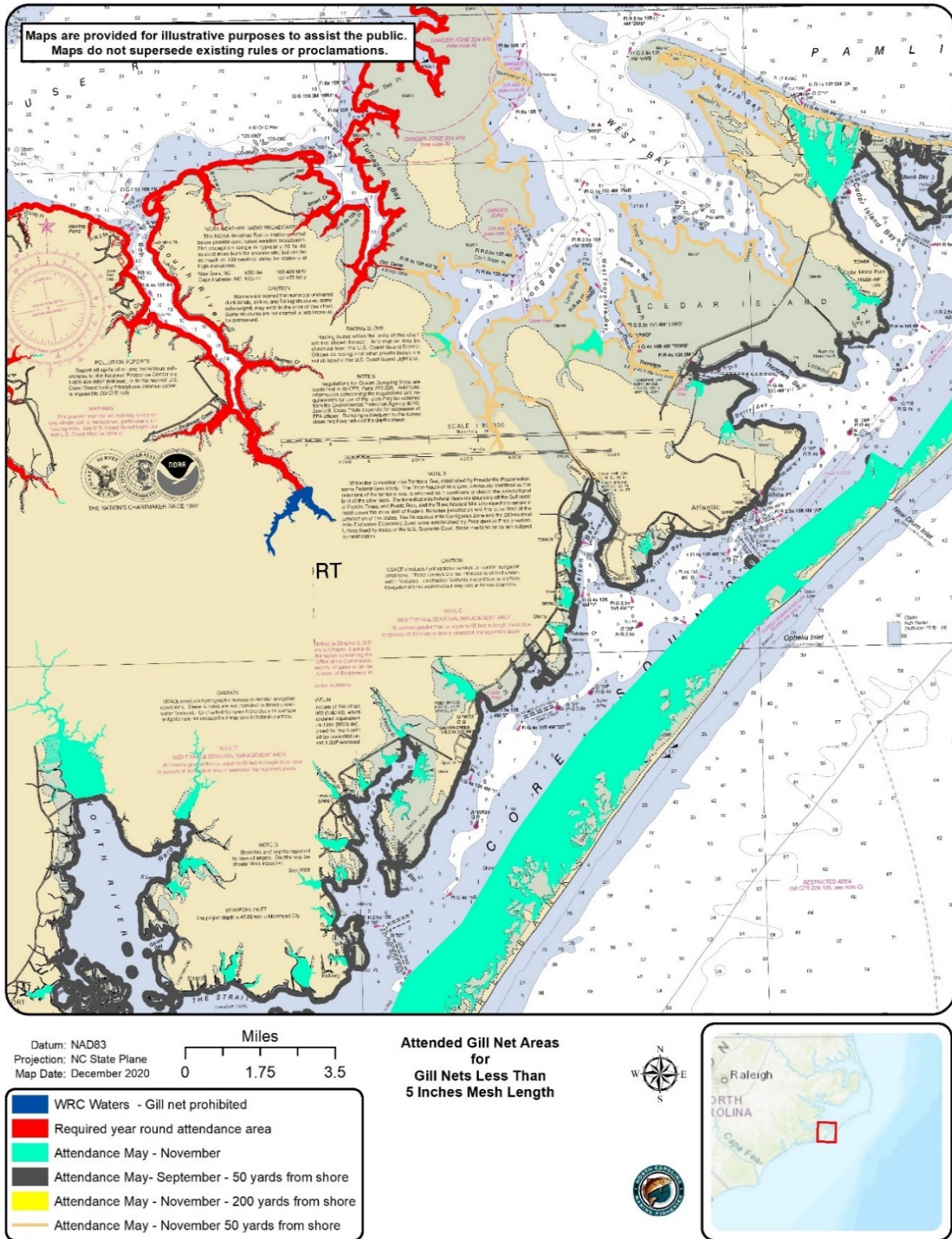


Figure 2.2.9. Map of current gill net attendance (<5-inch stretch mesh) and primary and permanent secondary nursery areas in West Thorofare, Long Bay-Ditch, Turnagain, Cedar Island, Thorofare-Barry, Nelson, Brett, Jarrett bays as well as North River and Ward Creek.

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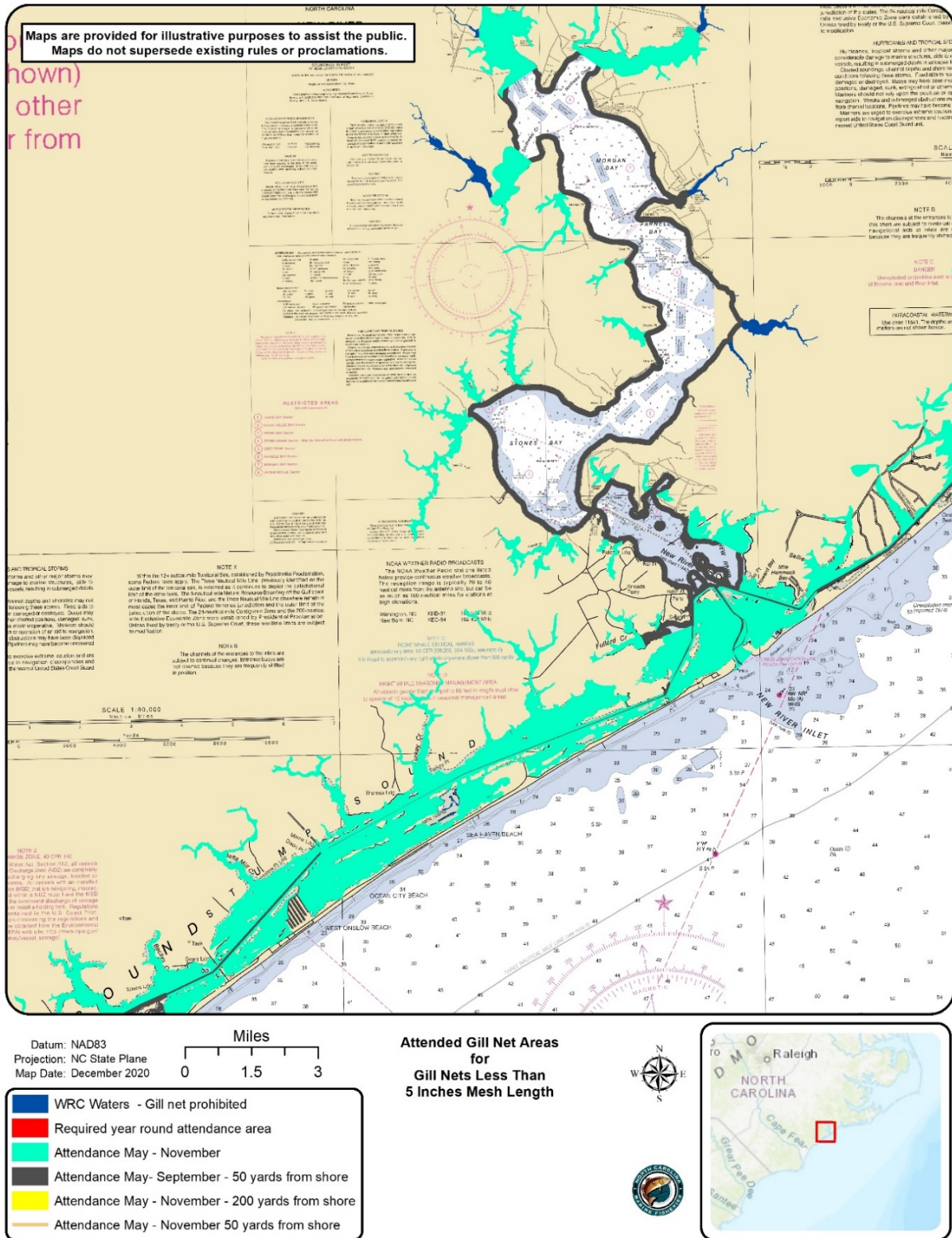


Figure 2.2.10. Map of current gill net attendance (<5-inch stretch mesh) and primary and permanent secondary nursery areas in New River, Chadwick Bay, Stump Sound (IWW).

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APPENDIX 2.3. REDUCING SHRIMP TRAWL BYCATCH THROUGH AREA CLOSURES THAT INCREASE CONNECTIVITY BETWEEN CLOSED AREAS

I. ISSUE

Implementation of area closures in estuarine waters to increase connectivity between currently closed areas to further reduce shrimp trawl bycatch in North Carolina's Internal Coastal Waters.

II. ORIGINATION

The North Carolina Division of Marine Fisheries (NCDMF) Shrimp Plan Development Team (PDT).

III. BACKGROUND

The shrimp trawl fishery is one of the most economically valuable commercial fisheries in North Carolina and primarily targets brown (*Farfantepenaeus aztecus*), pink (*F. duorarum*), and white (*Litopenaeus setiferus*) shrimp using otter trawls, skimmer trawls, channel nets, and other minor gears. From 1994 to 2019, commercial shrimp landings averaged 7,430,164 pounds and are highly variable for year to year (Table 2.3.1). While commercial landings are variable, the number of commercial trips and participants landing shrimp has generally declined since 2004. From 1994 to 2004, an average of 17,955 commercial trips landed shrimp and from 2005 to 2019, an average of 8,201 commercial trips landed shrimp. From 1994 to 2004 the average number of participants in the commercial shrimp fishery was 1,420, and from 2005 to 2019 the average number of participants was 746. From 1994 to 2004 an average of 7,130,582 pounds of shrimp were landed and from 2005 to 2019 and an average of 7,649,028 pounds of shrimp were landed. Static, or increased, average shrimp landings during periods of declining commercial shrimp trips and participants suggests increased efficiency of the shrimp fishery and/or increased abundance of shrimp. For further analysis of effort and shrimp trawl fleet characteristics, including trip days, see *Appendix 2.4: Managing Effort and Gear in the North Carolina Shrimp Fishery to Reduce Bycatch*.

The shrimp fishery is characterized as either estuarine (internal waters) or ocean. The estuarine fishery has accounted for 73% of the total commercial catch (Figure 2.3.1), 79% of the total commercial trips (Figure 2.3.2), and 81% of the participants (Figure 2.3.3) from 1994 to 2019 and generally accounts for over 50% of total landings each year. The Pamlico Region (Pamlico Sound, Pamlico/Pungo and Neuse rivers) has contributed over half of landings with minimal contributions coming from other regions from 1994 to 2019 (Figure 2.3.4). Despite minimal landings, the largest percentage of commercial trips landing shrimp occur in the Central Region (Bogue Sound, Core Sound, Newport River, North River, White Oak River; Figure 2.3.4). The largest percentage of participants in the commercial fishery are in the Pamlico and Central regions.

From 1994 to 2019, the fishery has an average annual value of \$16,071,856 with the Pamlico Region accounting for 59% of the value followed by the Atlantic Ocean at 28% (Figure 2.3.4). Since 1994, average annual value is \$46,411 in the Northern Region, \$9,572,987 in the Pamlico

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Region, \$1,233,769 in the Central Region, \$672,603 in the Southern Region, and \$4,546,084 in the Atlantic Ocean.

Bycatch in the shrimp trawl fishery is a primary source of controversy due to concerns about the effects on populations of non-target species. For a review of trawl impacts on habitat see *Appendix: 2.1 Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats*. Though the impact of discarding bycatch, or incidentally captured non-target species, on fish populations is not well understood, the amount of dead discards in the shrimp trawl fishery is perceived by many stakeholders to influence the amount of resources available to recreational and other commercial fisheries. Economically valuable finfish species like Atlantic croaker (*Micropogonias undulatus*), southern flounder (*Paralichthys lethostigma*), summer flounder (*P. dentatus*), spot (*Leiostomus xanthurus*), and weakfish (*Cynoscion regalis*) are commonly caught as bycatch in the shrimp trawl fishery (Brown 2010) and are of particular interest in North Carolina because of their popularity and value as target species in recreational and commercial fisheries (NCDMF 2019).

Removals of these species as bycatch in the shrimp trawl fishery has been estimated and used in stock assessments for Atlantic croaker (ASMFC 2017a), spot (ASMFC 2017b), and southern flounder (Flowers et al. 2019). However, speculation persists that bycatch from shrimp trawls may be a strong contributing factor to poor stock status (e.g., weakfish and southern flounder) and perceived low abundance (e.g., Atlantic croaker and spot). Southern flounder is overfished and overfishing is occurring, though the southern flounder stock assessment found discards from shrimp trawls contribute minimally to fishing mortality (Flowers et al. 2019). Weakfish is depleted but the stock assessment found natural mortality accounts for a large portion of total mortality (ASMFC 2019). Subsequent work has found weakfish natural mortality consistently and substantially exceeds fishing mortality and high natural mortality occurs from fall to spring, coinciding with periods of emigration from estuaries and overwintering on the continental shelf (Krause et al. 2020a, 2020b). Stock status for Atlantic croaker and spot is unknown because neither stock assessment was approved for management use (ASMFC 2017a, 2017b). A Traffic Light Analysis (TLA), used to monitor the Atlantic croaker and spot stocks between stock assessments, indicates moderate concern for both species primarily because of coastwide declines in commercial and recreational landings and abundance declines in mid-Atlantic (New Jersey-Virginia) fishery-independent surveys (ASMFC 2020a, 2020b). The Atlantic States Marine Fisheries Commission (ASMFC) Sciaenid Management Board met in March 2021 to approve state implementation plans for Atlantic croaker and spot Addendum III management measures triggered by the TLA (50 fish recreational bag limit, 1% reduction in commercial landings; ASMFC 2020a, 2020b).

Existing management strategies have substantially reduced bycatch in the shrimp trawl fishery since the early 1990s, but shrimp trawls continue to capture sizeable numbers of non-target species (Brown 2010; see *Appendix 2.4: Managing Effort in the North Carolina Shrimp Trawl Fishery to Reduce Bycatch* for review of shrimp trawl bycatch studies). Throughout the entire southeast (North Carolina to Florida), billions of Atlantic croaker (ASMFC 2020a) and millions of spot (ASMFC 2020b) are discarded in the shrimp trawl fishery despite large declines in shrimp trawl effort (net hours fished) and overall bycatch since the early 1990s. Similarity of life history characteristics, size of individuals captured, and habitat use by shrimp and other common estuarine

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species increases the difficulty of achieving bycatch reductions in shrimp trawl fisheries. In addition, high abundance and pervasiveness of juvenile Atlantic croaker and spot (Table 2.3.2 and 2.3.3; NCDMF 2020a see sections for Atlantic croaker and spot; Paris et al. 2020a, 2020b), among other species, in North Carolina estuaries makes their capture as bycatch in shrimp trawls unavoidable in areas where shrimp trawling occurs. Though, use of turtle excluder devices (TEDs) and bycatch reduction devices (BRDs) has reduced bycatch in individual shrimp trawl tows (Brown et al. 2019).

Brown shrimp, pink shrimp, white shrimp, Atlantic croaker, southern flounder, summer flounder and spot spawn in the ocean during the fall and winter (Table 2.3.4). After hatching, larvae enter estuaries and settle into the upper portions of rivers, creeks, and bays. Weakfish spawn in estuaries and nearshore ocean habitats over an extended period from March through September and upon hatching, larvae disperse throughout the estuary. These species grow rapidly, moving out of shallow nearshore habitats into deeper open water habitats of lower estuaries as they grow.

This movement is evident when examining abundance and length-frequency data from the NCDMF Estuarine Trawl Survey (Program 120) and the Pamlico Sound Trawl Survey (Program 195; NCDMF 2020b, 2020c). Program 120 is conducted in nearshore creeks and bays during May and June while Program 195 occurs in Pamlico Sound and its major tributaries during June and September. For most species, abundance between the two surveys is positively correlated and length-frequency distributions show larger individuals are captured in Pamlico Sound than in adjacent smaller tributaries, suggesting movement.

While some species, like Atlantic croaker and spot are ubiquitous and can be found in diverse habitats, others like summer flounder and weakfish use a narrower range of habitat and are found primarily in higher salinity, deeper water areas (Paris et al. 2020a, 2020b). Just as shrimp become available to harvest by trawls as they grow and move from protected to open areas, non-target finfish species may become bycatch as they too grow and move.

Area restrictions are an effective management measure to meet sustainability objectives, reduce bycatch and protect vulnerable habitat (Fujioka 2006; O’Keefe et al. 2014; McConnaughey et al. 2019; Hilborn et al. 2020). In North Carolina, area restrictions have been implemented in coastal estuarine waters to protect important habitats, reduce bycatch, or reduce user group conflicts (Table 2.3.5; Appendix 3, Maps 3.1-3.12). For example, 170,531 acres of North Carolina’s estuarine waters have been designated as Primary Nursery Area (PNA) or Secondary Nursery Area (SNA), primarily in the upper portions of estuarine rivers, creeks, and bays. Since the use of trawl nets is prohibited in nursery areas, these designations provide protection for juvenile shrimp and finfish during the early part of their life. Other areas where shrimp trawls are prohibited provide similar protections to bycatch species or important habitats.

IV. AUTHORITY

North Carolina General Statutes

§ 113-134 RULES

§ 113-173 RECREATIONAL COMMERCIAL GEAR LICENSE

§ 113-182 REGULATION OF FISHING AND FISHERIES

§ 113-182.1 FISHERY MANAGEMENT PLANS

DRAFT – SUBJECT TO CHANGE

§ 113-221.1 PROCLAMATIONS; EMERGENCY REVIEW

§ 143B-289.52 MARINE FISHERIES COMMISSION – POWERS AND DUTIES

North Carolina Marine Fisheries Commission Rules

15A NCAC 03H .0103 Proclamations, General

15A NCAC 03J .0104 Trawl Nets

15A NCAC 03L .0101 Shrimp Harvest Restrictions

15A NCAC 03L .0103 Prohibited Nets, Mesh Lengths and Areas

V. DISCUSSION

- Section discusses estuarine areas where shrimp trawling occurs, characteristics of those areas and current shrimp trawl closures
- Management options are a starting point for discussion and are not recommendations
- Options are meant to illustrate concepts to increase connectivity between currently closed areas with the goal of reducing bycatch
- Options from adjacent areas must be considered in conjunction to accomplish increased connectivity
- The focus of this paper is area closures in Pamlico Sound and adjacent waterbodies
- *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitat* and *Appendix 2.2: Shrimp Management in Special Secondary Nursery Areas* should be referenced for area closure options from Core Sound and south
- Amount of bycatch reduction from area closures is non-quantifiable (see *Appendix 1: Shrimp Trawl Bycatch Assessment*)
- Current and potential closures in the Atlantic Ocean are not discussed or considered

The acreage of area permanently or seasonally closed to trawling in North Carolina is extensive (approximately 1,216,163 acres; Table 2.3.5). Current closures represent a patchwork that in conjunction with other management measures (i.e., gear modifications, TEDs, BRDs), are likely effective in reducing bycatch at a local level. However, because shrimp and fish move throughout their life cycle and distributions in abundance change seasonally, daily, or even hourly, localized, fragmented area closures alone may be ineffective at reducing total bycatch (see *Appendix 2.4: Managing Effort and Gear Modifications in the North Carolina Shrimp Fishery to Reduce Bycatch* for further discussion of area and bycatch). If the goal of implementing additional area restrictions is to reduce bycatch, the objective should be increasing connectivity between currently closed areas to better encompass the life cycle and distribution of common bycatch species.

Seasonal Closures

Time and area closures are an effective management tool for achieving sustainability goals and reducing bycatch (O’Keefe et al. 2014; Hoos et al. 2019; Hilborn et al. 2020) and have been implemented in the North Carolina shrimp trawl fishery to reduce bycatch, delay harvest of shrimp (see *Appendix 2.2: Shrimp Management in Special Secondary Nursery Areas* issue paper), and reduce conflict between fishing sectors. For example, Special Secondary Nursery Areas (SSNA) can only be opened to shrimp trawling by proclamation from August 16 to May 14 and timing of openings corresponds to periods when shrimp are larger and the abundance of bycatch species is

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reduced. Seasonal area closures may be effective in reducing bycatch, while continuing to allow access to the shrimp resource and could be considered as a component of any area closure considered for implementation.

Under existing regulations in Pamlico Sound shrimp trawlers can choose when to fish except in areas with existing restrictions (i.e., PNAs, SNAs, shrimp trawl net prohibited areas, etc.). An option that has been suggested is to open the sound when shrimp count (number of shrimp per pound heads-on) reaches a desired size, similar to how SSNAs are managed (see *Appendix 2.2: Shrimp Management in Special Secondary Nursery Areas*) which could delay shrimp harvest and reduce bycatch. However, because of variable openings this strategy may not delay shrimp harvest or reduce bycatch. For example, analysis of NCDMF Trip Ticket data indicates that a 60 count opening target size for Pamlico Sound (as proposed in a 2016 petition for rulemaking) may not provide a predictable outcome in delaying the opening of shrimp season (NCDEQ 2019). Shrimp landings (by count size) in Pamlico Sound indicate the shrimping season may not close if a 60 count opening target size is established and shrimp species is not accounted for. Roughly 90% or greater of all shrimp (brown, white, pink) harvested in Pamlico Sound are 60 count or lower (larger shrimp have lower count sizes). A minimal delay in the opening date would occur if a 60 count opening target size were to include species-specific openings. By May, 52% of all brown shrimp landed in Pamlico Sound from 1994 to 2015 were 56/60 count or lower, and by June, 95 percent were 56/60 count or lower. The same count size of white shrimp landed ranged from a low of 87% in June to a high of 100% in January. By April, 95% of the pink shrimp landed from Pamlico Sound were 56/60 count or lower.

Enacting a closure until shrimp count size reaches 60 shrimp per pound in Pamlico Sound could also result in “grand openings,” where many vessels operate in an area following a closure. Reductions in bycatch may be negated by recoupage from the increased effort once an area is opened. Previous fishing seasons observed by NCDMF have shown that delayed openings in SSNAs, like those in New River and Stump Sound, have resulted in many vessels in a small area trying to recoup harvest and effort once the areas are opened. Additionally, early season openings could occur if environmental conditions are favorable; thus, count sizes may not be an effective means of reducing bycatch. Setting a static season, with set opening and closing dates may be a more appropriate strategy to achieve bycatch reductions.

Gear Exemptions

Allowing continued use of gears with less bycatch concern could be considered for any areas closed to shrimp trawling (see NCDMF 2015 for review of gear types including, characteristics, limitations, and bycatch concerns). For example, since 2010 it has been unlawful to use trawl nets, except skimmer trawls, upstream of the Highway 172 Bridge in New River (NCDMF 2006; NCMFC Rule 15A NCAC 03J .0208). The benefits of skimmer trawls include reduction of finfish bycatch, less bottom disturbance, less fuel consumption, more effective fishing time, and less culling time (Coale et al. 1994; Ruderhausen and Weeks 1999; Scott-Denton et al. 2006). In addition, skimmer trawl tailbags can be hauled back more frequently allowing for increased survival of bycatch. However, skimmer trawls are less effective for brown or pink shrimp (Coale et al. 1994) and can only be used over bottom that is free from obstructions and perform best in

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shallow water. If additional areas are closed to shrimp trawling, use of other gear types whose use has less bycatch concerns, like skimmer trawls, could be allowed to continue harvesting shrimp.

Fishery Impacts

Any additional shrimp trawl area closures would reduce access to the shrimp resource by the commercial and recreational sectors resulting in economic impacts to the shrimp fishery and those operating and working on shrimp trawlers. Reduced effort resulting from area closures will likely reduce the efficiency of the shrimp trawl fishery and consequently reduce the amount of shrimp harvested and likewise profitability of each trip. This may also lead to reduced employment in the shrimp trawl fishery as operators have to deal with tighter profit margins. However, there is also the possibility for economic gains in other portions of the shrimp fishery as well as other fisheries. Additional opportunities for recreational and commercial fishermen using non-trawl gears may lead to some economic gains for commercial fishermen using these gears and recreational fishery suppliers as fishermen purchase additional gear. Another potential benefit of reduced shrimp trawl effort in closed areas may be improved habitat and reduced bycatch mortality (hence increased survival) of bycatch and other species and thus have more available for harvest as recruits grow into other fisheries (both commercially and recreationally). Additionally, improved habitat may improve other economic niches like eco-tourism. Although, these types of economic benefits are more abstract, uncertain, and dependent on other external factors.

Closures in nearshore waters or smaller waterbodies would be particularly detrimental to smaller commercial boats and the recreational sector. Though brown shrimp and white shrimp can be caught throughout the summer, brown shrimp are generally available to the fishery earlier and the white shrimp fishery primarily occurs in the late summer and fall (NCDMF 2015). As the brown shrimp fishery has declined in some areas of the state, brown shrimp landings in others, like Pamlico Sound and Neuse River, have remained consistent or increased allowing the fishery to meet market demands for shrimp throughout the summer. Many areas that might be considered for closure are important to the early season brown shrimp fishery and may disproportionately impact participants in this fishery.

If additional area closures occur in locations with high shrimp abundance, shrimp trawling efficiency may be affected, leading to increased effort and higher bycatch. For example, nearshore creeks and bays can act as a bottleneck, concentrating shrimp as they move out of these areas making them easier to capture in high volumes with less effort. Closing these areas creates additional area for shrimp to disperse and spread out into larger waterbodies. Increased dispersal may make shrimp more difficult to capture which could increase effort in open areas and consequently increase bycatch. If additional areas are closed, shrimp trawl effort may shift to open areas where bycatch would still occur. Concentrating effort in small areas could lead to localized depletion of shrimp and bycatch species and may have negative impacts to habitat (see *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom*). In addition, if remaining open areas are unproductive for shrimp, the shrimp trawling industry would experience additional negative impacts.

DRAFT – SUBJECT TO CHANGE

Quantifying Benefits

The expected amount of bycatch reduction from any additional area closures is unquantifiable and the population level benefits to species like Atlantic croaker, spot, southern flounder, summer flounder, and weakfish are impossible to predict due to confounding factors like natural mortality and offshore migration. The objective of additional area closures would be to create connectivity between closed areas to better encompass the life cycle of common bycatch species more completely because once they enter open estuarine waters or the ocean they become less susceptible to shrimp trawls because of the increased area for dispersal.

Measuring the success of area closures implemented to reduce bycatch is difficult. At the population level, the method for gauging success is a stock assessment. Atlantic croaker, spot, southern flounder, summer flounder and weakfish are interjurisdictional stocks managed and assessed by regional commissions and councils. For example, Atlantic croaker is managed and assessed as a single population from the Atlantic coast of Florida through New Jersey (ASMFC 2011). Atlantic croaker spawn in the ocean, larvae are transported inshore, and juveniles settle in coastal nurseries. Upon emigrating from North Carolina waters, Atlantic croaker contribute to the coastwide stock. The objective of reducing bycatch of juvenile Atlantic croaker in North Carolina waters would be to increase the coastwide population. However, population level benefits may not be realized if significant mortality (fishing or natural) occurs elsewhere along the coast or at different life stages (e.g., larval or adult). If bycatch is reduced through shrimp trawl area closures in North Carolina waters and stock assessments do not indicate increases in population size, that does not mean management measures have failed, rather it suggests these are dynamic stocks whose population is influenced by complex natural and anthropogenic factors. In contrast, if stock assessments indicate increases in population size it would be difficult to credit management measures in North Carolina because of the other influences on these stocks. For management measures in North Carolina waters to significantly increase the coastwide population of any of these species, juveniles residing in North Carolina would need to contribute a significantly larger portion to the stock than other areas. Data needed to evaluate the contribution of North Carolina waters to coastwide stocks does not exist and would be difficult to obtain.

One method that could be used to gauge success of management measures is fishery-independent surveys. The Pamlico Sound Survey (Program 195; NCDMF 2020b) and the Independent Gill Net Survey (P915; NCDMF 2020d, 2020e) provide indices of relative abundance for important commercial recreational finfish species including Atlantic croaker, spot, southern flounder, and weakfish. While the Pamlico Sound Survey primarily samples juveniles, the survey provides an annual index of abundance for age-1 and older spot (ASMFC 2020b). The fishery-independent gill net survey provides indices of adult abundance that are evaluated annually for many North Carolina species (NCDMF 2020a). Evaluating long term trends in adult abundance, length frequency, and age structure from these surveys is the most direct and immediate method for inferring success of any area closures.

Fishery-independent surveys are not equivalent to stock assessments and increasing or decreasing trends in abundance cannot be extrapolated to the population level for interjurisdictional species. Fishery independent surveys do provide invaluable information about species abundance in North Carolina waters and what might be available to recreational and commercial fisheries. Increasing

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abundance and expanding age structure of adult fish could indicate management measures to reduce bycatch are successful in allowing increased survival of juvenile fish to older ages making them available to fisheries in North Carolina waters. However, decreasing, or neutral trends in abundance are not necessarily indicative of a failure to reduce bycatch. As noted, these species have complex life cycles with many confounding factors influencing recruitment and abundance. Since all of these species spend at least part of their life in the Atlantic Ocean, inshore fishery-independent surveys may not detect increases in abundance and the expected benefits of reducing bycatch to North Carolina inshore fisheries may never be realized.

Area Closure Examples

Bycatch in the North Carolina shrimp trawl fishery has been reduced but still occurs at a high level. However, the degree to which shrimp trawl bycatch impacts fish stocks at the population level is either unknown or thought to be minimal. Given inconclusive information about the adverse effects of shrimp trawl bycatch on fish populations, a balanced approach to area closures considering areas where shrimp trawling occurs, distribution and life history of common bycatch species and economic impact should be considered. Similar approaches have been proposed for habitat protection. Fujioka (2006) recommended a balanced approach to area closures and suggested closing large amounts or lightly fished areas and small amounts of heavily fished areas to protect habitat and maintain catch. While this specific example may not effectively reduce bycatch, similar balanced approaches may work.

The following issue paper sections discuss estuarine areas where shrimp trawling occurs, characteristics of those areas, and existing closed areas. The management options presented in this paper are a starting point for discussion of shrimp trawl area closures to limit or reduce bycatch. The options illustrate concepts for area closures that could be implemented to increase connectivity between closed areas with the goal of reducing overall bycatch. Public input could provide additional options.

Because of the disparity in shrimp landings and fishing effort between estuarine waters and the ocean (Figures 2.3.1; 2.3.2; 2.3.3), available data and the ecological concepts being considered, the focus of this issue paper is estuarine waters. North Carolina's coastline on the Atlantic Ocean is comprised of barrier islands that stretch approximately 300 miles. Shoals extending perpendicular from shore accompany capes and inlets along the coastal ocean. Nearshore hard bottom areas, dense concentrations of marine algae, artificial reefs and shipwrecks limit the amount of trawlable bottom available. Of North Carolina's 724,434 acres of Atlantic Ocean waters 59,834 acres are closed to shrimp trawling and 664,603 acres are open or managed. In the Atlantic Ocean off Brunswick County, it is unlawful to use shrimp trawls from 9:00 pm to 5:00 am each day, because studies have shown bycatch in this area is higher at night than during the day (Ingraham 2003).

The division does not conduct any fishery-independent sampling in the Atlantic Ocean that could be used to determine the distribution of fish and inform management options. The South Carolina Department of Natural Resources conducts the SEAMAP-SA Coastal Survey which occurs in the coastal zone of the South Atlantic Bight from Cape Hatteras, North Carolina to Cape Canaveral Florida. The Virginia Institute of Marine Science conducts the NEAMAP Mid Atlantic survey

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which occurs from Cape Cod Massachusetts to Cape Hatteras North Carolina. The distribution of sampling effort in the coastal ocean surveys may not be sufficient to adequately represent species distribution at a scale fine enough to inform area closures in North Carolina coastal waters. In addition, because North Carolina only has jurisdiction within three miles of shore, which represents a small portion of most species Atlantic Ocean range, any closures are likely to be minimally effective in reducing bycatch.

Pamlico Area (Pamlico Sound, Neuse River, Bay River, Pamlico/Pungo River)

PAMLICO SOUND

The sound is divided into two basins east and west of Bluff Shoal. Most feeder creeks and bays are classified as PNA, SNA, SSNA, or no trawl areas. Along the Hyde County shoreline all bays and tributaries are closed to trawling except for West Bluff Bay, East Bluff Bay, Parched Corn Bay, and Sandy Bay (Appendix 3, Maps 3.1-3.3). There are no other area restrictions related to shrimp trawling along the Hyde County shoreline of Pamlico Sound.

Along the eastern side of Pamlico Sound, no trawling is allowed in an area described in NCMFC Rule 15A NCAC 03R .0106 (1) to protect sea grass beds (Appendix 3, Maps 3.1-3.3), though the Fisheries Director may, by proclamation, open this area to peeler crab trawling (NCMFC Rule 15A NCAC 03J .0104 (4)). In crab spawning sanctuaries designated at Oregon, Hatteras, Ocracoke, and Drum inlets, it is unlawful to use trawls from March 1 to August 31. Trawling is also prohibited in three Military Danger Zone and Restricted areas located southeast of the mouth of Long Shoal River, east of the mouth of Bay River, and near Piney Island including Point of Marsh and Newstump Point. Along the southern shore, parts of West Bay can be opened to trawling by proclamation.

Since 1994, the Pamlico Sound has accounted for 56% of total commercial shrimp landings in North Carolina and within the Pamlico Region (Pamlico Sound, Bay River, Pamlico/Pungo River), the sound has accounted for 96.1% of shrimp landings (Table 2.3.6), 81.6% of the trips and 73.9% of the participants from 1994 to 2019 (Table 2.3.7). Within the Pamlico Region, the Pamlico Sound has accounted for 96.5% of the value (Figure 2.3.5). Shrimp landings and trips have fluctuated since 1994 and after declining from 1994 to 2005, have generally increased or remained consistent. Shrimp landings from 2015 to 2018 were amongst the highest recorded and landings in 2017 were the highest in the time series. High landings during these years occurred without substantial increases in trips. Historically, brown shrimp have been the primary species caught in the Pamlico Sound with lesser numbers of white and pink shrimp landed. However, since 2011 white shrimp landings have increased and in 2017 white shrimp comprised most of the landings.

Management Considerations for Pamlico Sound

The Pamlico Sound is an important habitat for many fish species and is used extensively as juvenile habitat for estuarine dependent species like Atlantic croaker, spot, southern flounder, summer flounder and weakfish. Atlantic croaker and spot are amongst the most abundant finfish species and are generally ubiquitous throughout the sound (Table 2.3.3; Paris et al. 2020a, 2020b). While trawl closures are designated in most bays and tributaries of the sound and along the eastern shore,

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most of the sound is open to trawling. Because of the extent to which some species use the sound, additional isolated closures would be unlikely to substantially reduce bycatch. Any additional area closures should aspire to create linkages between habitats currently closed to trawling. Achieving this objective would create a network of areas where juvenile fish and crustaceans could move between nursery areas, open sound habitats, and adult habitat in the ocean. While most of the sound has soft, muddy, or sandy bottom that is more resilient to damage from shrimp trawls (see *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* for review of trawl impacts on habitat), additional closures could help minimize bottom disturbance and decrease periods of turbidity further aiding survival and growth of estuarine dependent species.

Closing the entire Pamlico Sound to shrimp trawling would be a severe management measure, essentially eliminating half of the multi-million-dollar shrimp fishing industry in North Carolina. While a complete closure would reduce bycatch, the goal and benefits would be uncertain given current abundance, stock status, and life history characteristics of most species of concern (i.e., Atlantic croaker, spot, weakfish). More refined area closures implemented with the objective of linking areas already closed to trawling may be effective in reducing bycatch without severe impacts to the shrimp fishing industry that would occur with a complete closure.

Despite high abundance and non-specific habitat use by some estuarine dependent species, shrimp and juvenile fish are not uniformly distributed throughout the sound. Some areas exhibit consistently higher abundance and are termed clusters or “hot spots”. Identification of abundance hot spots in Pamlico Sound, in combination with life history information can inform designations of more refined area closures that could achieve bycatch reductions.

The Pamlico Sound Trawl Survey (Program 195) is conducted by NCDMF in Pamlico Sound and its tributaries during June and September and has run continuously since 1987. The primary objective of Program 195 is to produce fishery-independent indices of abundance for important recreational and commercial fish species. The survey uses a stratified random design with strata designated by geographic location and water depth. Stations (one-minute by one-minute grid system equivalent to one square nautical mile) are randomly selected, with 54 stations sampled in June and 54 stations sampled in September (108 annually; see NCDMF 2020b; Paris et al. 2020a, 2020b for detailed survey methodology).

To identify hot spots, abundance at survey sites falling within a predetermined distance are compared to each other. When abundance is high at a site, and the site is surrounded by other sites with high abundance they are labeled high-high clusters, indicating that area is likely a hot spot for a species. Sites with low abundance that are surrounded by other low abundance sites are labeled low-low clusters, indicating the area is likely not a hot spot for a species. Sites with low abundance surrounded by sites with high abundance are labeled low-high clusters indicating that the overall area may be a hot spot, but the individual site had lower catch abundance compared to the surrounding sites. Sites with high abundance surrounded by sites with low abundance are labeled high-low clusters indicating that while the overall area may not be a hot spot, the individual site had higher catch abundance compared to the surrounding sites. See *Appendix 2.3.A: Hot Spot Analysis* for further description of hot spot analysis methodology.

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Hot spots of abundance in Pamlico Sound during June and September were identified for Atlantic croaker, spot, weakfish, southern flounder, summer flounder, brown shrimp, white shrimp, and pink shrimp (Figures 2.3.6-2.3.13; Appendix 2.3.B, Maps 2.3.B.1-2.3.B.16); for aggregate finfish (Atlantic croaker, spot, southern flounder, summer flounder, and weakfish; Figure 2.3.14); and shrimp (white shrimp, brown shrimp, and pink shrimp; Figure 2.3.15).

Distribution of hot spots varies by species and season. Atlantic croaker hot spots are distributed throughout the sound but are clustered closer to the Hyde County shoreline in September compared to June (Figure 2.3.6). Spot hot spots show a distinct seasonal shift from the center of the sound in June to near the mouth of the Pamlico and Neuse rivers in September (Figure 2.3.7). Southern flounder hot spots are distributed throughout the western Pamlico Sound with hot spots in June clustered near the mouth of the Neuse River and hot spots in September clustered near the mouth of the Pamlico River (Figure 2.3.8). Summer flounder hot spots are concentrated in the northern Pamlico Sound and Croatan Sound in June and September (Figure 2.3.9). Weakfish hot spots are concentrated in the center of Pamlico Sound and are more widespread in June compared to September (Figure 2.3.10).

White shrimp hot spots are more prevalent in September than in June and are concentrated in the center of the sound in June and closer to shore in September (Figure 2.3.11). Brown shrimp hot spots are located close to shore in June and more toward the center of the sound in September (Figure 2.3.12). Pink shrimp hot spots are more prevalent in September than June and are concentrated in the center of the sound (Figure 2.3.13).

Because of the disparity in hot spot distribution between species and seasons (Figures 2.3.14-2.3.15), no single area closure encompasses the range of all species, except for a complete closure. However, because of patterns in hot spot distribution and known life history characteristics, certain area closure configurations could be implemented to create linkages between closed areas, encompass hot spots, and allow for movement of fish species, while continuing to allow access to shrimp. Creating an area closure linking the bays and tributaries with other closed areas and coastal inlets may be an effective measure to reduce bycatch.

Most common bycatch species (i.e., Atlantic croaker, spot) use nursery areas located in estuarine bays and creeks before moving into the open sound and eventually through coastal inlets into the ocean. Creating a no shrimp trawling buffer area along the northern/western shore of Pamlico Sound would create a link between nursery areas and coastal inlets, with larger area closures encompassing the distribution of more species and creating greater linkages (Figure 2.3.16; Table 2.3.8). Essentially, this strategy provides greater area for fish and shrimp to disperse as they leave nursery areas along the northern/western shore of Pamlico Sound which lessens the likelihood of being caught in shrimp trawls. In addition, this type of closure protects habitats near the mouths of the Neuse, Bay and Pamlico rivers and in Croatan and Roanoke sounds.

Because distribution of fish and shrimp shifts seasonally this option could be implemented seasonally, or a seasonal extension could be added to incorporate additional important habitats (Figure 2.3.17). Early season closures may not effectively reduce bycatch because shrimp and fish have not started to move from nursery areas, and shrimp trawl effort is low. Later season area closures, like August 1 through November 30, may be effective in reducing bycatch because

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shrimp and fish have moved into open water habitats and shrimp trawl effort is higher. For example, weakfish hot spots have been identified in the area east of Bluff Shoal in central Pamlico Sound (Figure 2.3.10; Appendix 2.3.B, Maps 2.3.B.9-2.3.B.10). Incorporating this area as a seasonal closure would reduce bycatch of weakfish locally, while accommodating movement throughout the season.

Example Options for Pamlico Sound

(+ Potential positive impact of action)

(- Potential negative impact of action)

1. *Status quo* – No additional area or seasonal closures
 - + Continues to allow access to the shrimp resource in Pamlico Sound
 - + No impact to shrimp trawling industry
 - + Bycatch reductions may still be achieved through other strategies (i.e., gear modifications)
 - No additional bycatch reductions from area closures
 - Continued conflict between trawlers and other sectors
2. Create no shrimp trawl buffer with seasonal extension (Figure 2.3.17)
 - + Continues to allow access to the shrimp resource in most of Pamlico Sound
 - + Buffer closures in combination with other strategies (i.e., gear modifications) may reduce bycatch
 - + Reduces some conflict between trawlers and other sectors
 - + Creates connectivity between other closed areas
 - + Habitat protections
 - Limits access to shrimp resource in areas that might be very productive for shrimp harvest
 - May increase trawl effort in open areas
 - May not reduce bycatch if size of closed area is not sufficient to account for movement of fish
3. Complete closure
 - + Reduces bycatch
 - + Reduces conflict between trawlers and other sectors
 - + Creates increased area for juvenile fish to disperse into larger water bodies
 - + Habitat protections
 - Eliminates access to shrimp resource in areas that are very productive for shrimp harvest
 - May increase trawl effort in open areas
 - Would create economic hardship

NEUSE RIVER

Within the Neuse River, shrimp are generally only found as far upstream as Slocum Creek. From 1994 to 2019, the Neuse River accounted for 3.2% of shrimp landings in the Pamlico area (Pamlico Sound, Bay River, Pamlico/Pungo River; Table 2.3.6), 15.8% of the trips, and 18.2% of participants (Table 2.3.7). Within the Pamlico Region, the Neuse River has accounted for 2.8% of

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the value (Figure 2.3.5). There has been little trend in landings or trips since 1994. Brown shrimp are the primary species caught in the Neuse River with lesser numbers of white shrimp and very few pink shrimp landed.

Shrimp trawling is prohibited upstream of a line from the Minnesott Beach Ferry running south to a point at the Cherry Branch Ferry (Appendix 3, Map 3.3). This closure was implemented through the 2006 shrimp FMP based on management recommendations from the 2005 Southern Flounder FMP to address the issue of sublegal southern flounder discards in the shrimp trawl fishery (NCDMF 2006). Most Neuse River tributaries are designated as nursery area, but trawling is allowed in parts of Clubfoot Creek, Adams Creek, South River and Turnagain Bay. Only small portions of Clubfoot Creek are open to trawling and most effort is by smaller commercial boats. Trawling activity in Adams Creek is from a mix of small to mid-size commercial and recreational trawlers. South River and Turnagain Bay receive mostly commercial trawling activity but effort in South River has declined in recent years and Turnagain Bay is not a significant area to the shrimp trawl fishery. Within areas of the Neuse River and its tributaries that are open to trawling, there is a prohibition on trawling in water depths less than six feet from June 1 through November 30 to reduce conflict with the crab pot fishery.

Management Considerations for Neuse River

If a complete closure or an option that closes areas in the northern and western portion of Pamlico Sound is chosen, a complete closure of Neuse River should be strongly considered. If status quo or other smaller scale options are chosen for Pamlico Sound, additional options could be considered for Neuse River.

Because large portions of the Neuse River are already permanently or seasonally closed to trawling, additional small-scale closures may not significantly reduce bycatch. In addition, the existing six-foot contour closure creates connectivity between nursery areas and the Pamlico Sound allowing for a degree of unobstructed movement of shrimp and fish. However, areas near the mouths of Dawson, Green (Oriental), and Lower Broad Creek are excluded from the shallow water closure, allowing shrimp trawlers to harvest shrimp as they leave these creeks. Filling these gaps with additional closures at the mouths of these creeks would create a continuous closure between nursery area habitat and Pamlico Sound. The area around the mouth of Dawson Creek is not a popular area for shrimp trawling but the area around the mouth of Greens Creek is very popular for commercial and recreational trawlers and the mouth of Lower Broad Creek is a popular area for commercial trawlers. In 1999 and 2000, a shoreline buffer closed to shrimp trawling running along the channel markers from Dawson Creek to the mouth of Neuse River was implemented by proclamation to address protection of small shrimp while allowing for shrimp trawling in the main stem of the river (NCDMF 2006). However, this buffer was difficult to enforce and often resulted in the same size shrimp being found on the open side of the line as on the closed side.

Parts of Clubfoot Creek, Adams Creek, South River, and Turnagain Bay are open to shrimp trawling to allow access to the shrimp resource but are located adjacent to PNA and SNA designations. Prohibiting shrimp trawling in these creeks would create a broader linkage between PNA's and SNA's and habitats used as the species grow and move. Restricting trawling in smaller

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tributaries could allow juvenile fish and crustaceans to disperse into larger water bodies where the probability of interacting with trawls is decreased, potentially reducing bycatch.

Example Options for Neuse River (Dependent on selected options for Pamlico Sound)

If all of Pamlico Sound or large areas in northern and western Pamlico Sound are closed, a complete closure of Neuse River should be the only option considered.

4. Prohibit shrimp trawling in Neuse River and its tributaries in combination with Pamlico Sound closures.
 - + Reduces bycatch
 - + Reduces conflict between trawlers and other sectors
 - + Creates increased area for juvenile fish to disperse into larger water bodies
 - + Creates a complete closure link between Neuse River and Pamlico Sound
 - + Habitat protections
 - Limits access to shrimp resource in areas that might be very productive for shrimp harvest
 - May increase trawl effort in open areas
 - Particularly limiting to smaller commercial and recreational shrimpers
 - Would limit brown shrimp fishery

If status quo or smaller scale options are chosen for Pamlico Sound, additional options could be considered for Neuse River.

5. *Status Quo* – No additional area or seasonal closures for Neuse River and its tributaries
 - + Continues to allow access to the shrimp resource in Neuse River and open tributaries
 - + No impact to shrimp trawling industry
 - + Bycatch reductions may still be achieved through other strategies (i.e., gear modifications)
 - No additional bycatch reductions from area closures
 - Continued conflict between trawlers and other sectors
6. Close open areas in Clubfoot Creek, Adams Creek, South River, Turnagain Bay and the mouths of Dawson, Greens and Lower Broad Creek
 - + Continues to allow access to the shrimp resource in most of Neuse River
 - + Impact to the shrimp trawling industry is minimized
 - + Additional closures in combination with other strategies (i.e., gear modifications) may reduce bycatch
 - + Reduces some conflict between trawlers and other sectors
 - + Allows juvenile fish more area to disperse before becoming susceptible to trawls
 - + Creates continuous connectivity of closed area between Neuse River and Pamlico Sound
 - Limits access to shrimp resource in areas that might be very productive for shrimp harvest
 - May increase trawl effort in open areas
 - May not reduce bycatch

DRAFT – SUBJECT TO CHANGE

- Particularly limiting to smaller commercial and recreational shrimpers
 - Would limit brown shrimp fishery
7. Prohibit shrimp trawling in Neuse River and its tributaries
- + Closure in combination with other strategies (i.e., gear modifications) may reduce bycatch
 - + Reduces conflict between trawlers and other sectors
 - + Creates increased area for juvenile fish to disperse into larger water bodies
 - + Creates a complete closure link between Neuse River and Pamlico Sound
 - + Habitat protections
 - Limits access to shrimp resource in areas that might be very productive for shrimp harvest
 - May increase trawl effort in open areas
 - Particularly limiting to smaller commercial and recreational shrimpers
 - Would limit brown shrimp fishery

BAY RIVER

Bay River is a tributary of Pamlico Sound, located in Pamlico County, between the Pamlico and Neuse rivers. From 1994 to 2019, Bay River accounted for 0.2% of shrimp landings in the Pamlico area (Pamlico Sound, Bay River, Pamlico/Pungo River; Table 2.3.6), 1.3% of the trips, and 2.8% of participants (Table 2.3.7). Within the Pamlico Region, the Bay River has accounted for 0.2% of the value (Figure 2.3.5). The disparity between landings and trips suggests most of the shrimp trawl effort in the river is by smaller boats. Landings and trips have declined substantially since the late 1990s and early 2000s but have little trend since. Brown shrimp are the primary species caught in Bay River accounting for nearly all landings.

Shrimp trawling is only allowed in the main stem of the river because all tributary creeks and bays are classified as PNA, SNA, or no trawl areas (Appendix 3, Map 3.3). The area of the river, open to trawling, bound by the shoreline to the depth of six feet is closed to trawling from June 1 through November 30. Despite its smaller size, Bay River is a major area for small and larger commercial shrimp trawlers.

Management Considerations for Bay River

If a complete closure or an option that closes areas in the northern and western portion of Pamlico Sound is chosen, a complete closure of Bay River should be strongly considered. If status quo or other smaller scale options are chosen for Pamlico Sound additional options could be considered for Bay River.

Because large portions of Bay River are already permanently or seasonally closed to trawling, additional small-scale closures may not significantly reduce bycatch. In addition, the existing six-foot contour closure creates connectivity between Bay River nursery areas and the Pamlico Sound allowing for a degree of unobstructed movement of shrimp and fish between these areas. However, areas near the mouths of Vandemere Creek and along the eastern shore of Moore Bay are not

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included in this closure. Filling these gaps with additional closures would create a continuous closed area between nursery habitat and the Pamlico Sound.

Example Options for Bay River (Dependent on selected options for Pamlico Sound)

If all of Pamlico Sound or large areas in northern and western Pamlico Sound are closed, a complete closure of Bay River should be the only option considered.

8. Prohibit shrimp trawling in Bay River and its tributaries
 - + Reduces bycatch
 - + Reduces conflict between trawlers and other sectors
 - + Creates increased area for juvenile fish to disperse into larger water bodies
 - + Creates a complete closure link between Bay River and Pamlico Sound
 - + Habitat protections
 - Limits access to shrimp resource in areas that might be very productive for shrimp harvest
 - May increase trawl effort in open areas
 - Particularly limiting to smaller commercial and recreational shrimpers
 - Would limit brown shrimp fishery

If status quo or smaller scale options are chosen for Pamlico Sound, additional options could be considered for Bay River.

9. *Status Quo* - No additional area or seasonal closures in Bay River
 - + Continues to allow access to the shrimp resource in Bay River
 - + No impact to shrimp trawling industry
 - + Bycatch reductions may still be achieved through other strategies (i.e., gear modifications)
 - No additional bycatch reductions from area closures
 - Continued conflict between trawlers and other sectors
10. Prohibit shrimp trawling at the mouth of Vandemere Creek and the shoreline area of Moore Bay
 - + Continues to allow access to the shrimp resource in most of Bay River
 - + Impact to the shrimp trawling industry is minimized
 - + Additional closures in combination with other strategies (i.e., gear modifications) may reduce bycatch
 - + Reduces some conflict between trawlers and other sectors
 - + Allows juvenile fish more area to disperse before becoming susceptible to trawls
 - + Creates continuous connectivity of closed area between Bay River and Pamlico Sound
 - Limits access to shrimp resource in areas that might be very productive for shrimp harvest
 - May increase trawl effort in open areas
 - May not reduce bycatch
 - Particularly limiting to smaller commercial and recreational shrimpers
 - Would limit brown shrimp fishery

DRAFT – SUBJECT TO CHANGE

11. Prohibit shrimp trawling in Bay River

- + Closure in combination with other strategies (i.e., gear modifications) may reduce bycatch
- + Reduces conflict between trawlers and other sectors
- + Creates increased area for juvenile fish to disperse into larger water bodies
- + Creates a complete closure link between Bay River and Pamlico Sound
- + Habitat protections
- Limits access to shrimp resource in areas that might be very productive for shrimp harvest
- May increase trawl effort in open areas
- May not reduce bycatch
- Particularly limiting to smaller commercial and recreational shrimpers
- Would limit brown shrimp fishery

PAMLICO/PUNGO RIVER

From 1994 to 2019, the Pamlico/Pungo River accounted for 0.5% of shrimp landings in the Pamlico area (Pamlico Sound, Bay River, Pamlico/Pungo River; Table 2.3.6), 1.4% of the trips, and 5.0% of participants (Table 2.3.7). Within the Pamlico Region, the Pamlico/Pungo River has accounted for 0.5% of the value (Figure 2.3.5). Landings and trips have both declined substantially since the late 1990s and early 2000s. In 2014 no landings or trips were attributed to the Pamlico/Pungo River and in 2019, 194 pounds were attributed to the Pamlico/Pungo River. Brown shrimp are the primary species caught in the Pamlico/Pungo River accounting for nearly all shrimp landings.

Trawling is prohibited in the Pungo River and upstream of a line running from Pamlico Beach southwest to a point at Reed Hammock (Appendix 3, Map 3.3). These closures were implemented through the 2006 Shrimp FMP based on management recommendations from the 2005 Southern Flounder FMP to address the issue of sublegal southern flounder discards in the shrimp trawl fishery (NCDMF 2005, 2006). Trawling is allowed in lower Goose Creek north of a line running from the north shore of Snode Creek easterly to Store Point though tributaries of the creek are designated as PNA or SNA and are closed to trawling. The open area of Pamlico River bound by the shoreline to the depth of six feet is closed to trawling from June 1 through November 30. This includes the open portion of lower Goose Creek.

Management Considerations for Pamlico/Pungo River

If a complete closure or an option that closes areas in the northern and western portion of Pamlico Sound is chosen, a complete closure of Pamlico/Pungo River should be strongly considered. If status quo or other smaller scale options are chosen for Pamlico Sound additional options could be considered for Pamlico/Pungo River.

Because nearly all of Pamlico River is permanently or seasonally closed to trawling, additional small-scale closures may not significantly reduce bycatch. In addition, the existing six-foot contour closure creates connectivity between nursery areas and the Pamlico Sound allowing for a degree of unobstructed movement of shrimp and fish. The only gap in this closure occurs near the mouth

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of the Pungo River because water depth is greater than six feet. Filling this gap with a trawl closure would create a continuous closed area between nursery habitats and the Pamlico Sound.

The area of lower Goose Creek that is open to trawling is adjacent to PNA and SNA designations. Prohibiting trawling in lower Goose Creek would create a broader linkage between PNA and SNA habitats and habitats used as the species grow and move. Restricting trawling in smaller tributaries could allow juvenile fish to disperse into larger water bodies where the probability of interacting with trawls is decreased potentially reducing bycatch. However, lower Goose Creek is an important area to recreational shrimpers because of easy access and high productivity of shrimp.

Example Options for Pamlico/Pungo River (Dependent on selected options for Pamlico Sound)

If all of Pamlico Sound or large areas in northern and western Pamlico Sound are closed, a complete closure of Pamlico/Pungo River should be the only option considered.

12. Prohibit shrimp trawling in Pamlico/Pungo River and its tributaries
 - + Reduces bycatch
 - + Reduces conflict between trawlers and other sectors
 - + Creates increased area for juvenile fish to disperse into larger water bodies
 - + Creates a complete closure link between Pamlico/Pungo River and Pamlico Sound
 - + Habitat protections
 - Limits access to shrimp resource in areas that might be very productive for shrimp harvest
 - May increase trawl effort in open areas
 - Particularly limiting to smaller commercial and recreational shrimpers
 - Would limit brown shrimp fishery

If status quo or smaller scale options are chosen for Pamlico Sound, additional options could be considered for Pamlico/Pungo River.

13. *Status Quo* - No additional area or seasonal closures in Pamlico/Pungo River and its tributaries
 - + Continues to allow access to the shrimp resource in Pamlico River
 - + No impact to shrimp trawling industry
 - + Bycatch reductions may still be achieved through other strategies (i.e., gear modifications)
 - No additional bycatch reductions from area closures
 - Continued conflict between trawlers and other sectors

14. Prohibit shrimp trawling in lower Goose Creek and at the mouth of Pungo River
 - + Continues to allow access to the shrimp resource in most of Pamlico River
 - + Impact to the shrimp trawling industry is minimized
 - + Additional closures in combination with other strategies (i.e., gear modifications) may reduce bycatch
 - + Reduces some conflict between trawlers and other sectors
 - + Allows juvenile fish more area to disperse before becoming susceptible to trawls

DRAFT – SUBJECT TO CHANGE

- + Creates increased area for juvenile fish to disperse into larger water bodies
- + Creates continuous connectivity of closed area between Pamlico River and Pamlico Sound
- Limits access to shrimp resource in areas that might be very productive for shrimp harvest
- May increase trawl effort in open areas
- May not reduce bycatch
- Particularly limiting to recreational shrimpers
- Would limit brown shrimp fishery

15. Prohibit shrimp trawling in Pamlico River

- + Closure in combination with other strategies (i.e., gear modifications) may reduce bycatch
- + Reduces conflict between trawlers and other sectors
- + Creates increased area for juvenile fish to disperse into larger water bodies
- + Creates a complete closure link between Pamlico River and Pamlico Sound
- + Habitat protections
- Limits access to shrimp resource in areas that might be very productive for shrimp harvest
- May increase trawl effort in open areas
- May not reduce bycatch
- Particularly limiting to smaller commercial and recreational shrimpers
- Would limit brown shrimp fishery

Northern Area

Discussion of commercial shrimp landings and trips for the Northern Region do not include areas north of Croatan and Roanoke sounds (i.e., Albemarle and Currituck sounds). Since 1987, it has been unlawful to use trawl nets in Albemarle Sound and its tributaries (15A NCAC 03J .0104(b)(3); Appendix 3, Map 3.4). This action was implemented to protect the flounder gill net fishery in this area (NCDMF 2006) and because of conflicts between trawlers and crab potters (NCDMF 2015). Because of high freshwater inputs, shrimp abundance is not high in Albemarle Sound, but minimal shrimp landings have occurred from non-trawl gear (i.e., crab pots, cast nets, pound nets, etc.) since 1994 (i.e., Albemarle Sound, Alligator River, Pasquotank River, Currituck Sound).

CROATAN SOUND

Croatan Sound is bound by Pamlico Sound to the south, extends along the west side of Roanoke Island, to Albemarle Sound to the north. From 1994 to 2019, Croatan Sound accounted for 67.9% of shrimp landings in the Northern Region (Croatan and Roanoke sounds), 51.1% of the trips, and 51.7% of participants (Table 2.3.9). Within the Northern Region, Croatan Sound has accounted for 69.0% of the value (Figure 2.3.18). Landings and trips have both increased substantially since around 2014, because of increased white shrimp landings. Historically, brown shrimp were the primary species landed from Croatan Sound, but landings of white shrimp began increasing in 2016.

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There is no trawling permitted north of a line running northwesterly from the north end of Roanoke Island to Caroon Point (Appendix 3, Map 3.4). Except for feeder creeks and two oyster seed management areas along the southern part of Roanoke Island being closed to trawling there are no other trawling restrictions in Croatan Sound.

ROANOKE SOUND

Roanoke Sound extends north from Oregon Inlet along the east side of Roanoke Island to Albemarle Sound. From 1994 to 2019, Roanoke Sound accounted for 32.1% of shrimp landings in the Northern Region (Croatan and Roanoke sounds), 48.9% of the trips, and 48.3% of participants (Table 2.3.9). Within the Northern Region, Roanoke Sound has accounted for 30.3% of the value (Figure 2.3.18). Landings and trips have both increased substantially since around 2015 because of increased white shrimp landings. Historically, brown shrimp have accounted for most of the landings from Roanoke Sound. While Roanoke Sound accounts for nearly half of the trips in the Northern Region, landings are much lower than in Croatan Sound suggesting this area is trawled by smaller boats or is less productive for shrimp.

Shrimp trawling is allowed in most of Roanoke Sound but shallow water and other impediments limit the amount of area that can be trawled (Appendix 3, Map 3.4). Except for Outer Broad Creek, all feeder creeks and bays are designated as PNA, SNA, or no trawl areas. SSNAs are designated in Shallowbag Bay and the Kitty Hawk and Buzzards Bay area between the east side of Colington Island and the west side of Kill Devil Hills (see *Appendix 2.2: Management of Special Secondary Nursery Areas* for further information).

Management Considerations for Croatan Sound and Roanoke Sound

Because of proximity and connection, Croatan and Roanoke sounds should be combined when considering management options. If a complete closure or an option that closes areas in the northern and western portions of Pamlico Sound is chosen, a complete closure of Croatan and Roanoke sounds should be strongly considered. If status quo or other smaller scale options are chosen for Pamlico Sound additional options could be considered for Croatan Sound.

Because Roanoke Sound is a smaller waterbody with limited areas where shrimp trawling can occur, comprehensive potential area closures are not discussed. In addition, because of the SSNAs adjacent to Roanoke Sound and the presence of extensive critical habitat (i.e., SAV and shell bottom), options relating to additional area closures in Roanoke Sound are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.2: Shrimp Management in Special Secondary Nursery Areas*.

Croatan and Roanoke sounds are small, shallow waterbodies with some areas of deeper water that contribute minimally to the shrimp fishery in North Carolina. This area acts as a major corridor for the movement of fish, particularly Atlantic croaker (Figure 2.3.6) and summer flounder (Figure 2.3.9), and invertebrates (i.e., blue crab; NCDMF 2020f) between Albemarle Sound and the ocean. Because of migration timing, habitat use, and other life history characteristics anadromous species like striped bass (*Morone saxatilis*), alewife (*Alosa pseudoharengus*), blueback herring (*A. aestivalis*), and American shad (*A. sapidissima*) that use this area as a migration pathway between

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coastal rivers and the ocean are not a concern as bycatch in the estuarine shrimp trawl fishery. Consideration of Croatan and Roanoke Sound area closures should consider decisions regarding Pamlico Sound area closures. The objective of area closures in Croatan and Roanoke sounds should be creating connectivity between the closed area in the Albemarle Sound, Pamlico Sound, and the ocean.

Example Options for Croatan Sound and Roanoke Sound (Dependent on selected options for Pamlico Sound)

If all of Pamlico Sound or large areas in northern and western Pamlico Sound are closed, a complete closure of Croatan and Roanoke sounds should be the only option considered.

16. Prohibit shrimp trawling in Croatan and Roanoke sounds

- + Reduces bycatch
- + Reduces conflict between trawlers and other sectors
- + Creates increased area for juvenile fish to disperse into larger waterbodies
- + Creates a complete closure link between Croatan Sound and Pamlico Sound
- + Habitat protections
- Limits access to shrimp resource in areas that might be very productive for shrimp harvest
- May increase trawl effort in open areas
- May not reduce bycatch
- Particularly limiting to smaller commercial and recreational shrimpers
- Would limit brown shrimp fishery

If status quo or smaller scale options are chosen for Pamlico Sound, it would be difficult to consider additional small-scale options for Croatan Sound. Note that area closures may be considered for Roanoke Sound in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.2 Management of Special Secondary Nursery Areas*.

17. *Status Quo* - No additional area or seasonal closures in Croatan and Roanoke sounds

- + Continues to allow access to the shrimp resource in Croatan and Roanoke sounds
- + No impact to shrimp trawling industry
- + Bycatch reductions may still be achieved through other strategies (i.e., gear modifications)
- No additional bycatch reductions from area closures
- Continued conflict between trawlers and other sectors

18. Prohibit shrimp trawling in Croatan and Roanoke sounds

- + Closure in combination with other strategies (i.e., gear modifications) may reduce bycatch
- + Reduces conflict between trawlers and other sectors
- + Creates increased area for juvenile fish to disperse into larger water bodies
- + Creates a complete closure link between Croatan Sound and Pamlico Sound
- + Habitat protections

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- Limits access to shrimp resource in areas that might be very productive for shrimp harvest
- May increase trawl effort in open areas
- May not reduce bycatch
- Particularly limiting to smaller commercial and recreational shrimpers
- Would limit brown shrimp fishery

Central Area

This section discusses areas where shrimp trawling occurs, characteristics of those areas and existing closed areas in the Central Area. Because of the smaller waterbodies in the Central Area and the limited areas where shrimp trawling can occur, comprehensive potential area closures are not discussed. Because of the numerous SSNAs in the Central Area and the presence of extensive critical habitat (i.e., SAV and shell bottom), options relating to additional area closures in the Central area are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.2: Shrimp Management in Special Secondary Nursery Areas*.

CORE SOUND

Core Sound is a relatively small and shallow body of water that has maximum depths around ten feet with shrimp trawling occurring in the sound and its bays. From 1994 to 2019, Core Sound accounted for 56.0% of shrimp landings in the Central Region (Bogue Sound, Core Sound, Newport River, North River, White Oak River; Table 2.3.10), 61.5% of the trips, and 46.6% of participants (Table 2.3.11). Within the Central Region, Core Sound has accounted for 64.0% of the value (Figure 2.3.19). Landings and trips have both generally declined since the early 2000s. Historically brown shrimp accounted for most of the shrimp landings from Core Sound followed by pink shrimp, but since 2010 white shrimp have made up a larger portion of the landings while pink shrimp landings have declined.

The area on the eastern side of Core Sound is designated as a no trawl area by NCMFC Rule 15A NCAC 03R .0106 (1) and is in place to protect SAV but can be opened to peeler crab trawling by proclamation (NCMFC Rule 15A NCAC 03J .0104 (4); Appendix 3, Map 3.5). The bays on the mainland side of Core Sound including Jarrett Bay, Brett Bay, Nelson Bay, Thorofare Bay-Barry Bay and Cedar Island Bay are designated as SSNAs which can be opened to trawling by proclamation from August 16th to May 14th. All other tributaries and bays to Core Sound are designated as PNAs. The only other shrimp trawling restriction in the area is the crab spawning sanctuary at Ophelia and Drum inlets which is closed to the use of bottom disturbing gear from March 1 to August 31. Refer to the *Appendix 2.2: Management of Special Secondary Nursery Areas* issue paper for detailed description of opening and closing dates of SSNAs in the Core Sound Area.

Example Option, additional options are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Management of Special Secondary Nursery Areas*.

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19. Complete Closure of Core Sound

- + Reduces bycatch
- + Protects critical habitat
- + Reduces conflict between trawlers and other sectors
- + Creates increased area for juvenile fish to disperse into larger water bodies
- Eliminates shrimp trawling in the most important area in the Central Area
- May increase trawl effort in open areas
- Particularly limiting to smaller commercial and recreational shrimpers

BOGUE SOUND

Bogue Sound is a relatively small and shallow body of water located in Carteret County between the State Port in Morehead City to the east and the town of Emerald Isle to the west and has maximum depths around five feet. From 1994 to 2019, Bogue Sound has accounted for 4.8% of shrimp landings in the Central Region (Bogue Sound, Core Sound, Newport River, North River, White Oak River; Table 2.3.10), 5.4% of the trips, and 11.0% of participants (Table 2.3.11). Within the Central Region, Bogue Sound has accounted for 4.4% of the value (Figure 2.3.19). There has been little trend in landings or trips since 1994. White shrimp have generally accounted for most landings from Bogue Sound.

Tributaries including Pettiford, Goose, Sanders, Broad, Gales, and Archer creeks are designated as PNAs and the sound is closed to trawling north of the Intracoastal Waterway (IWW) on the mainland side (Appendix 3, Map 3.5-3.6). The closure of the mainland side of the IWW serves as a buffer zone to the PNAs and SAV habitat. There is also a rectangular section of Bogue Sound in the western portion that is closed to trawling to protect seagrass beds and bay scallop habitat (NCDMF 2007). Some nearshore areas on the south side of Bogue Sound, including Tar Landing Bay, Coral Bay and Hoop Pole Creek are also closed to trawling. Crab spawning sanctuaries, where trawling is prohibited from March 1 to October 31, have been designated at Beaufort and Bogue inlets. Shrimp are harvested from the IWW as they migrate toward the inlets (Beaufort and Bogue).

Example Option, additional options are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.2: Management of Special Secondary Nursery Areas*.

20. Complete Closure of Bogue Sound

- + Reduces bycatch
- + Protects critical habitat
- + Reduces conflict between trawlers and other sectors
- + Creates increased area for juvenile fish to disperse into larger water bodies
- Eliminates shrimp trawling in a potentially productive area
- May increase trawl effort in open areas
- Particularly limiting to smaller commercial and recreational shrimpers

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NORTH RIVER

North River is a relatively small and shallow body of water that has maximum depths around five feet. From 1994 to 2019, North River accounted for 14.0% of shrimp landings in the Central Region (Bogue Sound, Core Sound, Newport River, North River, White Oak River; Table 2.3.10), 11.3% of the trips, and 18.0% of participants (Table 2.3.11). Within the Central Region, North River has accounted for 12.4% of the value (Figure 2.3.19). There has been little trend in landings, though annual fluctuations can be large while trips have generally declined since the early 2000s. White shrimp have generally accounted for most landings from North River with some large peaks in brown shrimp landings.

Most of the upper portion of North River is designated as PNA or SSNA. Ward Creek and its tributaries are also designated as either PNA or SSNA (Appendix 3, Map 3.5-3.6). Turner Creek, a small tributary near the mouth of North River, is designated as PNA and other tributaries of the river are closed to trawling. Refer to the *Management of Special Secondary Nursery Areas* issue paper for detailed description of opening and closing dates of SSNAs in the Core Sound Area. The entire North River was closed to shrimp trawling once in 2003 (Proclamation SH-7-2003).

Example Option, additional options are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.2: Management of Special Secondary Nursery Areas*.

21. Complete Closure of North River

- + Reduces bycatch
- + Protects critical habitat
- + Reduces conflict between trawlers and other sectors
- + Creates increased area for juvenile fish to disperse into larger water bodies
- Eliminates shrimp trawling in a potentially productive area
- May increase trawl effort in open areas
- Particularly limiting to smaller commercial and recreational shrimpers

NEWPORT RIVER

Newport River is generally deeper than Bogue Sound and North River and has more area that can be trawled. From 1994 to 2019, Newport River has accounted for 20.5% of shrimp landings in the Central Region (Bogue Sound, Core Sound, Newport River, North River, White Oak River; Table 2.3.10), 17.2% of the trips, and 18.2% of participants (Table 2.3.11). Within the Central Region, Newport River has accounted for 16.0% of the value (Figure 2.3.19). Landings and trips have generally been declining since the early 2000s, though annual fluctuations are large. White shrimp have generally accounted for most landings from Newport River with lesser, but consistent, landings of brown shrimp.

The upper portion of the Newport River is permanently closed to trawling through the 2006 FMP and encompasses PNA and SSNA (NCDMF 2006; Appendix 3, Map 3.5-3.6). Through management recommendations implemented as part of the May 2021 Revision to Amendment 1, the Newport River SSNA was re-designated as an SNA (NCDMF 2015, 2021). Except for Core

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Creek, most tributaries and bays of the Newport River including Calico Creek, Crab Point Bay, Harlow Creek, Oyster Creek, Eastman Creek, Bell Creek, Ware Creek, and Russel Creek are designated as PNAs. There are no other trawling restrictions in the Newport River.

Example Option, additional options are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.2: Management of Special Secondary Nursery Areas*.

22. Complete Closure of Newport River

- + Reduces bycatch
- + Protects critical habitat
- + Reduces conflict between trawlers and other sectors
- + Creates increased area for juvenile fish to disperse into larger water bodies
- Eliminates shrimp trawling in a potentially productive area
- May increase trawl effort in open areas
- Particularly limiting to smaller commercial and recreational shrimpers

WHITE OAK RIVER

White Oak River is located on the Onslow/Carteret County line and has the town of Swansboro at its mouth. Due to the presence of oyster rocks and shoals, there are only a few places that are trawled in the river. From 1994 to 2019, White Oak River accounted for 4.7% of shrimp landings in the Central Region (Bogue Sound, Core Sound, Newport River, North River, White Oak River; Table 2.3.10), 4.5% of the trips, and 6.1% of participants (Table 2.3.11). Within the Central Region, White Oak River has accounted for 3.1% of the value (Figure 2.3.19). Landings and trips have generally declined since the early 2000's, though annual fluctuations are large. White shrimp account for most landings from White Oak River.

The middle portion of the White Oak River above Cahoon's Slough across to Hancock Point was closed to trawling through the 2006 FMP (NCDMF 2006; Appendix 3, Map 3.5-3.6). The upper portion of the river and tributaries including Pettiford Creek, Holland Mill Creek, Hawkins Creek, and parts of Queens Creek are designated as PNAs. There are no other trawling restrictions in the White Oak River.

Example Option, additional options are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.1: Management of Special Secondary Nursery Areas*.

23. Complete Closure of White Oak River

- + Reduces bycatch
- + Protects critical habitat
- + Reduces conflict between trawlers and other sectors
- + Creates increased area for juvenile fish to disperse into larger water bodies
- Eliminates shrimp trawling in a potentially productive area
- May increase trawl effort in open areas
- Particularly limiting to smaller commercial and recreational shrimpers

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Southern Area

This section discusses areas where shrimp trawling occurs, characteristics of those areas and existing closed areas in the Southern Area. Because of the smaller waterbodies in the Southern Area and the limited areas where shrimp trawling can occur, comprehensive potential area closures are not discussed. Because of the numerous SSNAs in the Southern Area and the extensive presence of critical habitat (i.e., SAV and shell bottom), options relating to additional area closures in the Southern Area are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.2: Shrimp Management in Special Secondary Nursery Areas*.

INTRACOASTAL WATERWAY AND SOUNDS FROM QUEENS CREEK TO HOLOVER CREEK

Queens and Bear creeks are usually opened to shrimp trawling in conjunction with White Oak River (NCDMF 2006). Queens Creek is located southeast of the White Oak River in Onslow County. The waters upstream of the NC 1509 Bridge and the tributary creeks below the bridge (Halls, Parrot Swamp, and Dicks creeks) are designated as PNAs and are closed to trawling. Limited trawling occurs below the bridge by skimmer trawlers and RCGL holders. Bear Creek is a shallow water creek located south of Queens Creek. In Bear Creek, the waters upstream of the closure line at Willis Landing are designated as PNA and are closed to trawling and very limited trawling occurs below Willis Landing due to the presence of shoals. Browns, Freeman, Gillets, and Holover creeks as well as Salliers Bay are designated as PNAs and are closed to trawling. The bays and tributaries that surround the IWW from Queens Creek to Holover Creek are designated as PNAs and are closed to trawling; however, trawling is allowed in the main channel of the IWW. Trawling is allowed in channels that connect the IWW to the ocean (West and Suanders/Sander creeks). From March 1 to October 31 trawling is prohibited in the designated crab spawning sanctuary at Bear and Browns inlets.

In 2002, the NCTTP waterbody code for the “Inland Waterway” was split into two waterbody codes [Inland Waterway (Onslow), Inland Waterway (Brunswick)]; however, some dealers using older trip tickets continued to use the code up until 2007. Thus, landings from 2003-2019 do not reflect total landings, trips, and participants from this waterbody and are not shown.

Example Option, additional options are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.2: Management of Special Secondary Nursery Areas*.

24. Complete Closure of IWW and Sounds from Queens Creek to Holover Creek
 - + Reduces bycatch
 - + Protects critical habitat
 - + Reduces conflict between trawlers and other sectors
 - + Creates increased area for juvenile fish to disperse into larger water bodies
 - Eliminates shrimp trawling in a potentially productive area
 - May increase trawl effort in open areas
 - Particularly limiting to smaller commercial and recreational shrimpers

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NEW RIVER

The New River is approximately 50 miles long and is in Onslow County (Appendix 3, Map 3.7-3.8). The lower portion of the river adjoins portions of Bogue and Topsail sounds via the IWW. The Chadwick Bay SSNA also borders the lower portion of the New River (see *Appendix 2.2: Management of Special Secondary Nursery Areas*). In 1995, the waters upstream of the Highway 172 bridge were designated as SSNA. The use of otter trawls in the SSNA was phased out in 2010 as part of the 2006 Shrimp FMP (NCDMF 2006). Trawling is prohibited in all tributary creeks downstream of the closure line at Grey and Wards Point and in the military restricted zone that extends from the western shoreline of the river below Grey Point to the northeastern shoreline of Stones Bay. NCDMF actively manages eight Shellfish Management Areas (SMAs) that are closed to trawling in the area. Below the Highway 172 Bridge, trawling is prohibited in all bays and tributary creeks and additional areas were closed to match the mechanical clam harvest line to protect SAV. From March 1 to October 31 trawling is prohibited in the designated crab spawning sanctuary at New River Inlet.

Landings from New River (above and below Highway 172 Bridge) accounted for 49.8% of shrimp landings in the Southern Region (Cape Fear River, Inland Waterway, Inland Waterway (Brunswick), Inland Waterway (Onslow), Lockwood Folly, Masonboro Sound, New River, Shallotte River, Stump Sound, Topsail Sound; Table 2.3.12), 41.8% of the trips and 37.5% of participants from 1994 to 2019 (Table 2.3.13 and 2.3.14). Within the Southern Region, New River has accounted for 53.8% of the value (Figure 2.3.20). While landings and trips have declined since the 1990s, landings from the New River made up 72.4% of the total landings from the Southern Region in 2019. Historically, brown shrimp made up roughly a quarter of the landings; however, over the last decade white shrimp have comprised approximately 70% of the landings.

Example Option, additional options are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.2: Management of Special Secondary Nursery Areas*.

25. Complete Closure of New River

- + Reduces bycatch
- + Protects critical habitat
- + Reduces conflict between trawlers and other sectors
- + Creates increased area for juvenile fish to disperse into larger water bodies
- Eliminates shrimp trawling in a potentially productive area
- May increase trawl effort in open areas
- Particularly limiting to smaller commercial and recreational shrimpers

INTRACOASTAL WATERWAY AND SOUNDS FROM NEW RIVER TO RICH INLET

The estuarine waters of the IWW as well as the adjacent sounds and bays between the New River Inlet and Rich Inlet are managed as a single waterbody. Stump Sound lies between Marker #17 to the site of the “old” Highway 50 Bridge at Surf City and includes the waters of Alligator, Everett, Spicer, and Waters bays. Topsail Sound includes all waters south of the Highway 50 Bridge to Old Topsail Inlet. Landings from Stump and Topsail sounds accounted for 12.1% of shrimp landings

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in the Southern Region (Cape Fear River, Inland Waterway, Inland Waterway (Brunswick), Inland Waterway (Onslow), Lockwood Folly, Masonboro Sound, New River, Shallotte River, Stump Sound, Topsail Sound; Table 2.3.12), 16.4% of the trips, and 20.6% of participants from 1994 to 2019 (Table 2.3.13 and 2.3.14). Within the Southern Region, Stump and Topsail sounds have accounted for 11.0% of the value (Figure 2.3.20). Since the 1990s, landings and trips have declined in both areas. Historically, brown shrimp made up a large percentage of the landings; however, white shrimp have accounted for over 60% of the landings since 2016.

Trawling is allowed in the IWW main channel from Marker #72A in the New River to Marker #17 in Stump Sound (Appendix 3, Map 3.8-3.10). The tributaries and bays adjacent to the IWW are designated as PNAs and are closed to trawling. The area south of Marker #17 to the site of the old Highway 50 Bridge at Surf City is designated as SSNA and may be opened to trawling from August 16 through May 14. Trawling in the SSNA is primarily limited to the main channel only; however, trawling is allowed within 100 feet on either side of the channel from Marker #49 to the Surf City Bridge. South of the SSNA, trawling is allowed within 100 feet on either side of the channel to Marker #93. Trawling is restricted to the main channel only throughout the rest of the IWW to Rich Inlet. Trawling is allowed in channels that connect the IWW to the ocean (Howards and Green channel). The division maintains three SMAs throughout Topsail and Stump sounds as well as an oyster sanctuary in Stump Sound, all of which are located in waters closed to shrimp trawling. Trawling is further prohibited from March 1 to October 31 in crab spawning sanctuaries, located at New Topsail and Rich inlets.

Example Option, additional options are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.2: Management of Special Secondary Nursery Areas*.

26. Complete Closure of IWW and Sounds from New River to Rich Inlet

- + Reduces bycatch
- + Protects critical habitat
- + Reduces conflict between trawlers and other sectors
- + Creates increased area for juvenile fish to disperse into larger water bodies
- Eliminates shrimp trawling in a potentially productive area
- May increase trawl effort in open areas
- Particularly limiting to smaller commercial and recreational shrimpers

INTRACOASTAL WATERWAY AND SOUNDS FROM RICH INLET TO CAROLINA BEACH INLET

The estuarine waters of the IWW and adjacent sounds between Rich Inlet and Carolina Beach stretch over 21 miles and include four inlets separating four barrier islands, three of which (Figure Eight, Wrightsville, Carolina Beach) are heavily developed. The IWW stretches across Masonboro and Myrtle Grove sounds and are regularly dredged for navigation purposes. Landings from this area accounted for 0.9% of shrimp landings in the Southern Region (Cape Fear River, Inland Waterway, Inland Waterway (Brunswick), Inland Waterway (Onslow), Lockwood Folly, Masonboro Sound, New River, Shallotte River, Stump Sound, Topsail Sound; Table 2.3.12), 1.5% of the trips, and 2.9% of participants from 1994 to 2019 (Table 2.3.13 and 2.3.14). Within the

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Southern Region, the IWW and sounds from Rich Inlet to Carolina Beach Inlet accounted for 0.7% of the value (Figure 2.3.20). Landings and effort have sharply declined since 1994; no shrimp landings or trips were reported in 2018 and 2019. Shrimp from this area are smaller in size (40-50 shrimp per pound on average) relative to other waterbodies and are often sold as live bait. Over the last decade, white shrimp have accounted for almost 80% of the landings.

Many of the bays, creeks, and tributaries that surround the IWW from Rich Inlet to Carolina Beach are designated as PNAs and SNAs and are closed to trawling (Appendix 3, Map 3.8-3.10). Trawling is restricted to the main channel throughout the waterway; however, trawling is allowed in the Carolina Beach Yacht Basin as well as channels that connect to the Atlantic Ocean (Nixon Channel, Mason Channel, Stokley Cut/Old Moores Inlet Channel, Lee's Cut/Spring Landing Channel, Banks Channel, and Mott Channel). The area from Marker #105 to the Wrightsville Beach drawbridge was closed to trawling following the adoption of the 2006 Shrimp FMP. Actions were also taken as part of the 2006 FMP to manage the IWW from Marker #139 to Marker #146 (William's Landing) as a SSNA, opening by proclamation from August 16 through May 14 (NCDMF 2006). Due to the abundance of small shrimp and limited interest, this area has not opened since 2014 (SH-12-2014). Within the waters from Rich Inlet to Carolina Beach, the division maintains six SMAs as well as an oyster sanctuary at the mouth Hewlett's Creek, all of which are closed to trawling. Trawling is further prohibited from March 1 to October 31 in crab spawning sanctuaries, located at Rich, Mason, Masonboro, and Carolina Beach inlets.

Example Option, additional options are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.2: Management of Special Secondary Nursery Areas*.

- 27. Complete Closure of IWW and Sounds from Rich Inlet to Carolina Beach Inlet
 - + Reduces bycatch
 - + Protects critical habitat
 - + Reduces conflict between trawlers and other sectors
 - + Creates increased area for juvenile fish to disperse into larger water bodies
 - Eliminates shrimp trawling in a potentially productive area
 - May increase trawl effort in open areas
 - Particularly limiting to smaller commercial and recreational shrimpers

CAPE FEAR RIVER COMPLEX

The Cape Fear River complex includes the waters of the Wilmington Harbor navigation channel to the inlet and the bays behind Carolina and Kure Beach and Bald Head Island. The shrimp closure line in the Cape Fear River runs easterly across the river just upstream from the mouth of Lilliput Creek. Just downstream of this line, the upper portion of the shrimp trawl management area is connected to the IWW at Snow's Cut. The lower portion of the river adjoins the IWW at Marker #1 near Southport and borders the mouths of Dutchman Creek and the Elizabeth River. The Cape Fear River Complex accounted for 19.9% of shrimp landings in the Southern Region (Cape Fear River, Inland Waterway, Inland Waterway (Brunswick), Inland Waterway (Onslow), Lockwood Folly, Masonboro Sound, New River, Shallotte River, Stump Sound, Topsail Sound; Table 2.3.12), 16.0% of the trips and 9.4% of participants from 1994 to 2019 (Table 2.3.13 and 2.3.14). Within

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the Southern Region, the Cape Fear River has accounted for 19.7% of the value (Figure 2.3.20). Landings have continuously declined since the 1990s. Over the last decade, white shrimp have accounted for approximately 80% of the landings on average. In general, shrimp caught in the Cape Fear River are smaller in size (40-50 shrimp per pound on average) relative to other parts of the state and are often sold as live bait or to local markets and breeding operations.

Nearly all of the upper Cape Fear River is designated as PNA or Inland Waters and is therefore closed to shrimp trawling (Appendix 3, Map 3.11). Below Snow’s Cut, trawling is allowed in the main river channel and behind many of the spoil islands. The areas known as the “Dow Chemical Bay” and “Radar Bay” are closed to trawling. Most trawl effort occurs outside the main channel from the Fort Fisher Ferry to Battery Island. Trawling, and all other boating activity, is prohibited in the military restricted area at the Sunny Point Military Ocean Terminal. Trawling in the SSNA behind Kure Beach was prohibited following rule changes implemented in the May 2021 Revision to Amendment 1 that re-designated it as a permanent SNA (NCDMF 2021). The bays south of the Fort Fisher Ferry Terminal (First Bay or “the Basin”, Second Bay, Buzzard’s Bay) and behind Bald Head Island (Cape and Bay creeks) were designated as Trawl Net Prohibited areas with the implementation of the 2006 Shrimp FMP (NCDMF 2006). Trawling is further prohibited in the crab spawning sanctuary at the Cape Fear River Inlet from March 1 to October 31(NCDMF 2020f).

Example Option, additional options are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.2: Management of Special Secondary Nursery Areas*.

28. Complete Closure of Cape Fear River complex

- + Reduces bycatch
- + Protects critical habitat
- + Reduces conflict between trawlers and other sectors
- + Creates increased area for juvenile fish to disperse into larger water bodies
- Eliminates shrimp trawling in a potentially productive area
- May increase trawl effort in open areas
- Particularly limiting to smaller commercial and recreational shrimpers

BRUNSWICK COUNTY

The Brunswick County coastline stretches approximately 33 miles across four barrier islands (Oak Island, Holden Beach, Ocean Isle, Sunset Beach) and is bound by the Little River Inlet on the west end and the Cape Fear River Inlet on the east end. Brunswick County (IWW, Shallotte River, Lockwood Folly River) has accounted for 3.0% of shrimp landings in the Southern Region (Cape Fear River, Inland Waterway, Inland Waterway (Brunswick), Inland Waterway (Onslow), Lockwood Folly, Masonboro Sound, New River, Shallotte River, Stump Sound, Topsail Sound; Table 2.3.12), 6.1% of the trips, and 7.7% of participants from 1994 to 2019 (Table 2.3.13 and 2.3.14). Within the Southern Region, Brunswick County has accounted for 2.7% of the value (Figure 2.3.20). Landings and trips have significantly declined since 2010. Historically, landings consisted of a mix of brown and white shrimp with numerous closures occurring throughout the 1990s and early 2000s to protect recruiting white shrimp. In recent years, limited effort and poor

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catches of brown shrimp have limited the need for closures to protect white shrimp. Over the last decade, white shrimp have made up over 60% of the landings in Brunswick County.

Trawling in Brunswick County is primarily limited to the main channel of the IWW. Most of the shoreline bordering the IWW is designated as nursery area and is closed to trawling (Appendix 3, Map 3.11-3.12). With the adoption of Amendment 1, shrimp trawling was prohibited in the IWW from the Sunset Beach Bridge to the South Carolina line, including the Shallotte River, Eastern Channel, and lower Calabash River to protect small shrimp and reduce bycatch. Following rule changes implemented in the May 2021 Revision to Amendment 1, the Lockwood Folly River and Saucepan Creek SSNAs were re-designated as permanent SNAs (NCDMF 2021). Trawling is also prohibited in the Southport Boat Harbor and the Progress Energy Intake Canal. Trawling is allowed in the channels that connect the IWW to Atlantic Ocean, such as the Elizabeth River, Dutchman Creek, Montgomery Slough, Jinks Creek, and Bonaparte Creek. Trawling is prohibited from March 1 to October 31 in crab spawning sanctuaries located at Shallotte River Inlet, Lockwood Folly Inlet, and Tubbs Inlet (NCDMF 2020f).

Example Option, additional options are discussed in *Appendix 2.1: Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats* and *Appendix 2.2: Management of Special Secondary Nursery Areas*.

29. Complete Closure of Brunswick County

- + Reduces bycatch
- + Protects critical habitat
- + Reduces conflict between trawlers and other sectors
- + Creates increased area for juvenile fish to disperse into larger water bodies
- Eliminates shrimp trawling in a potentially productive area
- May increase trawl effort in open areas
- Particularly limiting to smaller commercial and recreational shrimpers

VI. PROPOSED RULE(S)

Completed after recommendations are brought forward.

VII. RECOMMENDATIONS

Division of Marine Fisheries

- Prohibit all trawling year round in Crab Spawning Sanctuaries
- Prohibit shrimp trawling in a portion of Croatan Sound
- Prohibit shrimp trawling within the entirety of Parched Corn Bay, Berrys Bay, East Bluff Bay, West Bluff Bay, and West Bay
- Extend existing closures by prohibiting shrimp trawling in areas near the mouth of Stumpy Point Bay, Pains Bay, Long Shoal River, and Otter Creek
- Prohibit shrimp trawling west of the 76° 28.0000' W longitude line which passes near Roos Point at the mouth of Pamlico River south to Point of Marsh at the mouth of the Neuse River

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- Prohibit shrimp trawling in the Newport River and its tributaries except within the MCHA and waters north and west between the MCHA and the Trawl Net Prohibited Area
- Prohibit shrimp trawling in the White Oak River and its tributaries
- Prohibit shrimp trawling in Queens and Bear creeks
- Prohibit shrimp trawling in the channels that connect to the Atlantic Ocean [Banks Channel (Topsail Sound), Green Channel, Nixon Channel, Mason Channel, Stokley Cut/Old Moores Inlet Channel, Lee’s Cut/Spring, Landing Channel, Banks Channel (Wrightsville Beach), Mott Channel, Muddy Slough, Dutchman Creek, Elizabeth River, Eastern Channel (Montgomery Slue), Jinks Creek, and Bonaparte Creek]
- Prohibit shrimp trawling in the Carolina Beach Yacht Basin

Northern Advisory Committee

- No motion passed.

Southern Advisory Committee

- Supports no additional area closures without supporting information to inform those closures.

Finfish Advisory Committee

- No recommendation

Shellfish and Crustacean Advisory Committee

- Does not agree with closing all internal waters.
- Does not agree with any additional seasonal closures in internal waters.

Habitat and Water Quality Advisory Committee

- No motion or recommendation.

NCMFC Selected Management Strategy

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DRAFT – SUBJECT TO CHANGE

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Tables

Table 2.3.1. Commercial landings (pounds) and number of commercial trips and participants landing shrimp in North Carolina, 1994-2019.

Year	Landings	Trips	Participants
1994	7,284,793	21,768	1,580
1995	8,669,257	23,891	1,891
1996	5,261,147	17,085	1,513
1997	6,988,243	20,442	1,526
1998	4,635,189	14,969	1,196
1999	8,991,521	19,821	1,504
2000	10,334,915	18,442	1,725
2001	5,254,132	14,072	1,213
2002	9,969,018	18,342	1,372
2003	6,167,371	14,057	1,110
2004	4,880,816	11,882	988
2005	2,357,516	6,582	703
2006	5,736,649	8,025	715
2007	9,537,230	9,291	804
2008	9,414,418	8,084	849
2009	5,407,708	7,770	735
2010	5,955,335	7,864	755
2011	5,140,360	5,361	573
2012	6,141,480	8,924	755
2013	4,858,885	8,689	728
2014	4,690,933	6,478	642
2015	9,116,730	8,182	751
2016	13,195,269	9,727	896
2017	13,905,392	9,571	892
2018	9,729,526	6,097	739
2019	9,547,982	5,909	652
Total	193,171,815	311,325	26,807
Average	7,429,685	11,974	1,031

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Table 2.3.2. Cumulative total count of the top 20 species captured in the Estuarine Trawl Survey (Program 120) from May and June, 2015-2019. Species in bold are those commonly associated with the North Carolina commercial shrimp trawl fishery.

Species	Count	Percent
Spot	1,719,494	43.0
Pinfish	685,624	17.2
Brown Shrimp	419,500	10.5
Atlantic Croaker	345,241	8.6
Bay Anchovy	335,827	8.4
Atlantic Menhaden	117,408	2.9
Silver Perch	86,129	2.2
Blue Crab	73,849	1.8
Pigfish	32,148	0.8
Southern Flounder	30,170	0.8
Rainwater Killifish	27,635	0.7
White Shrimp	10,607	0.3
Hogchoker	9,312	0.2
Inland Silverside	9,281	0.2
Atlantic Rangia	7,795	0.2
Naked Goby	5,910	0.1
Bluegill	5,776	0.1
Weakfish	4,836	0.1
Marsh Killifish	4,631	0.1
Fundulus Killifishes	3,897	0.1
Remaining 289 Species	.	1.6

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Table 2.3.3. Cumulative total count and biomass (kg) of the top 20 species captured in the Pamlico Sound Survey (Program 195) from June and September, 2015-2019. Species in bold are those commonly associated with the North Carolina commercial shrimp trawl fishery.

<u>June</u>	Number		Biomass		<u>September</u>	Number		Biomass	
Species	Number	Percent	Weight (kg)	Percent	Species	Number	Percent	Weight (kg)	Percent
Atlantic Croaker	485,083	39.7	9,941.0	28.8	Atlantic Croaker	428,071	37.7	12,774.2	35.6
Spot	455,062	37.2	10,396.7	30.1	Spot	376,797	33.1	9,843.6	27.5
Blue Crab	97,915	8.0	4,852.5	14.1	Weakfish	45,421	4.0	1,974.3	5.5
Weakfish	37,424	3.1	3,013.7	8.7	Pinfish	40,419	3.6	1,583.9	4.4
Brown Shrimp	20,904	1.7	246.8	0.7	Atlantic Menhaden	28,586	2.5	524.9	1.5
Bay Anchovy	19,621	1.6	34.9	0.1	Bay Anchovy	21,439	1.9	33.0	0.1
Hogchoker	17,848	1.5	685.0	2.0	White Shrimp	21,355	1.9	509.2	1.4
Pinfish	16,365	1.3	648.2	1.9	Blue Crab	20,054	1.8	1,761.5	4.9
Atlantic Menhaden	13,023	1.1	365.4	1.1	Silver Perch	18,509	1.6	682.8	1.9
Silver Perch	11,616	1.0	615.8	1.8	Harvestfish	14,921	1.3	371.6	1.0
Pink Shrimp	10,158	0.8	152.5	0.4	Pigfish	12,999	1.1	539.8	1.5
Summer Flounder	7,998	0.7	223.9	0.6	Pink Shrimp	11,599	1.0	109.4	0.3
Southern Flounder	6,698	0.5	420.5	1.2	Brown Shrimp	10,870	1.0	206.2	0.6
Butterfish	2,993	0.2	106.5	0.3	Striped Anchovy	10,269	0.9	80.5	0.2
Mantis Shrimp	2,764	0.2	48.3	0.1	Atlantic Thread Herring	8,008	0.7	150.7	0.4
Lesser Blue Crab	2,015	0.2	14.6	0.0	Hogchoker	7,934	0.7	290.0	0.8
Southern Kingfish	1,653	0.1	182.0	0.5	Lesser Blue Crab	6,564	0.6	109.6	0.3
Atlantic Thread Herring	1,451	0.1	47.6	0.1	Summer Flounder	6,487	0.6	381.4	1.1
Harvestfish	1,292	0.1	141.6	0.4	Atlantic Spadefish	5,771	0.5	130.7	0.4
Pigfish	1,290	0.1	84.0	0.2	Gizzard Shad	4,920	0.4	110.4	0.3
Remaining 137 Species	.	0.8	.	6.6	Remaining 144 Species	.	3.2	.	10.3

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Table 2.3.4. General life history characteristics of species commonly associated with the commercial shrimp trawl fishery in North Carolina.

Species	Spawning Period	Spawning Location	Larval Stage	Juvenile Stage	References
Brown Shrimp	February-March	Ocean	Enter estuaries February-April	Move to deeper portions of estuary as they grow	see NCDMF (2015) for review
Pink Shrimp	April-July	Ocean	Enter estuaries May-November	Move to deeper portions of estuary as they grow	see NCDMF (2015) for review
White Shrimp	March-November	Ocean	Enter estuaries May-July; 2-3 weeks after hatching	Move to deeper portions of estuary as they grow	see NCDMF (2015) for review
Atlantic croaker	October-March	Ocean; continental shelf	larvae enter estuaries late fall to late winter	Remain in upper estuarine habitats until mid-summer before moving into deeper open water habitats	see Odell et al. (2017) for review
Southern flounder	November-April	Ocean	Enter estuaries 30-45 days after hatching, settling throughout sounds and rivers in the winter and early spring	Overwinter in low salinity waters or rivers and bays for first two years of life before migrating offshore	see Flowers et al. (2019) for review
Summer flounder	Fall and early winter	Ocean	Enter estuary October-May	Spend first year in bays and other inshore areas	see Packer et al. (1999) for review
Spot	Fall-Winter	Ocean; continental shelf	Enter estuaries winter-early spring	As they grown move from shallow habitat to deeper water habitats	see Odell et al. (2017) for review
Weakfish	March-September	Nearshore ocean; lower reaches of estuaries	Larvae distribute throughout estuaries	Inhabit nearshore and deeper waters of bays, estuaries, and sounds	see Odell et al. (2017) for review

DRAFT – SUBJECT TO CHANGE

Table 2.3.5. Existing areas closed to the use of trawls in coastal and estuarine waters of North Carolina.

Type of Closure	Location	Restriction	Purpose	Reference
Primary Nursery Area	Statewide/Internal Coastal Waters	Unlawful to use trawl nets or other bottom disturbing gear	Protect habitat for juvenile fish and shrimp	15A NCAC 03N .0104 15A NCAC 03R .0103
Secondary Nursery Area	Statewide/Internal Coastal Waters	Unlawful to use trawl nets	Protect habitat for juvenile fish and shrimp	15A NCAC 03N .0105(a) 15A NCAC 03R .0104
Special Secondary Nursery Area	Statewide/Internal Coastal Waters	Can be opened to the use of trawl nets by proclamation from August 16 to May 14	Protect habitat for juvenile fish and shrimp while allowing taking of shrimp after they have grown or when juvenile fish have left area	15A NCAC 03N .0105 15A NCAC 03R .0105
Trawl Net Prohibited Areas	Statewide/Coastal and Internal Coastal Waters	Unlawful to use trawl nets; parts of Pamlico, Core and Back sounds can be opened to peeler crab trawling by proclamation	Protect sensitive habitat or reduce bycatch	15A NCAC 03J .0104(b)(3)(4) 15A NCAC 03R .0106
Military Danger Zones	Statewide/Coastal and Internal Coastal Waters	No public access	Public safety	15A NCAC 03R .0102
Crab Spawning Sanctuaries	All coastal inlets	From Barden Inlet north unlawful to use trawls in spawning sanctuaries from March 1 to August 31; From Beaufort inlet south unlawful to use trawls in spawning sanctuaries from March 1 to October 31	Provide protection for spawning blue crabs	15A NCAC 03L .0205 15A NCAC 03R .0110 Proclamation M-7-2020

DRAFT – SUBJECT TO CHANGE

Type of Closure	Location	Restriction	Purpose	Reference
Designated Pot Areas	Pamlico, Bay, Neuse rivers and their tributaries	Unlawful to use trawl nets in designated pot areas from June 1 to November 30	Reduce gear conflicts between trawls and crab pots	NCAC 03J .0104(b)(6) 15A NCAC 03J .0301(a)(2) 15A NCAC 03R .0107 Proclamation (i.e., SH-1-2020)
Seed Oyster Management Areas	Statewide/Internal Coastal Waters	Unlawful to use trawl nets in seed oyster management areas	Protect oyster habitat	15A NCAC 03K .0208 15A NCAC 03R .0116
Oyster Sanctuaries	Croatan Sound, Pamlico Sound, Neuse River	Unlawful to use trawl nets in oyster sanctuaries	Protect oyster habitat	15A NCAC 03k .0209 15A NCAC 03R .0117
Shrimp Trawl Prohibited Areas	Pungo, Pamlico, Neuse, Shallotte, Calabash rivers; Eastern Channel; Sunset Beach	Unlawful to use shrimp trawls	Protect habitat, reduce bycatch, reduce gear conflicts	15A NCAC 03L .0103(e) 15A NCAC 03R .0114
Other Trawl Closures				
Miscellaneous	Atlantic Ocean	Unlawful to use trawls in specified areas, during specified times	Protect habitat, reduce bycatch, reduce gear conflicts	15A NCAC 03J .0202 (1)(2) 15A NCAC 03J .0202 (8)
Miscellaneous	Albemarle Sound and Tributaries	Unlawful to use trawls	Protect habitat, reduce bycatch, reduce gear conflicts	15A NCAC 03J .0104 (b)(3)
Miscellaneous	Southport Boat Harbor	Unlawful to use any commercial fishing gear	Reduce user group conflict, public safety	15A NCAC 03J .0206
Miscellaneous	Duke Energy Progress Brunswick Nuclear Plant Intake Canal Closure	Unlawful to use any commercial fishing gear	Public safety	15A NCAC 03J .0207

DRAFT – SUBJECT TO CHANGE

Type of Closure	Location	Restriction	Purpose	Reference
Miscellaneous	Dare County	Unlawful to use commercial fishing gear within 750 feet of licensed fishing piers when open to the public	Reduce user group conflict	15A NCAC 03J .0402(a)(1)(ii)
Miscellaneous	Onslow and Pender counties	Unlawful to use commercial fishing gear during specified times and distances from fishing piers	Reduce user group conflict	15A NCAC 03J .0402(a)(2)(A)(B)(i)(ii)
Miscellaneous	New Hanover County	Unlawful to use commercial fishing gear during specified times and distances from fishing piers	Reduce user group conflict	15A NCAC 03J 0402(a)(3)(A)(B)(i)(iii)

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Table 2.3.6. Total commercial shrimp landings from each water body within the Pamlico Region (Pamlico Sound, Neuse River, Bay River, Pamlico/Pungo River), 1994-2019.

Year	Pamlico Sound	Neuse River	Bay River	Pamlico/Pungo River
1994	3,861,536	115,689	20,051	46,107
1995	4,096,835	114,705	10,021	34,756
1996	1,933,536	111,098	6,051	23,948
1997	3,722,785	164,538	16,409	41,096
1998	1,115,961	83,765	1,358	14,664
1999	3,876,339	216,922	27,913	50,703
2000	6,708,334	210,970	35,348	51,636
2001	2,890,943	19,942	5,935	27,090
2002	6,147,806	213,697	14,070	110,329
2003	2,023,826	102,366	2,010	11,944
2004	2,104,690	87,384	526	6,546
2005	558,104	110,286	1,915	4,367
2006	2,477,858	125,952	1,600	3,876
2007	6,761,768	139,720	858	30,015
2008	5,944,307	391,739	7,144	21,779
2009	3,686,102	116,298	4,192	18,710
2010	3,837,536	116,953	2,405	12,813
2011	3,636,369	115,586	6,069	399
2012	3,955,615	111,098	3,969	5,285
2013	3,041,974	107,772	3,230	4,352
2014	3,351,981	102,625	1,334	0
2015	6,529,484	188,902	21,613	17,844
2016	6,973,945	161,748	5,138	1,815
2017	8,542,675	168,309	3,361	2,640
2018	7,265,369	115,069	4,552	3,214
2019	2,897,791	85,715	383	194
Total	107,934,165	3,598,051	207,418	546,123
Average	4,151,314	138,387	7,978	21,005

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Table 2.3.7. Total commercial trips and participants landing shrimp from each water body within the Pamlico Region (Pamlico Sound, Neuse River, Bay River, Pamlico/Pungo River), 1994-2019.

Year	Trips				Participants			
	Pamlico Sound	Neuse River	Bay River	Pamlico/Pungo River	Pamlico Sound	Neuse River	Bay River	Pamlico/Pungo River
1994	3,512	555	98	85	288	63	13	25
1995	4,154	620	71	59	303	77	14	39
1996	1,956	510	39	20	212	70	10	11
1997	3,132	862	106	65	267	78	14	21
1998	1,269	383	54	9	151	49	4	7
1999	3,124	559	78	57	286	57	8	23
2000	4,011	541	91	128	383	106	47	37
2001	2,800	155	55	89	283	32	14	37
2002	3,576	603	40	119	340	85	15	64
2003	1,272	368	3	25	182	49	3	18
2004	1,944	554	3	7	209	52	2	5
2005	469	332	9	14	106	57	5	9
2006	1,509	306	3	29	172	35	1	10
2007	2,623	332	14	61	219	35	3	15
2008	2,020	685	19	36	234	81	5	13
2009	1,866	259	14	12	217	36	3	9
2010	1,625	395	9	52	207	56	3	10
2011	1,459	492	23	6	198	45	10	3
2012	1,756	359	23	40	179	55	8	5
2013	1,686	388	11	7	187	45	7	7
2014	1,608	446	8	0	190	48	4	0
2015	2,265	422	68	50	216	61	16	11
2016	2,411	449	22	16	231	63	5	7
2017	2,734	297	15	7	239	49	5	4
2018	2,294	240	19	26	226	40	4	9
2019	1,422	188	5	12	171	31	3	2
Total	58,497	11,300	900	1,031	5,896	1,455	226	401
Average	2,250	435	35	40	227	56	9	15

DRAFT – SUBJECT TO CHANGE

Table 2.3.8. Percentage of hot spots within 3, 4, 5, and 6 miles from the northern and eastern shores of Pamlico Sound.

Species	June				September			
	3 miles	4 miles	5 miles	6 miles	3 miles	4 miles	5 miles	6 miles
Atlantic croaker	15	32	39	44	39	50	57	68
Spot	20	24	31	43	52	65	72	80
Southern flounder	35	44	52	60	59	73	82	90
Summer flounder	38	44	51	64	39	53	60	65
Weakfish	13	21	27	30	22	28	33	40
Brown shrimp	78	100	100	100	15	18	18	21
Pink shrimp	14	29	29	29	13	25	33	38
White shrimp	9	9	9	13	27	38	44	51

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Table 2.3.9. Total commercial shrimp landings, trips, and participants landing shrimp from each water body within the Northern Region (Croatan and Roanoke sound), 1994-2019.

Year	Landings		Trips		Participants	
	Croatan Sound	Roanoke Sound	Croatan Sound	Roanoke Sound	Croatan Sound	Roanoke Sound
1994	7,701	14,776	102	251	16	24
1995	13,768	5,632	116	71	16	15
1996	6,590	7,896	109	183	17	29
1997	12,539	8,568	166	183	27	28
1998	1,389	188	26	9	7	3
1999	3,793	1,488	93	48	18	15
2000	40,989	7,298	490	124	56	23
2001	799	75	20	4	5	2
2002	10,010	32,080	109	390	18	58
2003	641	2,415	12	41	4	6
2004	6,856	6,646	96	142	19	23
2005	12	907	2	27	1	5
2006	2,421	642	23	20	7	3
2007	23,961	6,059	70	30	22	12
2008	4,761	2,189	32	51	12	10
2009	8,175	2,607	40	60	5	11
2010	1,075	429	18	9	3	6
2011	1,309	742	13	9	4	6
2012	4,072	713	31	21	7	3
2013	9,264	1,010	49	5	12	4
2014	2,487	289	22	11	6	3
2015	24,637	2,063	122	29	21	6
2016	23,068	15,213	60	106	16	22
2017	99,418	20,155	213	138	27	12
2018	27,507	13,685	150	152	20	19
2019	38,035	23,359	168	140	23	16
Total	375,278	177,123	2,352	2,254	389	364
Average	14,434	6,812	90	87	15	14

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Table 2.3.10. Total commercial shrimp landings from each water body within the Central Region (Bogue Sound, Core Sound, Newport River, North River, White Oak River), 1994-2019.

Year	Bogue Sound	Core Sound	Newport River	North River	White Oak River
1994	23,344	863,245	166,380	127,327	44,995
1995	34,345	1,069,213	275,201	196,322	39,013
1996	45,689	737,829	125,092	56,511	23,825
1997	17,009	636,805	213,818	92,489	12,986
1998	41,849	547,488	71,793	27,391	23,582
1999	48,219	884,325	307,501	160,649	37,984
2000	23,875	464,916	240,583	216,045	62,164
2001	9,906	431,489	176,502	71,739	62,361
2002	31,389	783,852	292,696	186,314	137,397
2003	127,781	821,174	142,654	117,353	52,052
2004	18,624	252,813	125,039	126,873	60,283
2005	12,729	317,370	70,030	84,838	6,655
2006	70,432	260,588	199,986	258,670	58,950
2007	39,385	241,093	170,636	179,602	24,277
2008	57,928	434,900	118,998	145,782	20,282
2009	31,643	191,151	73,951	65,725	36,720
2010	34,534	119,470	91,966	55,370	15,457
2011	20,769	25,117	13,964	16,849	3,005
2012	15,117	320,249	130,512	46,086	77,767
2013	26,989	365,379	114,235	75,308	30,286
2014	3,837	219,530	91,409	23,059	10,513
2015	37,253	252,384	237,588	69,397	11,465
2016	54,536	361,792	314,397	217,710	47,499
2017	39,795	275,215	170,247	71,402	16,510
2018	50,599	209,829	86,305	61,620	5,754
2019	46,819	62,329	72,587	38,744	5,858
Total	964,396	11,149,543	4,094,071	2,789,174	927,641
Average	37,092	428,829	157,464	107,276	35,679

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Table 2.3.11. Total commercial trips and participants landing shrimp from each water body within the Central Region (Bogue Sound, Core Sound, Newport River, North River, White Oak River), 1994-2019.

Year	Trips					Participants				
	Bogue Sound	Core Sound	Newport River	North River	White Oak River	Bogue Sound	Core Sound	Newport River	North River	White Oak River
1994	379	6,664	1,045	980	432	48	256	84	90	36
1995	363	7,366	1,033	938	265	62	290	75	157	25
1996	423	5,743	830	445	174	48	221	78	83	22
1997	259	5,627	1,350	765	187	28	213	87	93	14
1998	427	4,546	490	275	268	41	185	54	40	21
1999	257	4,696	1,313	490	177	47	184	89	67	33
2000	203	3,248	1,051	751	238	53	146	89	82	31
2001	119	3,278	921	440	352	23	146	76	68	27
2002	156	3,842	1,456	572	553	32	137	72	58	25
2003	312	3,663	893	549	387	48	143	56	61	20
2004	285	1,755	779	797	219	23	109	43	53	14
2005	183	1,343	497	465	68	13	97	33	38	8
2006	251	976	446	575	138	32	73	33	37	15
2007	174	916	543	573	132	16	68	29	44	13
2008	137	916	337	516	87	21	71	32	39	10
2009	174	903	423	361	203	12	82	24	34	13
2010	218	579	488	329	78	19	65	35	26	11
2011	115	140	98	145	34	17	37	13	14	7
2012	114	1,340	589	298	246	12	97	35	22	20
2013	179	1,442	436	315	112	21	89	31	26	17
2014	35	1,223	465	210	64	14	95	33	21	7
2015	170	835	689	197	38	20	70	40	12	3
2016	187	994	732	316	140	30	90	41	17	12
2017	166	942	476	186	35	28	93	26	19	6
2018	154	500	242	145	14	24	68	18	16	5
2019	114	170	147	99	23	17	48	12	11	1
Total	5,554	63,647	17,769	11,732	4,664	749	3,173	1,238	1,228	416
Average	214	2,448	683	451	179	29	122	48	47	16

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Table 2.3.12. Total commercial shrimp landings from each water body within the Southern Region, 1994-2019. Waterbody code for Inland Waterway was split in 2002 but was still periodically recorded on old Trip Tickets through 2007.

Year	Cape Fear River	Inland Waterway	Inland Waterway (Brunswick)	Inland Waterway (Onslow)	Lockwood Folly	Masonboro Sound	New River	Shallotte River	Stump Sound	Topsail Sound
1994	149,791	50,936	.	.	426	4,638	103,006	1,807	8,553	29,485
1995	114,261	110,409	.	.	477	1,952	274,212	1,491	25,546	59,202
1996	80,354	84,630	.	.	50	5,973	148,257	394	27,088	21,898
1997	138,424	66,675	.	.	16	5,715	244,360	2,413	29,139	22,508
1998	82,592	54,768	.	.	25	4,961	259,274	814	16,038	36,579
1999	118,742	66,506	.	.	12	2,266	271,883	176	20,522	72,561
2000	46,058	79,462	.	.	22	4,212	483,739	896	21,888	39,152
2001	17,850	51,538	.	.	1	1,514	189,084	6,123	11,795	21,888
2002	82,868	55,313	.	2,966	1	3,373	428,783	1,968	48,099	14,383
2003	101,424	47,487	18,404	31,972	1	6,561	230,381	4,333	25,010	43,141
2004	32,730	14,381	8,633	27,523	0	17,722	174,901	318	9,840	28,312
2005	46,241	13,018	16,746	45,855	0	4,745	49,506	1,352	17,202	26,535
2006	35,843	0	8,380	57,007	0	7,603	164,411	0	11,655	18,925
2007	46,124	4	11,512	25,631	2	335	151,743	0	16,497	10,657
2008	47,264	0	19,944	29,588	0	165	101,554	0	31,862	5,435
2009	44,658	0	15,873	53,465	0	125	22,552	0	20,612	24,652
2010	137,009	0	30,935	47,345	0	5,918	144,919	125	19,360	27,903
2011	79,197	0	21,042	13,421	1	66	66,584	0	2,631	25,405
2012	78,384	0	20,184	53,753	0	135	156,247	0	16,859	11,563
2013	63,635	0	6,520	88,799	0	344	135,937	0	28,334	16,203
2014	34,269	0	10,973	16,815	0	0	87,047	0	5,475	5,837
2015	33,526	0	12,766	50,143	0	0	156,882	483	17,643	15,483
2016	80,262	0	7,277	16,697	0	1,470	209,334	3,861	13,196	9,697
2017	68,323	0	16,725	12,254	0	2,408	87,073	387	10,319	5,310
2018	12,298	0	9,321	21,835	38	0	53,537	81	25,043	15,852
2019	29,326	0	2,711	4,768	0	0	106,900	712	1,784	1,547
Total	69,287	26,736	13,997	33,324	41	3,162	173,158	1,067	18,538	23,466
Average	69,287	49,652	13,997	33,324	41	3,162	173,158	1,067	18,538	23,466

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Table 2.3.13. Total commercial trips landing shrimp from each water body within the Southern Region, 1994-2019. Waterbody code for Inland Waterway was split in 2002 but was still periodically recorded on old Trip Tickets through 2007.

Year	Cape Fear River	Inland Waterway	Inland Waterway (Brunswick)	Inland Waterway (Onslow)	Lockwood Folly	Masonboro Sound	New River	Shallotte River	Stump Sound	Topsail Sound
1994	916	932	.	.	4	88	1,364	28	110	450
1995	476	1,156	.	.	7	22	2,283	21	189	660
1996	433	925	.	.	9	57	1,337	7	324	320
1997	583	819	.	.	6	111	2,344	30	315	322
1998	450	753	.	.	10	94	1,733	2	168	420
1999	447	694	.	.	6	69	2,681	3	246	641
2000	281	841	.	.	21	85	2,632	14	206	381
2001	219	719	.	.	1	39	1,626	41	180	311
2002	361	751	.	.	1	56	2,559	17	385	199
2003	323	387	203	290	1	79	1,677	37	285	351
2004	162	114	141	292	0	151	1,211	3	91	313
2005	183	63	278	341	0	36	348	7	160	216
2006	177	0	175	179	0	46	527	0	75	216
2007	362	1	183	161	1	10	628	0	163	134
2008	286	0	296	221	0	1	365	0	289	119
2009	376	0	301	454	0	1	180	0	174	242
2010	620	0	454	348	0	30	662	2	150	317
2011	479	0	371	113	1	1	349	0	46	207
2012	632	0	459	343	0	2	702	0	161	220
2013	625	0	277	682	0	3	617	0	176	212
2014	355	0	210	112	0	0	473	0	38	112
2015	331	0	235	303	0	0	386	3	139	142
2016	531	0	78	137	0	34	503	3	150	107
2017	585	0	215	92	0	19	327	6	151	71
2018	279	0	171	163	1	0	273	1	117	148
2019	456	0	74	48	0	0	226	3	47	77
Total	420	314	242	252	3	40	1,077	9	174	266
Average	409	575	220	227	3	39	1,068	9	166	252

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Table 2.3.14. Total commercial participants landing shrimp from each water body within the Southern Region, 1994-2019. Waterbody code for Inland Waterway was split in 2002 but was still periodically recorded on old Trip Tickets through 2007.

Year	Cape Fear River	Inland Waterway	Inland Waterway (Brunswick)	Inland Waterway (Onslow)	Lockwood Folly	Masonboro Sound	New River	Shallotte River	Stump Sound	Topsail Sound
1994	52	104	.	.	3	27	134	14	41	47
1995	36	132	.	.	2	12	182	5	48	64
1996	33	115	.	.	3	11	136	6	49	33
1997	40	101	.	.	2	9	158	6	42	38
1998	35	89	.	.	4	14	153	2	34	39
1999	40	139	.	.	1	14	321	3	52	69
2000	32	140	.	.	4	9	325	4	29	64
2001	26	119	.	.	1	15	197	8	32	63
2002	35	113	.	6	1	15	219	2	40	38
2003	33	76	27	41	1	18	192	4	46	47
2004	23	29	28	43	0	16	177	1	18	44
2005	19	25	37	51	0	13	93	1	31	36
2006	15	0	26	38	0	12	74	0	13	31
2007	19	1	38	23	1	7	103	0	20	30
2008	23	0	40	30	0	1	69	0	33	20
2009	22	0	43	50	0	1	38	0	32	31
2010	33	0	61	52	0	5	64	1	26	31
2011	23	0	49	18	1	1	40	0	9	22
2012	27	0	66	45	0	2	83	0	21	35
2013	27	0	36	71	0	3	68	0	28	36
2014	18	0	41	24	0	0	64	0	8	20
2015	19	0	34	45	0	0	55	2	20	24
2016	20	0	16	16	0	5	61	3	17	20
2017	24	0	26	18	0	5	42	4	20	13
2018	16	0	20	26	1	0	49	1	23	28
2019	23	0	10	9	0	0	31	2	7	9
Total	27	46	35	34	1	8	120	3	28	36
Average	43	128	43	41	2	13	171	5	43	51

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Figures

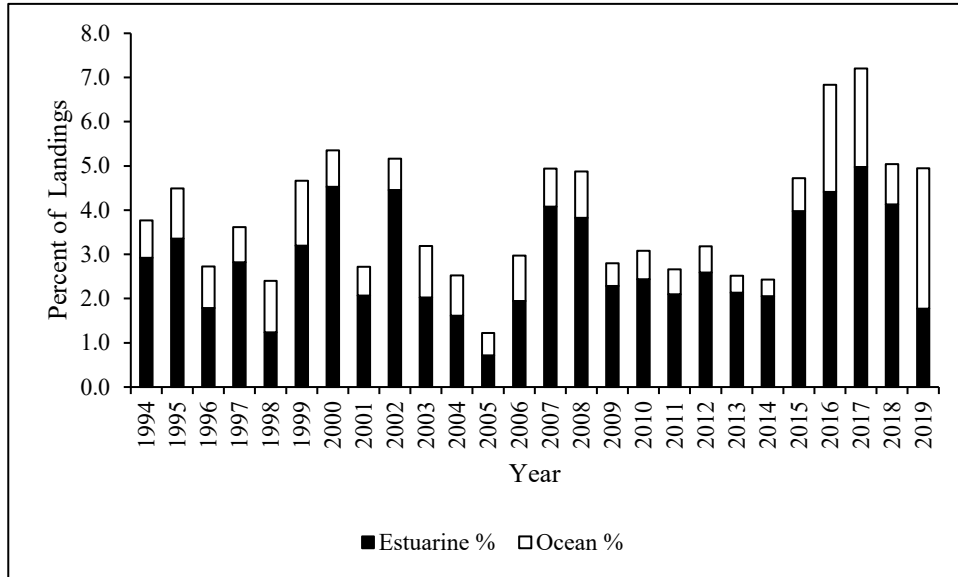


Figure 2.3.1. Percent of commercial shrimp landings reported from estuarine and ocean waters scaled to total commercial shrimp landings, 1994-2019.

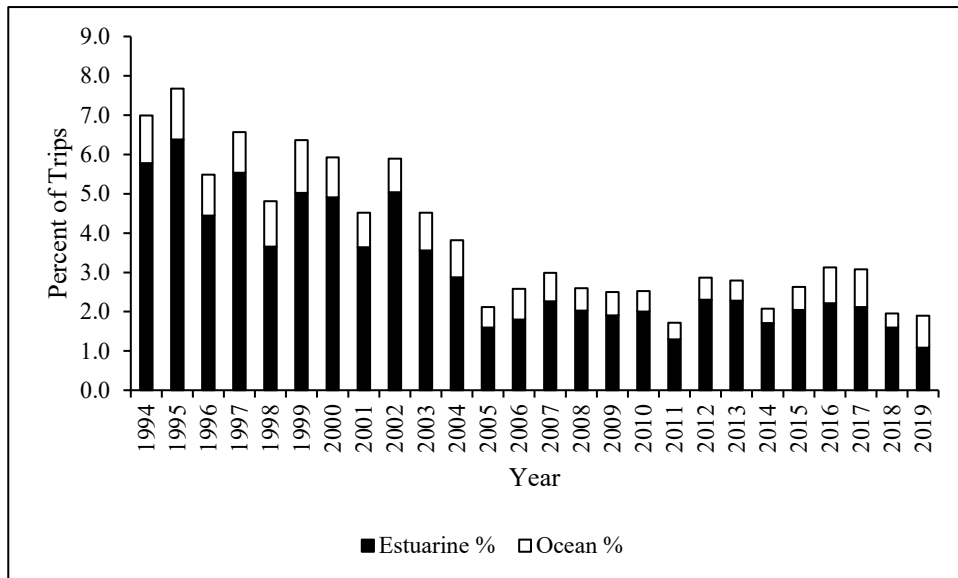


Figure 2.3.2. Percent of commercial trips landing shrimp reported from estuarine and ocean waters scaled to total commercial trips landing shrimp, 1994-2019.

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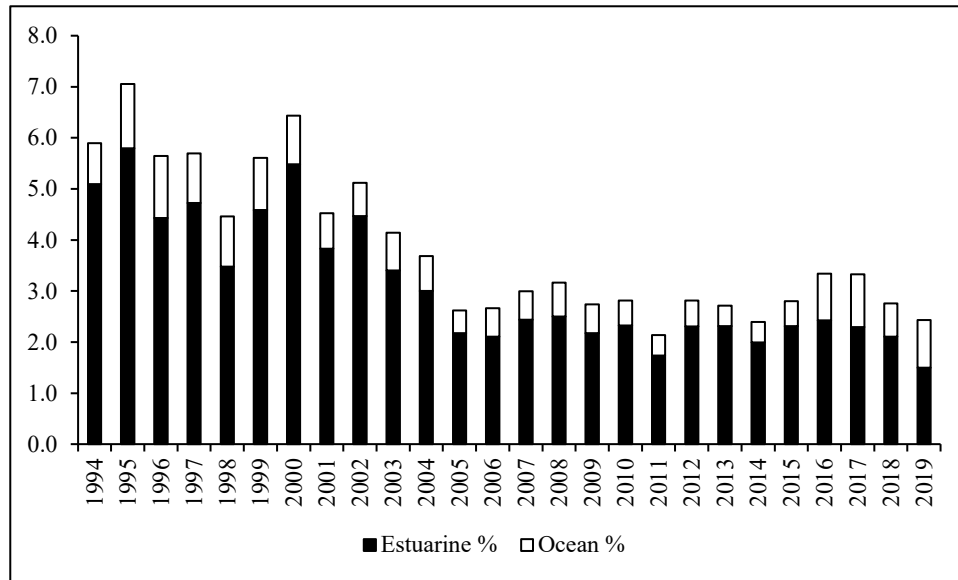


Figure 2.3.3. Percent of commercial participants landing shrimp reported from estuarine and ocean waters scaled to total commercial participants landing shrimp, 1994-2019.

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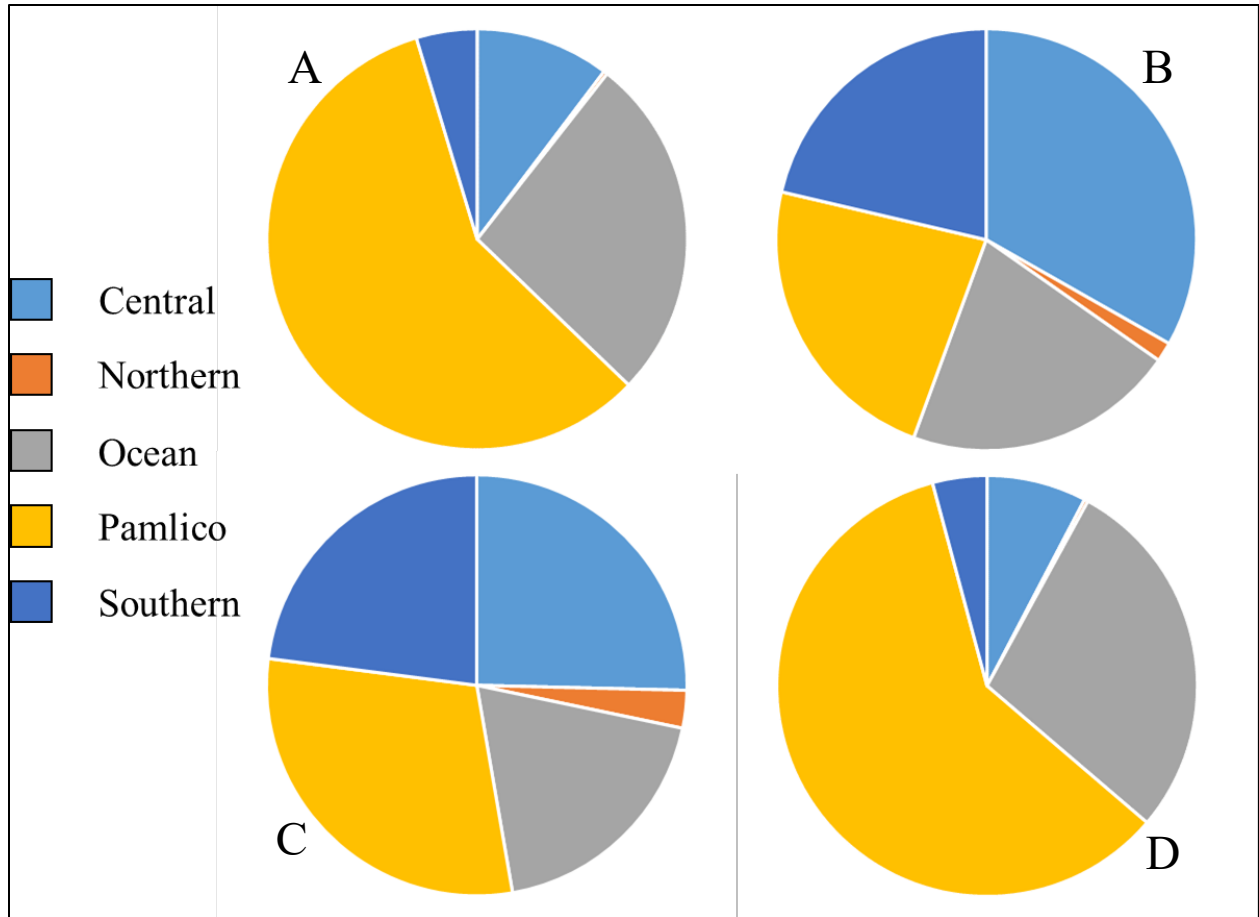


Figure 2.3.4. Percent of commercial shrimp landings (A), commercial shrimp trips (B), commercial shrimp participants (C) and value (D) in the Central, Northern, Ocean, Pamlico, and Southern Regions, 1994-2019.

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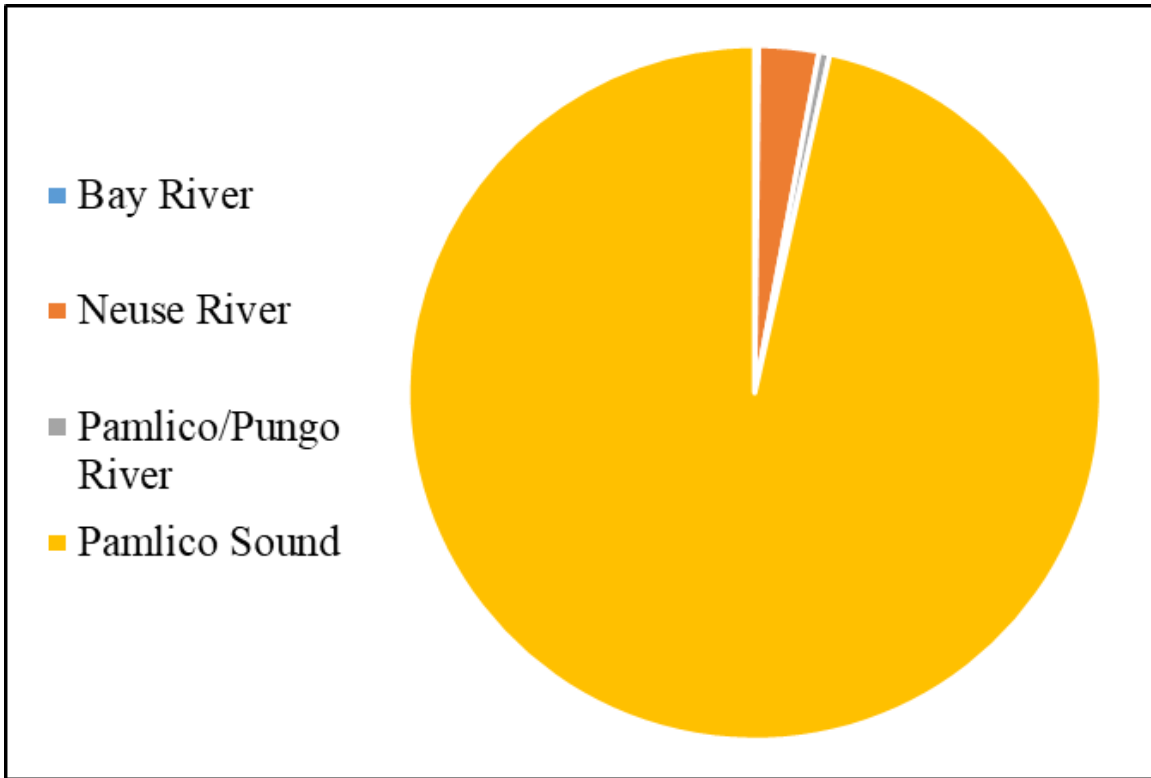


Figure 2.3.5. Percent of value by waterbody in the Pamlico Region (Pamlico Sound, Bay River, Pamlico/Pungo River).

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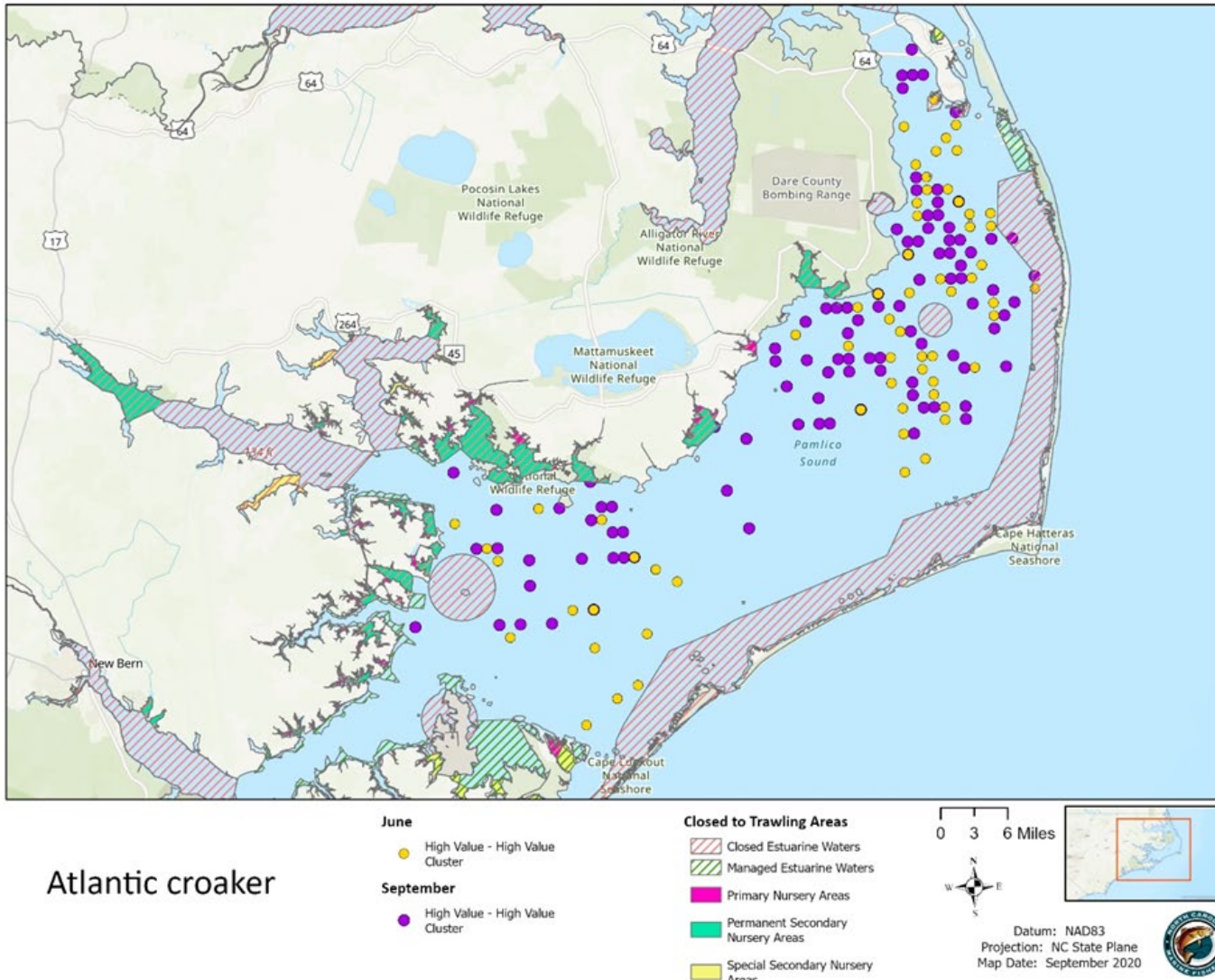


Figure 2.3.6. Hot spots of abundance for Atlantic croaker in the Pamlico Sound during June and September using aggregate data from Program 195, 1987-2019.

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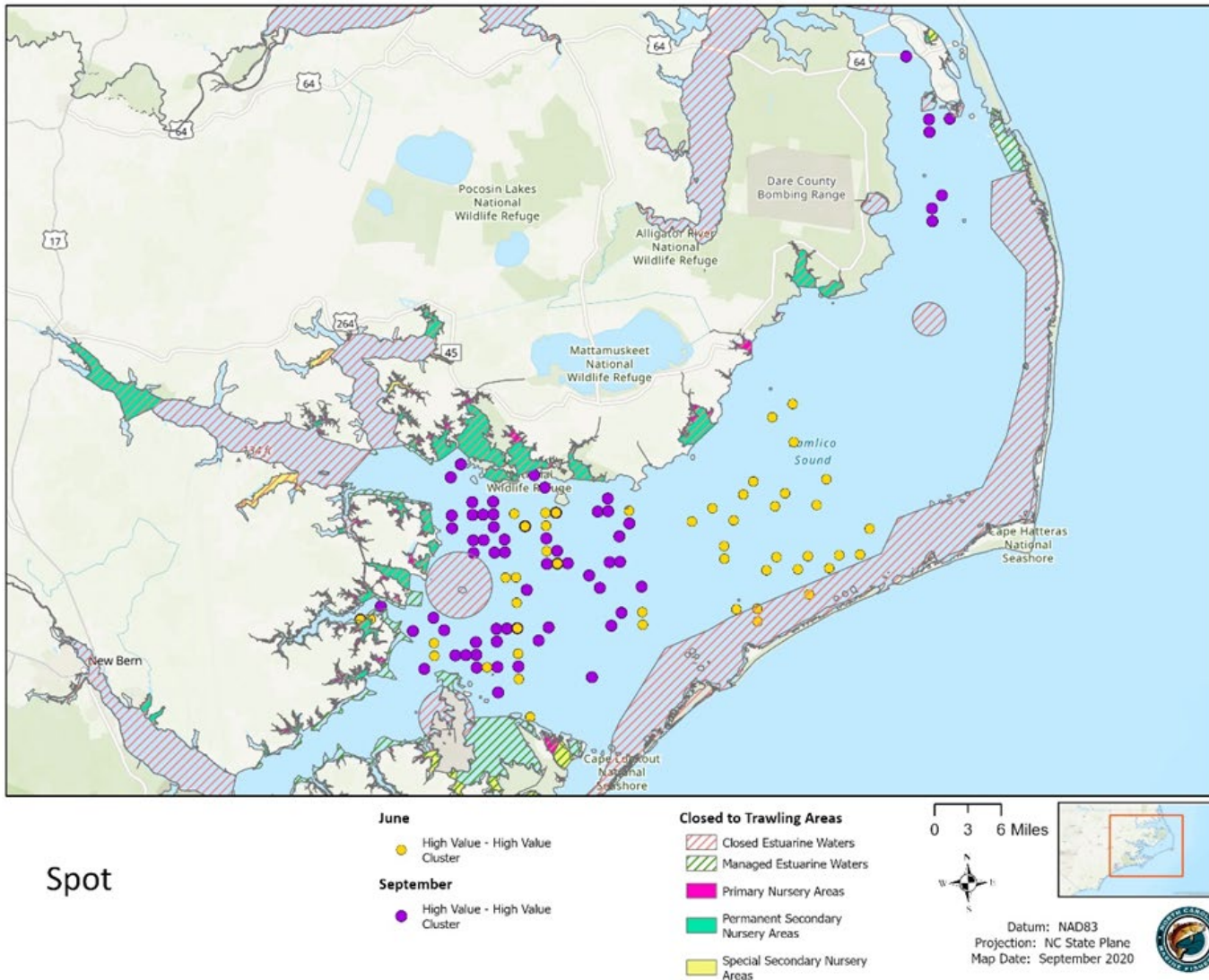


Figure 2.3.7. Hot spots of abundance for spot in Pamlico Sound during June and September using aggregate data from Program 195, 1987-2019.

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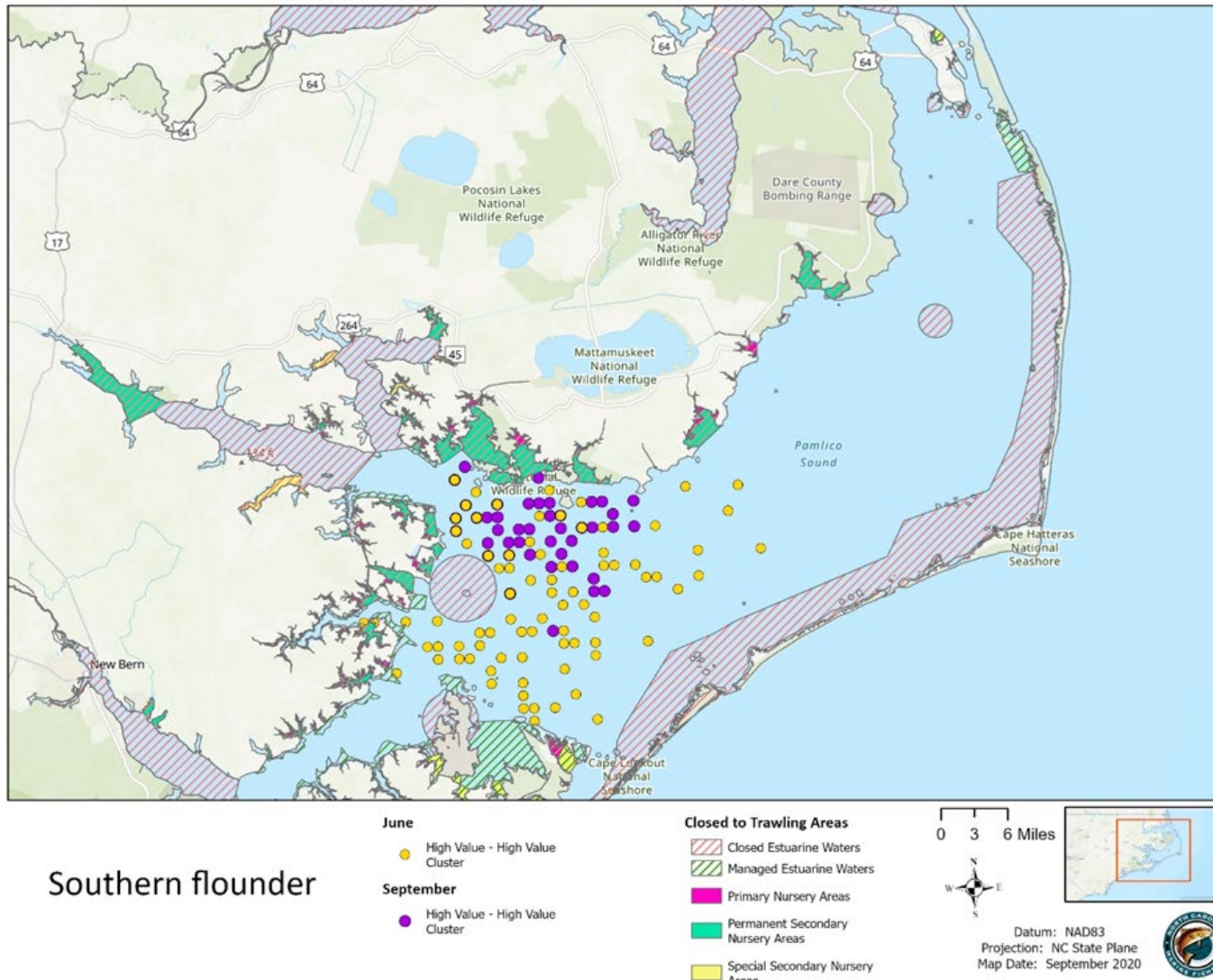


Figure 2.3.8. Hot spots of abundance for southern flounder in the Pamlico Sound during June and September using aggregate data from Program 195, 1987-2019.

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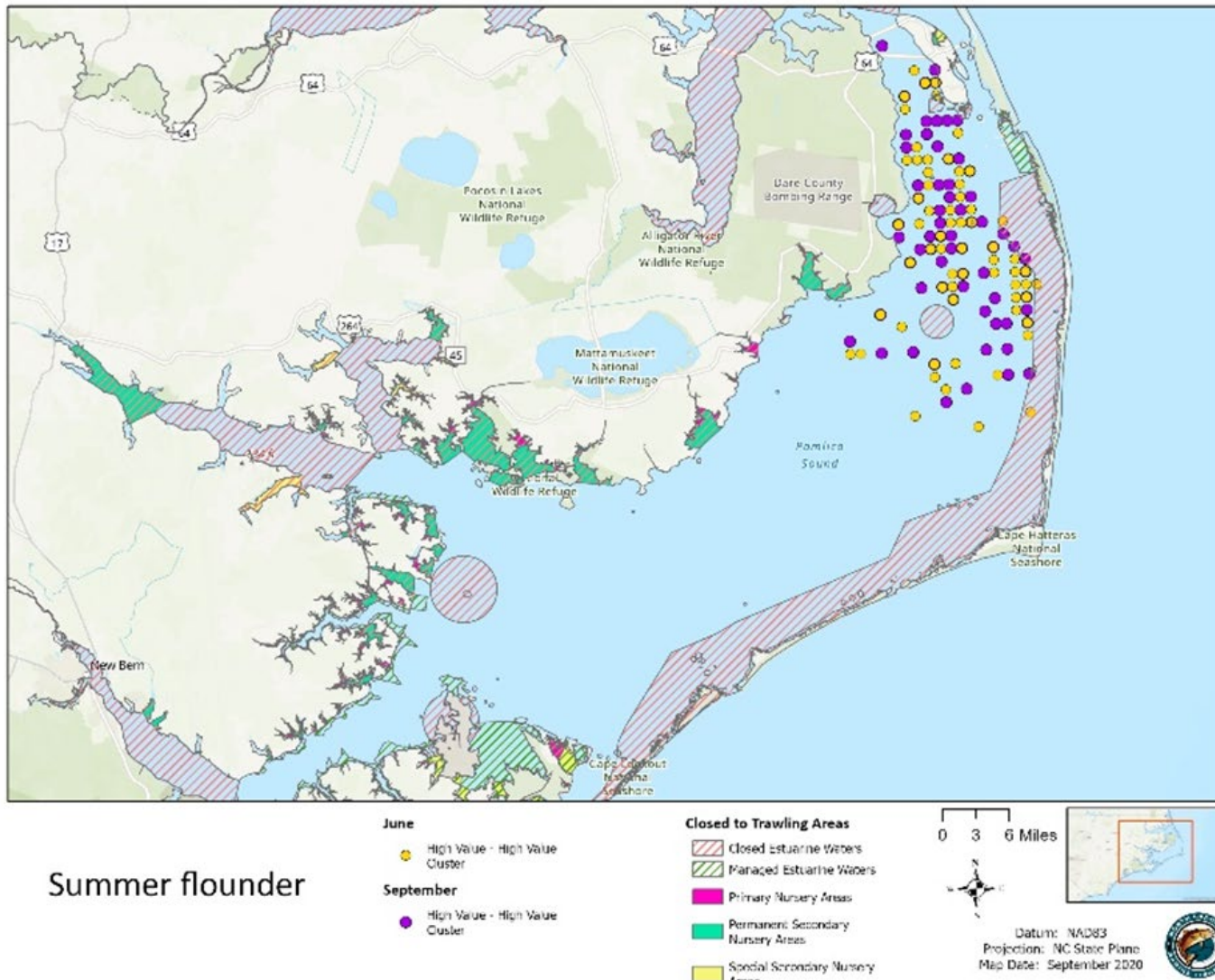


Figure 2.3.9. Hot spots of abundance for summer flounder in the Pamlico Sound during June and September using aggregate data from Program 195, 1987-2019.

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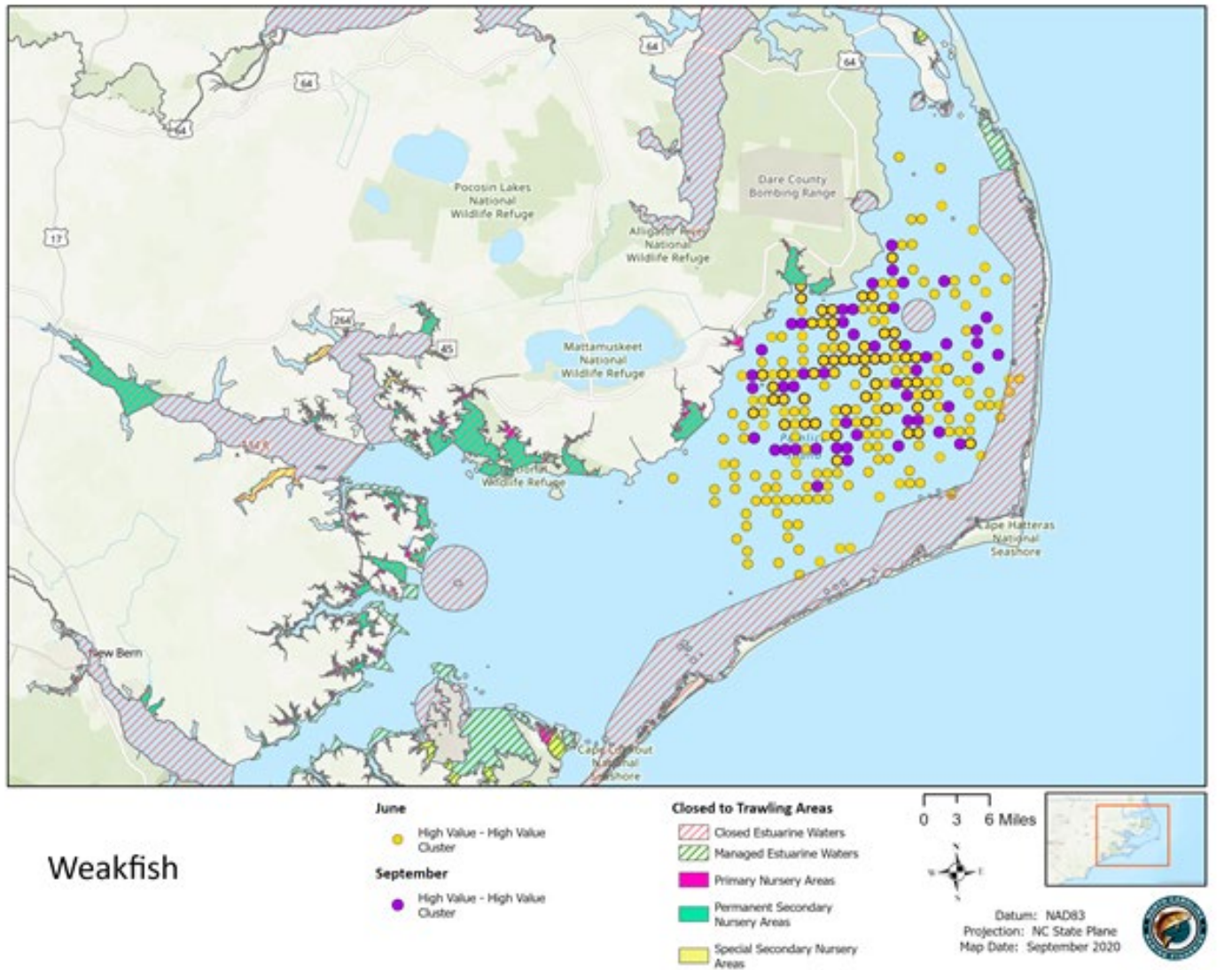


Figure 2.3.10. Hot spots of abundance for weakfish in the Pamlico Sound during June and September using aggregate data from Program 195, 1987-2019.

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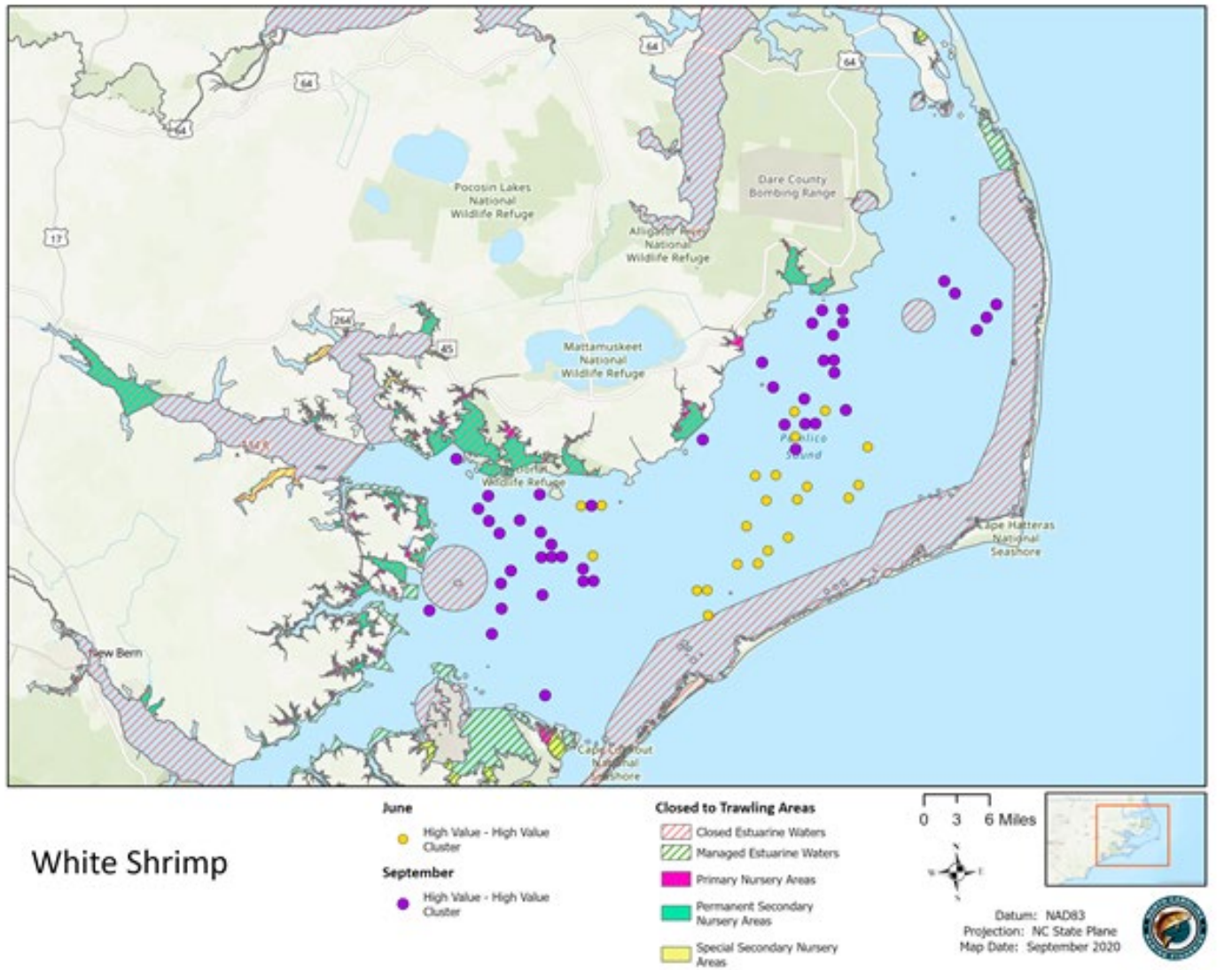


Figure 2.3.11. Hot spots of abundance for white shrimp in the Pamlico Sound during June and September using aggregate data from Program 195, 1987-2019.

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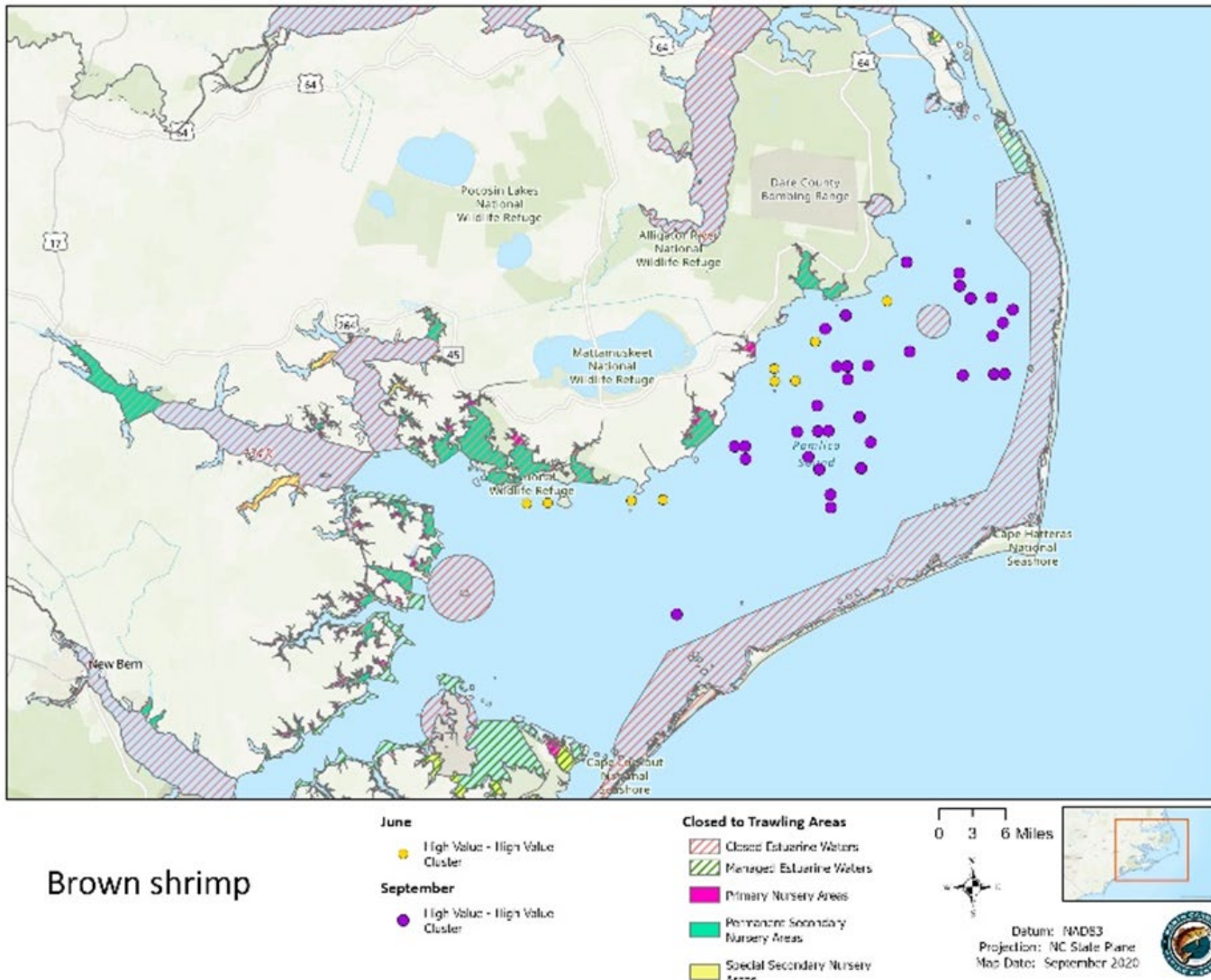


Figure 2.3.12. Hot spots of abundance for brown shrimp in the Pamlico Sound during June and September using aggregate data from Program 195, 1987-2019.

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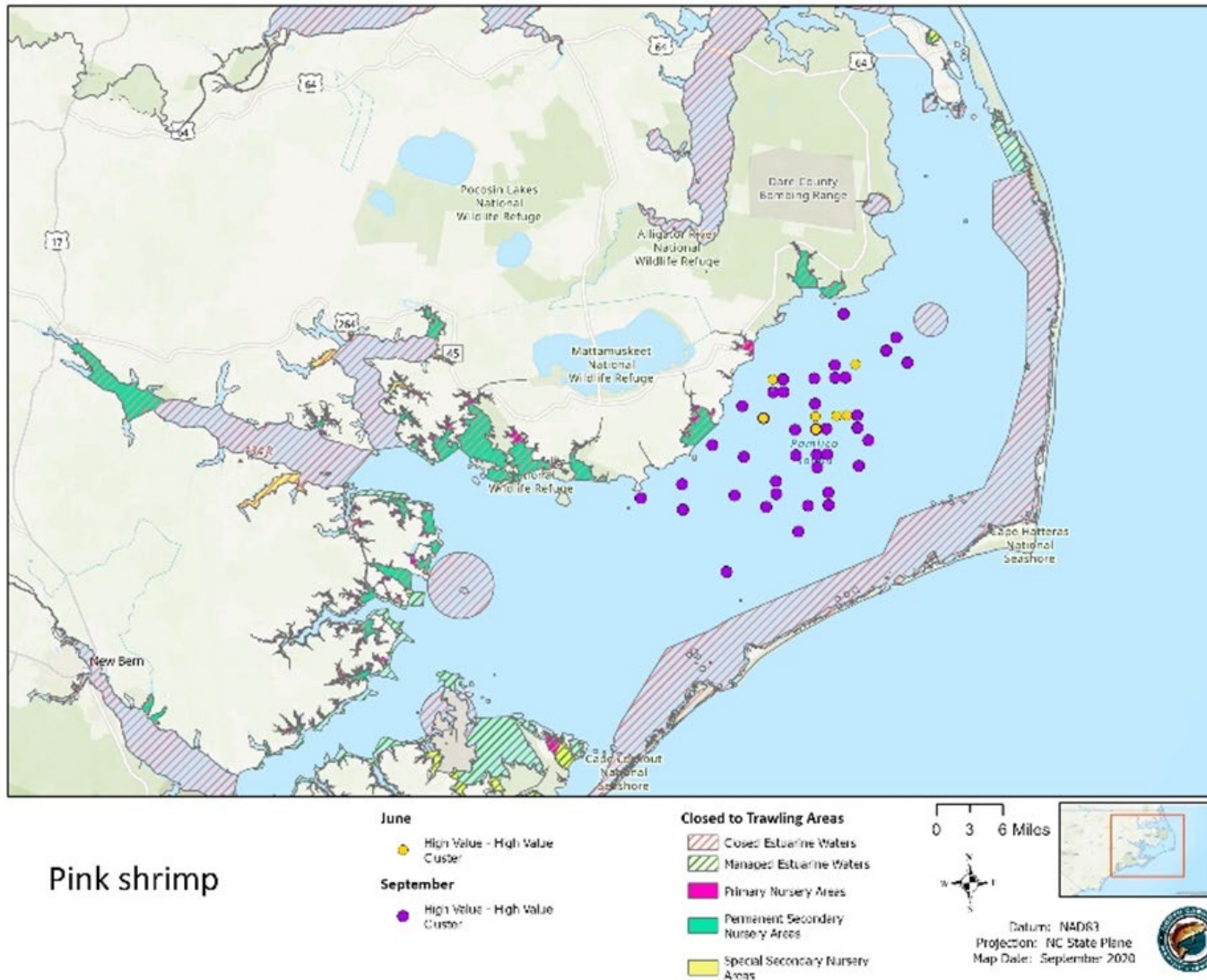


Figure 2.3.13. Hot spots of abundance for pink shrimp in the Pamlico Sound during June and September using aggregate data from Program 195, 1987-2019.

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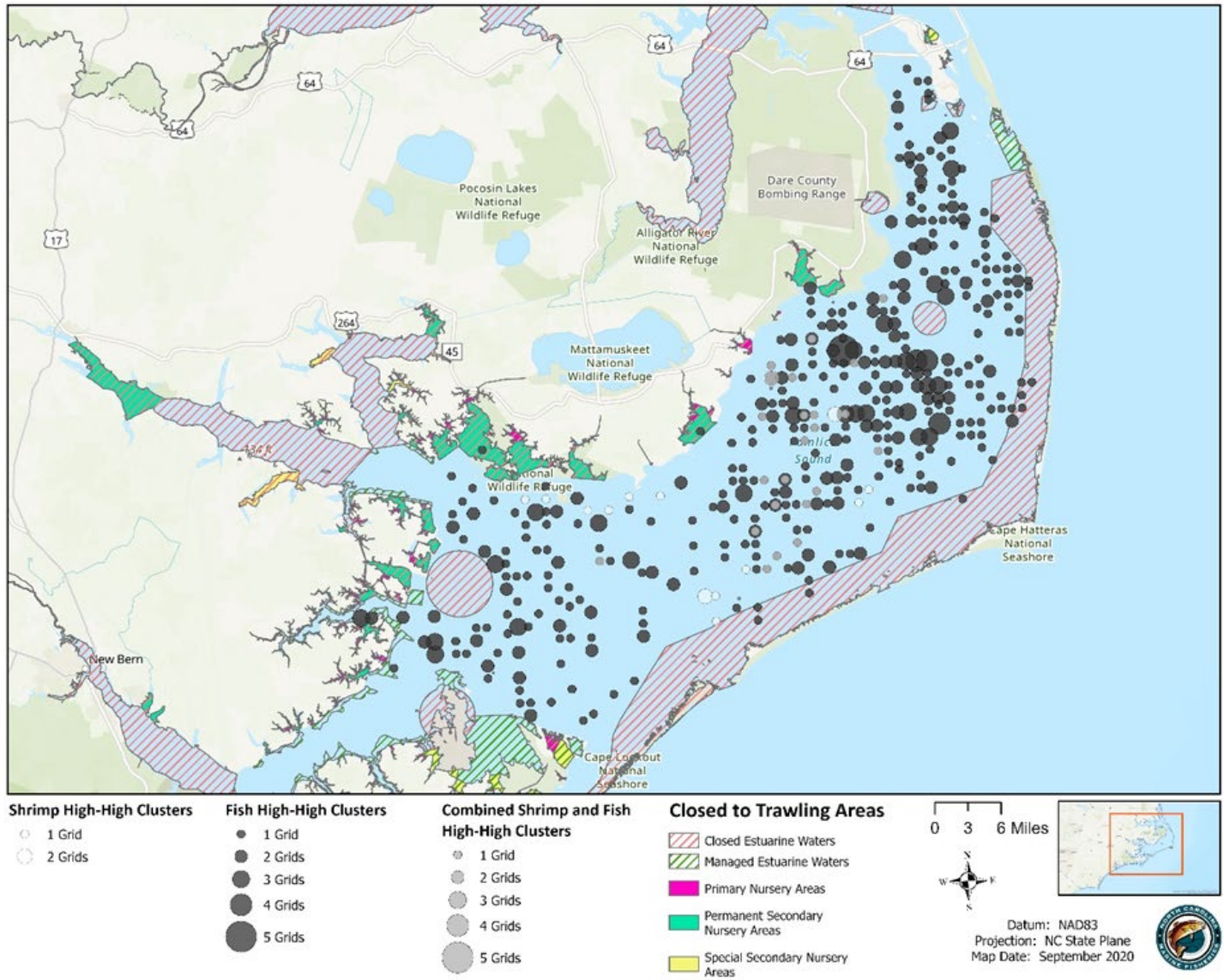


Figure 2.3.14. Frequency of hot spots for Pamlico Sound Survey sites during June using aggregate finfish and shrimp abundance data, 1987-2019.

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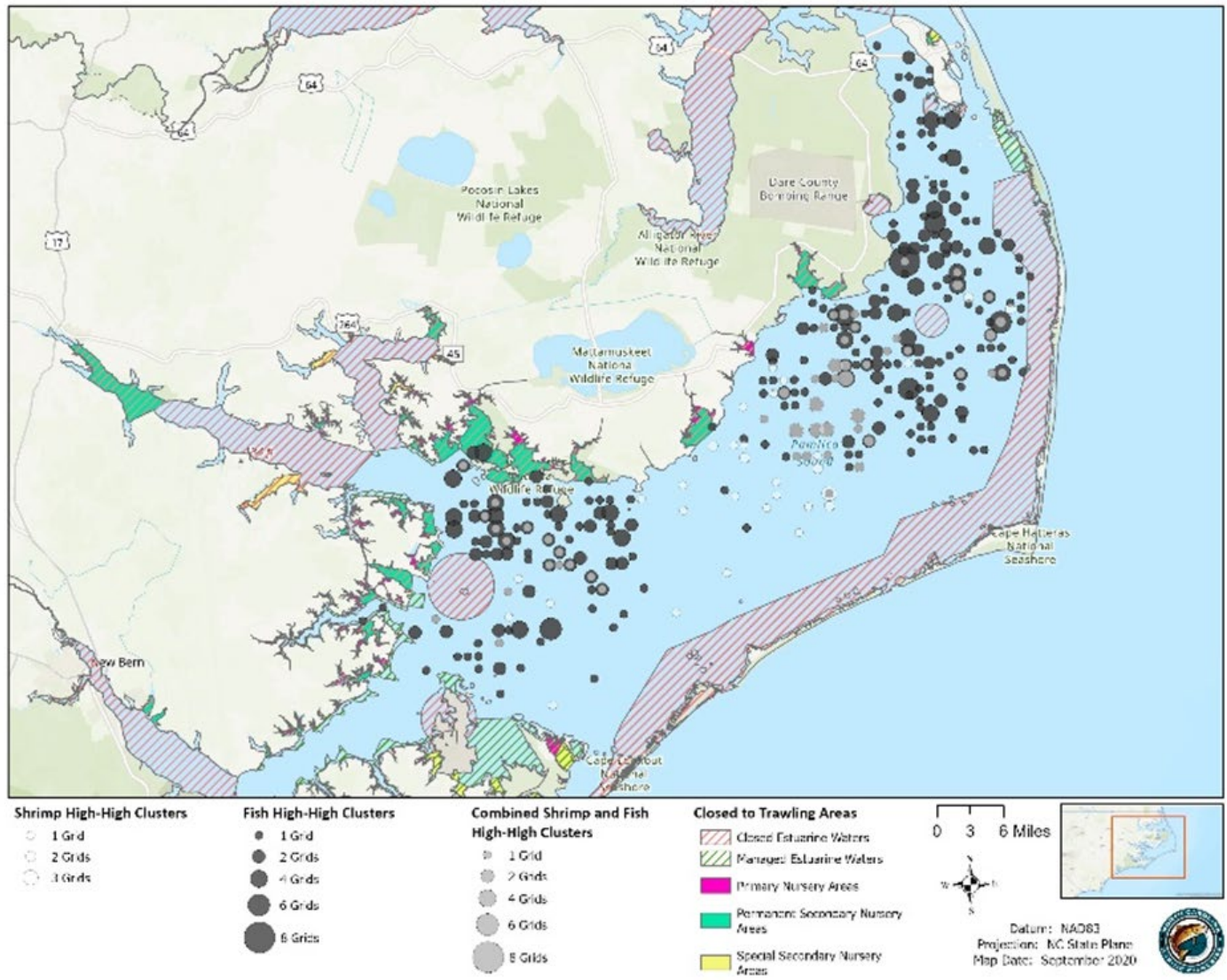


Figure 2.3.15. Frequency of hot spots for Pamlico Sound Survey sites during September using aggregate finfish and shrimp abundance data, 1987-2019.

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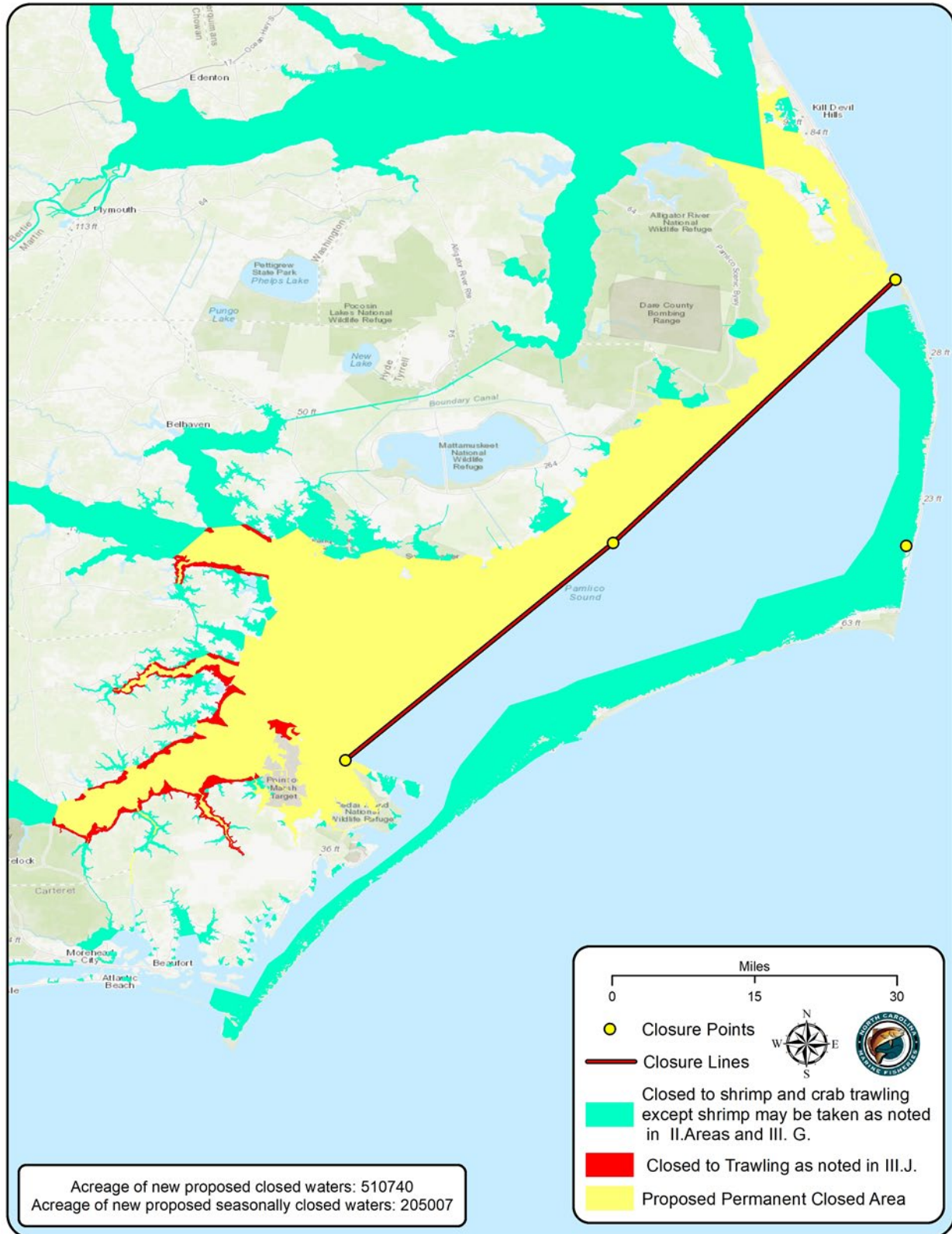


Figure 2.3.16. Example of Pamlico Sound area closure. No shrimp trawling would be permitted in internal coastal waters north and west of the red line (permanent closure).

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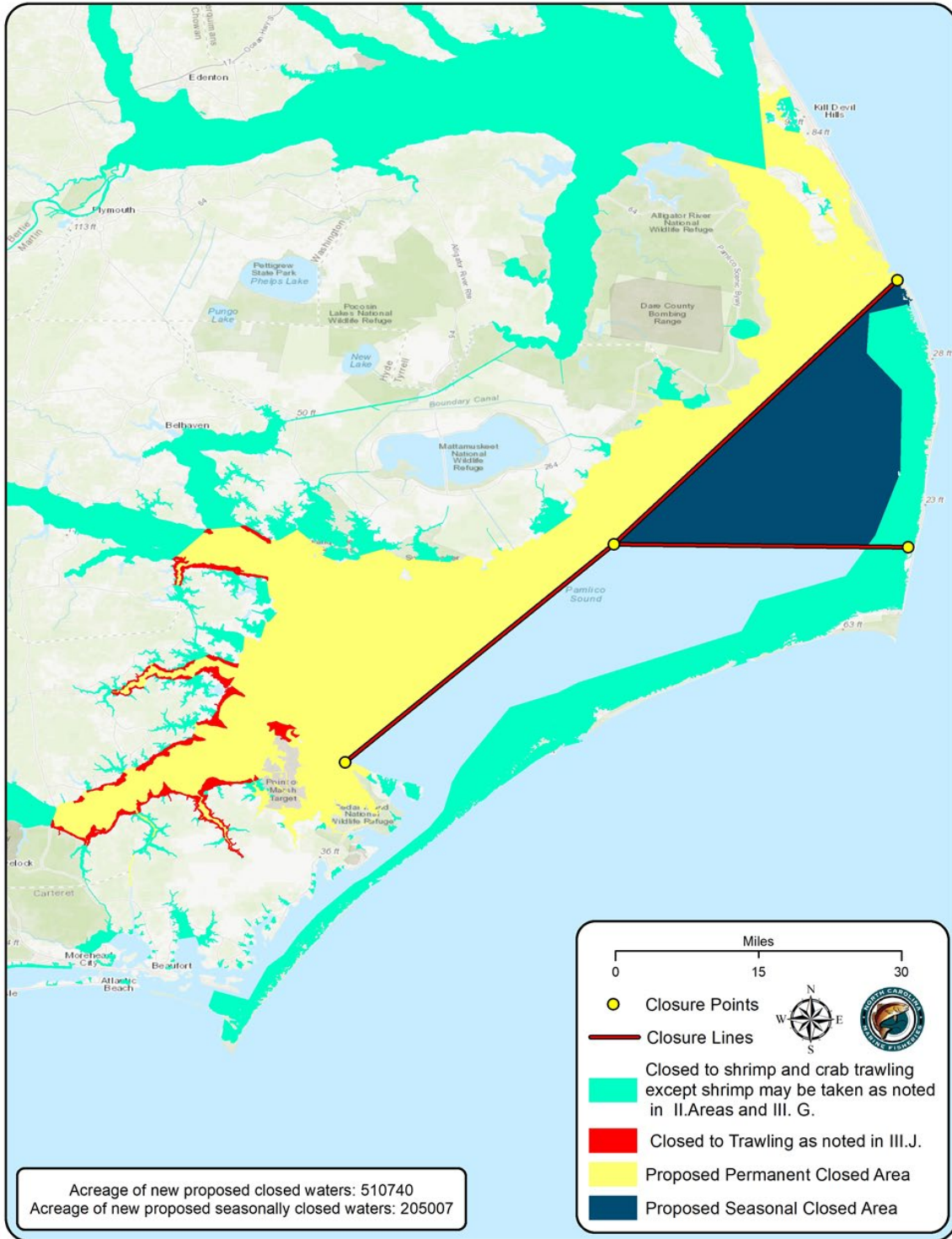


Figure 2.3.17. Example of Pamlico Sound area closure. No shrimp trawling would be permitted in internal coastal waters north and west of the larger red line (permanent closure). No shrimp trawling would be permitted north of the smaller red line from August 1 through November 30.

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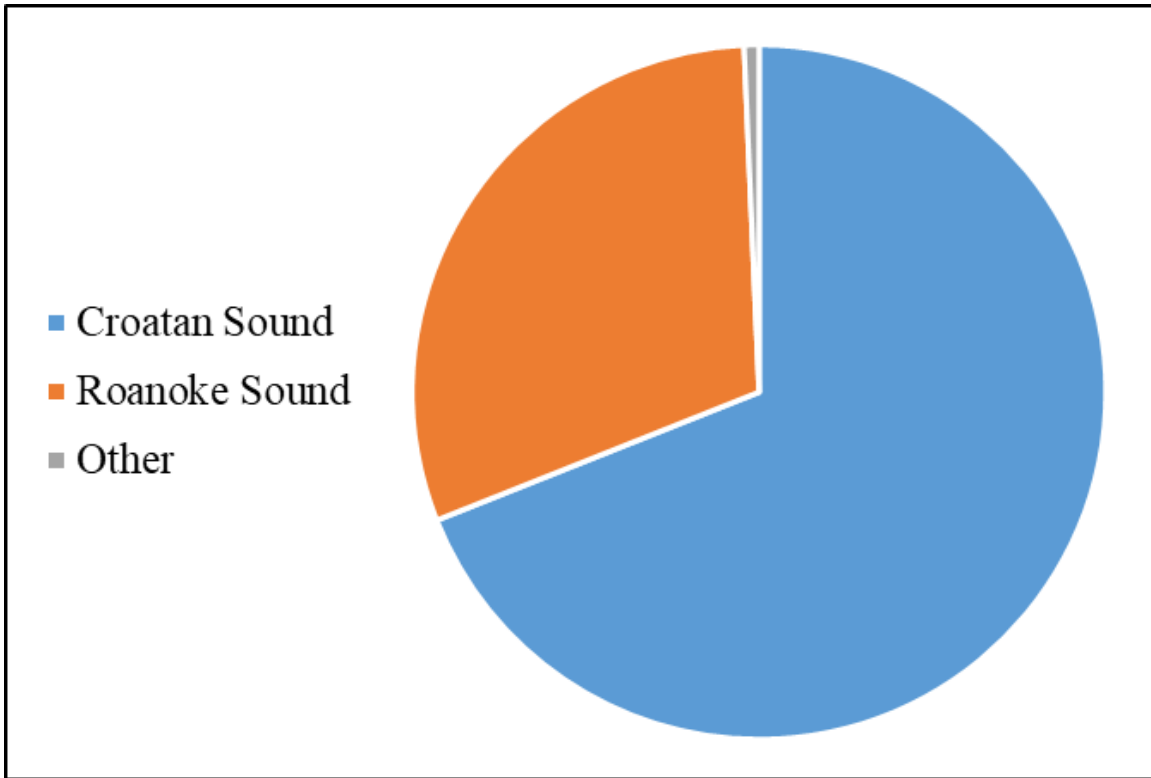


Figure 2.3.18. Percent of value by waterbody in the Northern Region (Croatan Sound, Roanoke Sound, other waterbodies). Other waterbodies include all waters north of Croatan and Roanoke sounds.

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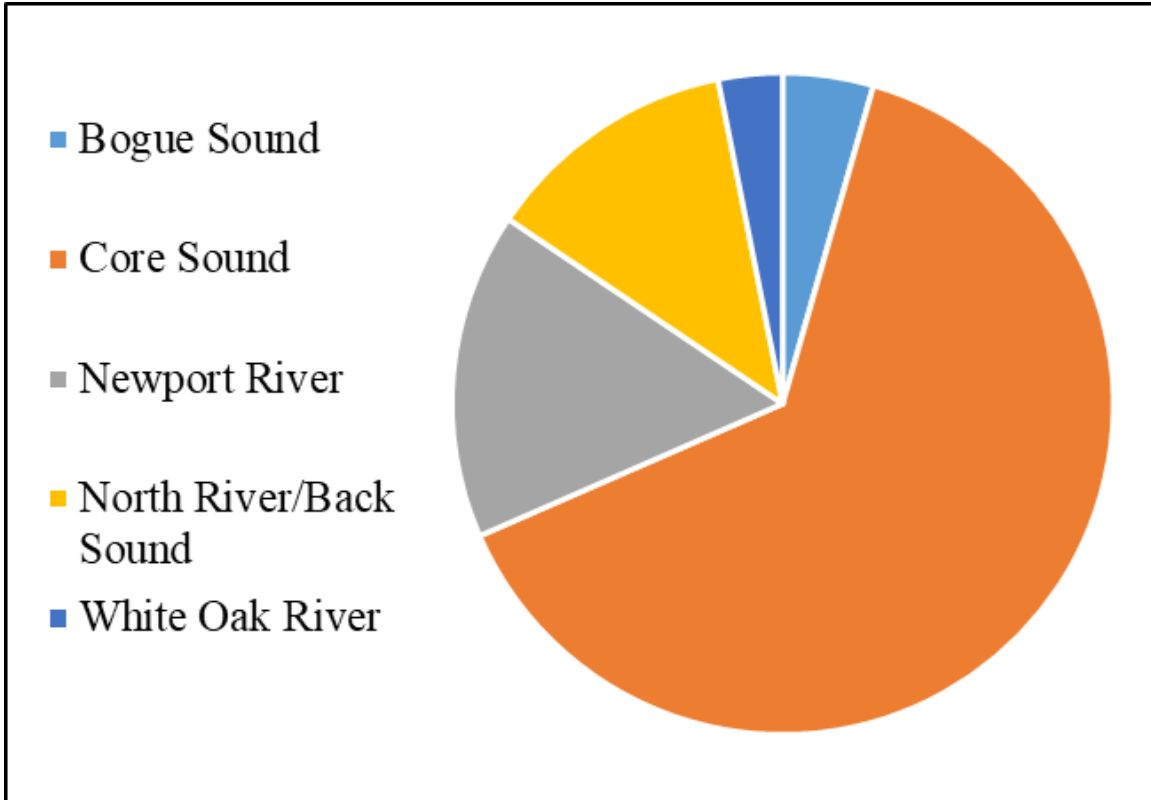


Figure 2.3.19. Percent of value by waterbody in the Central Region (Bogue Sound, Core Sound, Newport River, North River, White Oak River).

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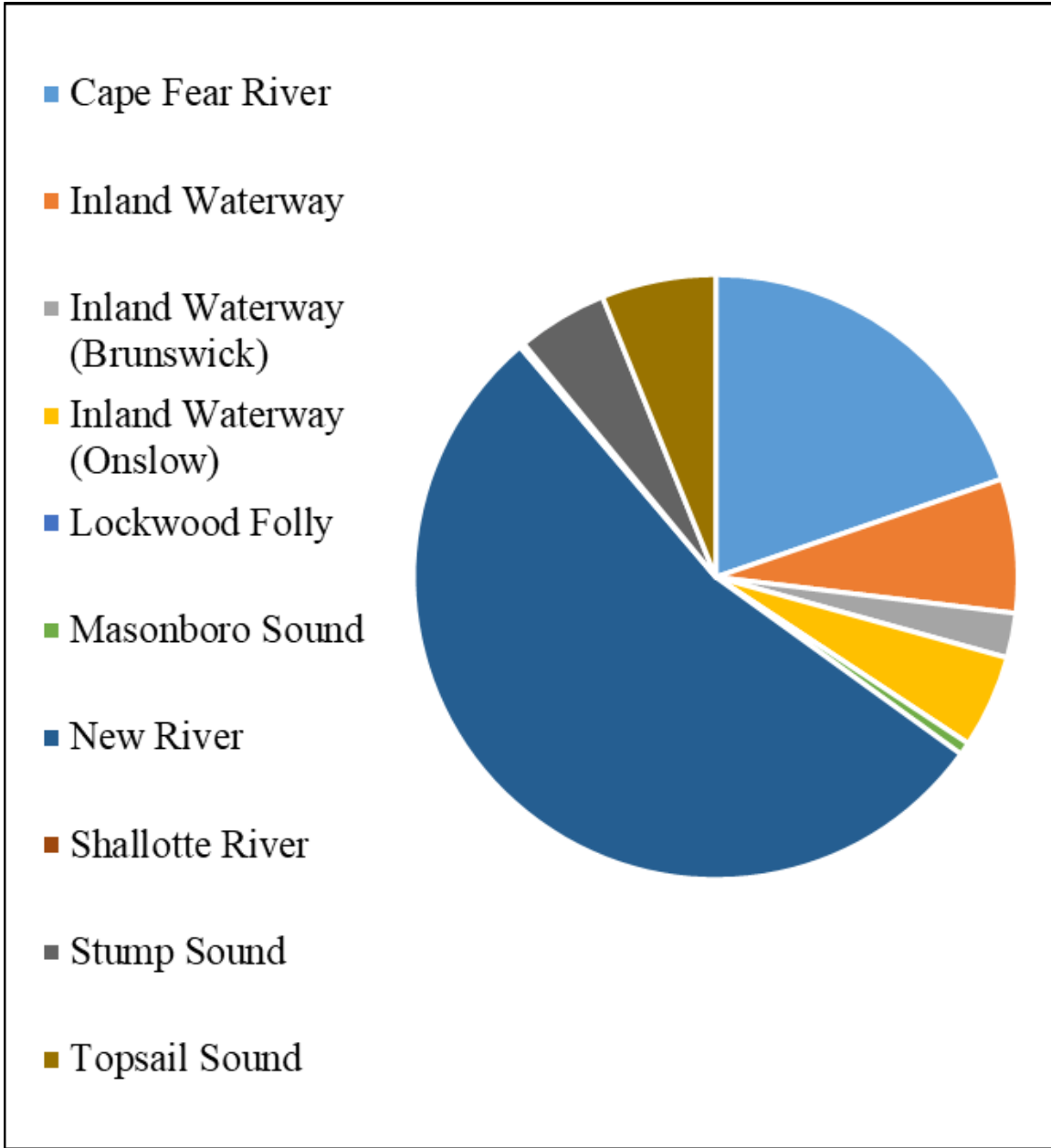


Figure 2.3.20. Percent of value by waterbody in the Southern Region (Cape Fear River, Inland Waterway, Inland Waterway Brunswick, Inland Waterway Onslow, Lockwood Folly, Masonboro Sound). Waterbody code for Inland Waterway was split in 2002 but was still periodically recorded on old Trip Tickets through 2007.

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APPENDIX 2.3.A. HOT SPOT ANALYSIS

Objective

The objective of this paper is to determine “hot spots” of abundance in the Pamlico Sound, North Carolina for shrimp and economically important species that are common as bycatch in the Pamlico Sound shrimp trawl fishery using fishery independent data collected from the Pamlico Sound Survey (Program 195).

Pamlico Sound Survey

The primary objective of the Pamlico Sound Survey is to produce fishery independent indices of abundance for important recreational and commercial fish species in Pamlico Sound, and the lower Neuse, Pamlico, and Pungo rivers (Figure 2.3.A.1). The survey is considered a stratified random design with strata designated by geographic location and water depth. Stations (one-minute by one-minute grid system equivalent to one square nautical mile) are randomly selected, with 54 stations sampled in June and 54 sampled in September (108 annually).

Tow duration is 20 minutes at 2.5 knots using the R/V Carolina Coast pulling double rigged 30 ft (9.14 m) mongoose-type Falcon trawls (manufactured by Beaufort Marine Supply; Beaufort, SC) without TEDs. The R/V Carolina Coast is a 44-ft fiberglass hulled double rigged trawler owned and operated by the North Carolina Division of Marine Fisheries (NCDMF). The body of the trawl is constructed of #30 twine with 1.5 in (38.1 mm) stretch mesh. The tailbag is 80 meshes around and 80 meshes long (approximately 10 ft). A 120 ft (36.58 m) three lead bridle is attached to each of a pair of wooden, chain doors that measure 4 ft by 2 ft (1.22 m X 0.061 m) and to a tongue centered on the headrope. A 60 cm “polyball” is attached between the end of the tongue and the tongue bridle cable. A 0.1875 in (4.76 mm) tickler chain, that is 3.0 ft (0.9 m) shorter than the 34 ft (10.36 m) footrope, is connected to the door next to the footrope.

Time Series

Sampling has occurred during the middle two weeks of June and September since 1987, with some exceptions when sampling was extended into July or October because of boat maintenance or bad weather. The time series for this analysis is 1987 to 2019 with June (summer) and September (fall) analyzed separately to capture seasonal variation in “hot spot” locations. Years were combined into three-year groupings (i.e., 1987-1989, 1990-1992, etc.) to create a more spatially robust selection of sampled stations (n=162 in a year grouping for each month) while maintaining the ability to identify potential temporal variation in “hot spot” locations.

Spatial Range

The sample area covers all of Pamlico Sound and its bays, Croatan Sound up to the Highway 64 Bridge, the Pamlico River up to Blounts Bay, the Pungo River up to Smith Creek, and the Neuse River up to Upper Broad Creek (Figure 2.3.A.1). Stations sampled are randomly selected from strata based on depth and geographic location. The seven designated strata are the Neuse River (NR), Pamlico River (PR), Pungo River (PUR), shallow and deep Pamlico Sound east of Bluff

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Shoal (PSE and PDE) and shallow and deep Pamlico Sound west of Bluff Shoal (PSW and PDW). For this analysis, only stations in the Pamlico Sound strata (PSE, PDE, PSW, PDW) were considered. This was done based on the analysis objective to identify “hot spots” of abundance in Pamlico Sound to explore potential management actions in the form of areas closed to trawling and including river strata in the analysis could bias the location of these areas and most of the rivers are currently closed to bottom trawl gear.

Target Species / Assemblages

“Hot spots” of abundance for brown shrimp (*Farfantepenaeus aztecus*), white shrimp (*Litopenaeus setiferus*), and pink shrimp (*F. duorarum*) were identified. In addition, “hot spots” of abundance for economically important finfish species that are common as bycatch in the Pamlico Sound shrimp trawl fishery were identified. Species analyzed included brown shrimp, white shrimp, pink shrimp, Atlantic croaker (*Micropogonias undulatus*), spot (*Leiostomus xanthurus*), southern flounder (*Paralichthys lethostigma*), summer flounder (*P. dentatus*), and weakfish (*Cynoscion regalis*). Analysis was performed on each species individually because of variable spatial and temporal habitat use.

Data Processing

To examine spatial and temporal clustering of fish abundance, analysis was performed by the Optimized Outlier Analysis (OOA) and Incremental Spatial Autocorrelation (ISA) tools using ArcGIS Pro 2.5.0 (ESRI) software. The OOA tool creates a map of statistically significant hot spots, cold spots, and spatial outliers using the Anselin Local Moran's I statistic. Moran's I evaluates the overall pattern and trend of the data to determine if it is clustered, random, or dispersed (Moran 1948). In this analysis, fish and shrimp abundances from each sampling site are compared with abundances at all other sampling sites creating an index by using the Anselin Local Moran's I statistic of spatial association:

$$I_i = \frac{x_i - \bar{X}}{S_i^2} \sum_{j=1, j \neq i}^n w_{i,j} (x_j - \bar{X}) \quad (1)$$

where x_i is an attribute for feature i , \bar{X} is the mean of the corresponding attribute, $w_{i,j}$ is the spatial weight between feature i and j , and:

$$S_i^2 = \frac{\sum_{j=1, j \neq i}^n (x_j - \bar{X})^2}{n - 1} \quad (2)$$

with n equating to the total number of features.

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The z_{I_i} -score for the statistics are computed as:

$$z_{I_i} = \frac{I_i - E[I_i]}{\sqrt{V[I_i]}} \quad (3)$$

where:

$$E[I_i] = \frac{\sum_{j=1, j \neq i}^n w_{ij}}{n - 1} \quad (4)$$

$$V[I_i] = E[I_i^2] - E[I_i]^2 \quad (5)$$

A positive value for I indicates that a site has neighboring sites with similarly high or low abundances; these sites will be labeled either a high or low value cluster. A negative value for I indicates that a site has a neighboring site with dissimilar values; this site is labeled an outlier. The local Moran's I is a relative measure and can only be interpreted within the context of its computed z-score or p-value. When the p-value for the site is $p < 0.05$, the cluster or outlier to be considered statistically significant.

Local statistics are calculated on the basis of a defined distance threshold or neighborhood and the results for locations containing similar neighbors are likely to be correlated (Anselin 1995; Getis and Ord 1996). For this analysis, the Incremental Spatial Autocorrelation tool was used to compute Moran's I statistics, z-scores and p-values (Table 2.3.A.1) Each of the eight finfish and three shrimp species in this analysis exhibit different spatial and temporal differences between spring and fall. Therefore, it was necessary to find an appropriate distance threshold where spatial autocorrelation is maximized for each species (Table 2.3.A.2; ESRI Events 2017).

Though the OOA tool will determine the distance band, the ISA tool was used to confirm the appropriate distance thresholds used in this analysis. The ISA tool measures spatial autocorrelation for a series of distances and optionally creates a line graph of those distances and their corresponding z-scores. ISA compares the abundance values at one site with the values at all other sites creating an index by using the following equation:

$$I = \frac{n \sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\left(\sum_{i=1}^n \sum_{j=1}^n w_{ij} \right) \left(\sum (x_i - \bar{x})^2 \right)}$$

Where:

n = the total number of sites

\bar{x} = the global mean value

x_i = the abundance value at a particular site

x_j = the abundance value at another site

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w_{ij} = the weight applied to the comparison between site i and site j ,
which is the inverse distance between the two sites ($1/d_{ij}$).

The statistical significance for Moran's I can be calculated using z-score methods. Based on the expected values ($E[I]$) for a random pattern and the variances ($VAR[I]$), the standardized z-score can be mathematically represented as follows:

$$Z = \frac{I - E(I)}{\sqrt{VAR(I)}}$$

The z-scores reflect the intensity of spatial clustering, and statistically significant z-score peaks indicate the distances where clustering is most pronounced (Figure 2.3.A.2). These peak distances are the most appropriate values to use for the distance band parameter in the various clustering and hot spot analysis tools in ArcGIS. When more than one statistically significant peak is present, the appropriate distance is often the first statistically significant peak encountered.

For this analysis, the OOA tool was run with each distance where a peak z-score occurred. The output for each distance threshold was examined for the number of significant clusters, number of locational outliers, and percent of sites with less than eight neighbors (Table 2.3.A.3). Cluster and hot spot analyses have three caveats in determining the appropriate distance threshold: all features should have at least one neighbor, no feature should have all other features as neighbors, and the most appropriate distance will allow a feature to have at least eight neighbors (ESRI 2017, 2021).

The OOA tool creates a map showing statistically significant clusters or outliers with 95% confidence level. Sites with high abundance values surrounded by other sites with high abundance values are labeled as high-high (HH) clusters; sites with low abundance values surrounded by other sites with low abundance values are labeled low-low (LL) clusters. Outlier sites, in which a site with a high abundance value is surrounded primarily by sites with low abundance values, are labeled as a high-low (HL) outlier; or a low abundance value primarily surrounded by sites with high abundance values are labeled a low-high (LH) outlier (Figure 2.3.A.3).

Results and Discussion

This analysis used Cluster and Outlier Analysis to identify high abundance clusters or, hot spots, for five species of finfish and three species and examines temporal and spatial differences in distribution. The OOA tool calculates a z-score to indicate the intensity of clustering at a distance where the clustering is most pronounced. All species analyzed seemed to have hot spots located near the west side of the Pamlico Sound and at the mouths of the Pamlico and Neuse Rivers. However, each of the eight finfish and shrimp species exhibited different distributions of hot spots and showed temporal differences between spring and fall. Atlantic croaker and spot are the two most abundant species captured in the Pamlico Sound Survey (Paris et al. 2020a, 2020b) and the resulting hot spots for both species were the most widely distributed of the five finfish species (Figures 2.3.6 and 2.3.7). The resulting z-scores and distance thresholds indicated similar clustering between the two species. Atlantic croaker had the greatest number of hot spots in

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September, $n = 115$; 26%, and third highest in June, $n = 75$; 14%, while spot had the least number of hot spots in June, $n = 51$; 9% and second least in September $n = 75$; 17% (Table 2.3.A.4). The distance threshold for both species in September was 25,600 m and z – scores were similar, Atlantic croaker $z = 12.29$ and spot, $z = 10.29$. In June, the distance threshold for Atlantic croaker was larger and had a greater z -score, 30,400 m and $z = 9.53$, compared to spot, 25,600 m, $z = 4.88$ (Table 2.3.A.5). Clustering for Atlantic croaker was stronger in the northern portion of the sound extending into the Croatan Sound during September, compared to June where hot spots occurred along the southwest portion of the sound. Spot hot spots in June were less concentrated at the mouth of the rivers, extending further east compared to Atlantic croaker and had much less clustering in the north.

Southern flounder showed strong clustering in the southern portion of the sound at the mouths of the Pamlico and Neuse Rivers in both June and September (Figure 2.3.7). More hot spots were identified in June, ($n = 97$; 18%) compared to September ($n = 49$; 11%). Hot spots in September were clustered at the mouth of the Pamlico River, compared to June where hot spots were centered at the mouth of the Pamlico and Neuse rivers extending east towards the center of the sound. The more concentrated clustering in September can also be identified by the lower distance threshold, 14,400 m compared to a distance threshold of 38,400 m in June.

Summer flounder and weakfish had the least temporal differences in hot spot distribution. The hot spots for summer flounder were all located in the northern Pamlico Sound and Croatan Sound in both June and September (Figure 2.3.9), though more hot spots were identified in September. Weakfish hot spots in September are more concentrated in the center of Pamlico Sound compared to June (Figure 2.3.10). The distance threshold for weakfish for both seasons was 25,600 m and with nearly identical z -scores for both seasons ($z = 12.52$ and $z = 12.53$) indicating similarly intense clustering with the same spatial scope for both seasons. Weakfish had the greatest number of hot spots, ($n = 258$; 47%, $n = 116$; 27%) while summer flounder had the second greatest number of hot spots in September ($n = 80$; 18%), and the fourth highest number in June ($n = 72$; 13%). Summer flounder was shown to have close to no temporal difference in hot spot distribution. The number of hot spots was very similar in both seasons ($n = 72$; 13% and $n = 80$; 18%) and had identical distance threshold and z -scores (25,600 m and $z = 11.62$) indicating the same level of clustering.

All three shrimp species had fewer hot spots in June compared to September. In June, shrimp utilize nearshore habitats before moving out to the ocean in the fall. White shrimp hot spots were more prevalent in September ($n = 45$; 38%) compared to June ($n = 23$; 59%) and hot spots were distributed throughout the center of the sound in June and closer to the shoreline in September (Figure 2.3.11). Though white shrimp hot spots were seemingly separated in two different regions, the clustering was strong in those areas. The white shrimp distance threshold in September was lower and the z -score higher (12,800 m; $z = 18.27$) compared to June (22,400 m; $z = 3.98$). Brown shrimp (Figure 2.3.12) had the fewest hot spots of the shrimp species in September ($n = 9$; 23%) and the second fewest in June ($n = 33$; 28%). Hot spots were located close to shore the norther shore of the sound in June and had a low z -score ($z = 4.30$) indicating low intensity clustering. In September, brown shrimp moved toward the center of the sound with a low z -score, $z = 3.39$. Pink shrimp hot spots were concentrated in the center of the sound in both seasons (Figure 2.3.13). Pink shrimp had the fewest hot spots in June ($n = 7$; 18%) increasing in September ($n = 40$; 34%).

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Clustering in June was not as strong (14,400 m; $z = 6.72$) compared to September (14,400 m; $z = 11.08$).

This analysis contained data from eight separate species with varied life histories and distributions over a 32-year time series. Examining each species individually was necessary to discern species specific temporal and spatial trends. When all species' hot spots were plotted on one map no clear pattern spatial pattern emerges. The map of June hot spot frequency shows distribution of finfish and shrimp throughout the sound (Figure 2.3.14). There is a concentration of high value clusters in the northern part of the sound between Hyde County and Cape Hatteras, likely because of weakfish hot spots in this region. The map of September hot spot frequency shows a distinct temporal shift in distribution from June. Finfish are concentrated at the mouths of the Pamlico and Neuse Rivers and in the northern portion of Pamlico Sound into Croatan Sound. Shrimp hot spots were found in the center of Pamlico Sound, but not in large numbers.

Identifying hot spots for commercially important bycatch species commonly found in the North Carolina shrimp trawl fishery can help managers determine regulations to protect areas that are important for these species. Examining hot spots for shrimp and bycatch species together helps identify area where finfish may not be abundance and shrimp may be abundant, therefore allowing the shrimp trawling in these areas may effectively reduce bycatch while allowing shrimp harvest to occur. This analysis does indicate a strong temporal shift in distribution for some finfish and shrimp species and provides evidence for mangers to propose seasonal regulations to protect important bycatch species.

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Paris, M., D. Zapf, and K. Harding. 2020b. Pamlico Sound Survey September 2019 Cruise Report. North Carolina Department of Environmental Quality, Division of Marine Fisheries. Morehead City, NC. 57 pp.

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Tables

Table 2.3.A.1. Output from the Incremental Spatial Autocorrelation Tool (ISA) from weakfish in June.

Year	Distance (ft)	Moran's I	z-score	p-value
1987_1989	20,800	0.25	12.62	0.00
1990_1992	14,400	0.30	10.23	0.00
1993_1995	33,600	0.14	11.93	0.00
1996_1998	28,800	0.02	2.29	0.00
1999_2001	33,600	0.15	12.52	0.02
2002_2004	17,600	0.15	7.21	0.00
2005_2007	25,600	0.11	7.39	0.00
2008_2010	36,800	0.01	2.26	0.02
2011_2013	24,000	0.17	10.20	0.00
2014_2016	14,400	0.31	11.56	0.00
2017_2019	14,400	0.22	7.63	0.00

Table 2.3.A.2. Distance thresholds and z-scores for the five finfish and three shrimp species used in this analysis.

Species	June		September	
	Distance (m)	z-score	Distance (m)	z-score
Atlantic croaker	30,400	9.53	25,600	12.29
southern flounder	38,400	13.91	14,400	11.06
spot	25,600	4.88	25,600	10.29
summer flounder	25,600	11.62	25,600	11.62
weakfish	33,600	12.52	19,200	12.53
brown shrimp	16,000	4.30	20,800	3.39
pink shrimp	14,400	6.72	14,400	11.08
white shrimp	22,400	3.98	12,800	18.27

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Table 2.3.A.3. Output from Optimized Outlier Analysis tool for identified peak z-scores with ISA, with June weakfish data.

Year	Distance (ft)	Features (N)	Locational outliers	Significant Clusters	High-value Outliers	Low-value Outliers	Low Value Clusters	High Value Clusters	% of Features Have Less Than 8 Neighbors
1993_1995	33,600	114	0	100	4	24	40	32	0
1999_2001	33,600	118	1	106	3	26	40	37	0
2014_2016	14,400	119	2	48	2	14	12	20	8.4

Table 2.3.A.4. Total amount of Hot Spots generated by species.

Species	June		September	
	Total	% of Total	Total	% of Total
Atlantic croaker	75	14	115	26
southern flounder	97	18	49	11
spot	51	9	75	17
summer flounder	72	13	80	18
weakfish	258	47	116	27
Finfish Total	553	100	435	100
brown shrimp	9	23	33	28
pink shrimp	7	18	40	34
white shrimp	23	59	45	38
Shrimp Total	39	100	118	100

Table 2.3.A.5. Distance thresholds and z-scores produced by the Optimized Outlier Analysis tool for each finfish and shrimp species.

Species	June		September	
	Distance (m)	z-score	Distance (m)	z-score
Atlantic croaker	30,400	9.53	25,600	12.29
southern flounder	38,400	13.91	14,400	11.06
spot	25,600	4.88	25,600	10.29
summer flounder	25,600	11.62	25,600	11.62
weakfish	33,600	12.52	19,200	12.53
brown shrimp	16,000	4.30	20,800	3.39
pink shrimp	14,400	6.72	14,400	11.08
white shrimp	22,400	3.98	12,800	18.27

Figures

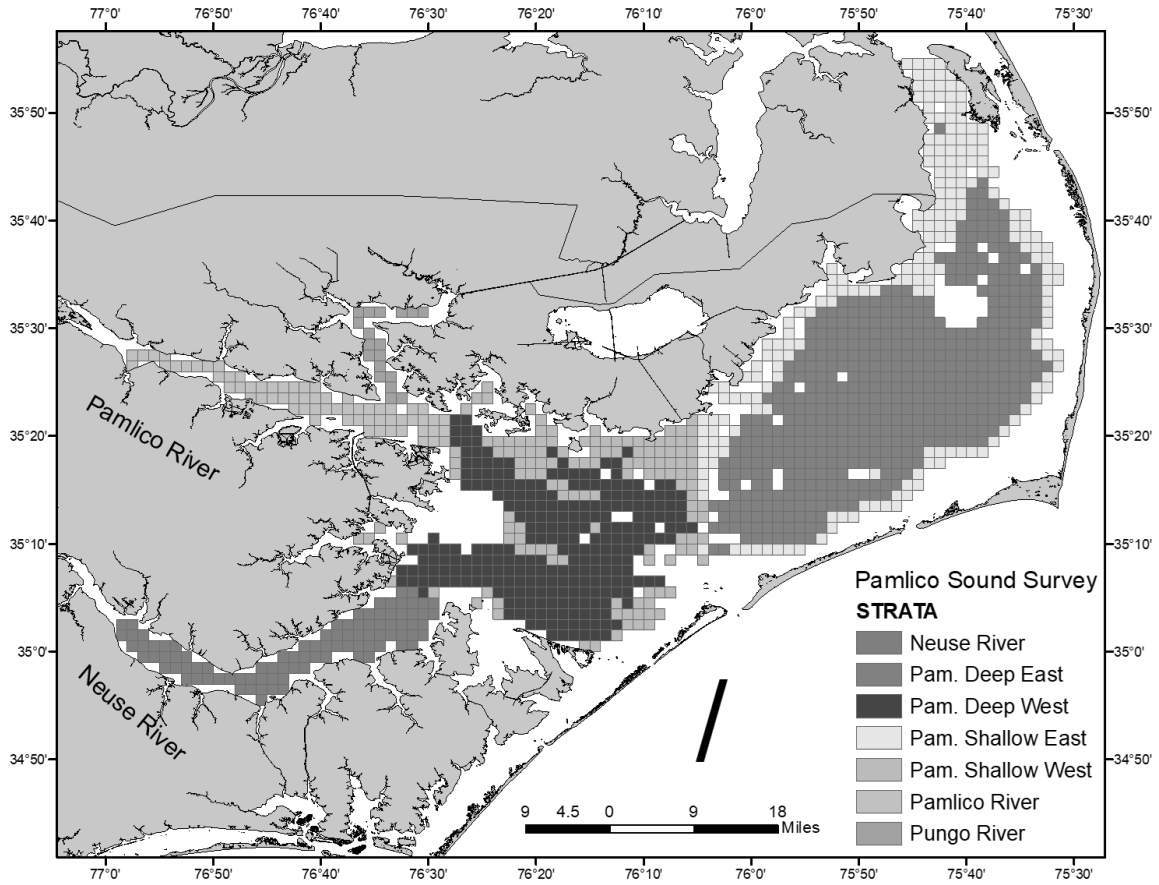


Figure 2.3.A.1. Pamlico Sound Survey sampling grids by strata.

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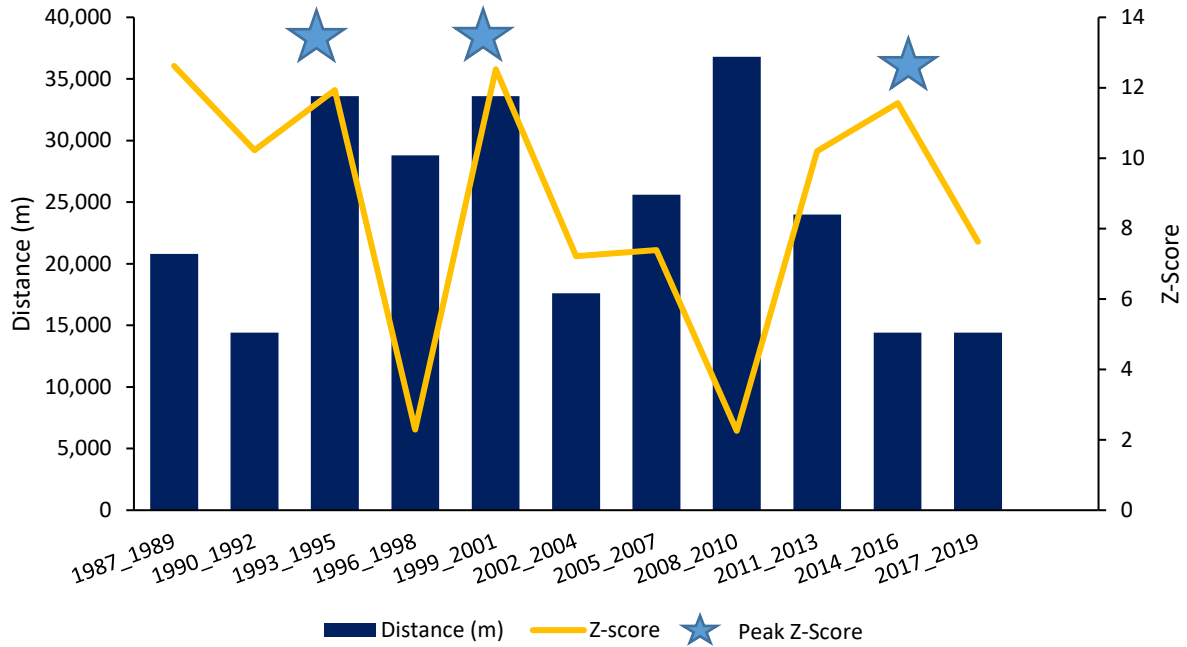


Figure 2.3.A.2. Results from Incremental Spatial Autocorrelation (ISA) tool (ArcGIS) on June weakfish survey data, showing the highest (peak) z-score values using a 33,600 m distance threshold. z-score peaks reflect distances where clustering is most pronounced.

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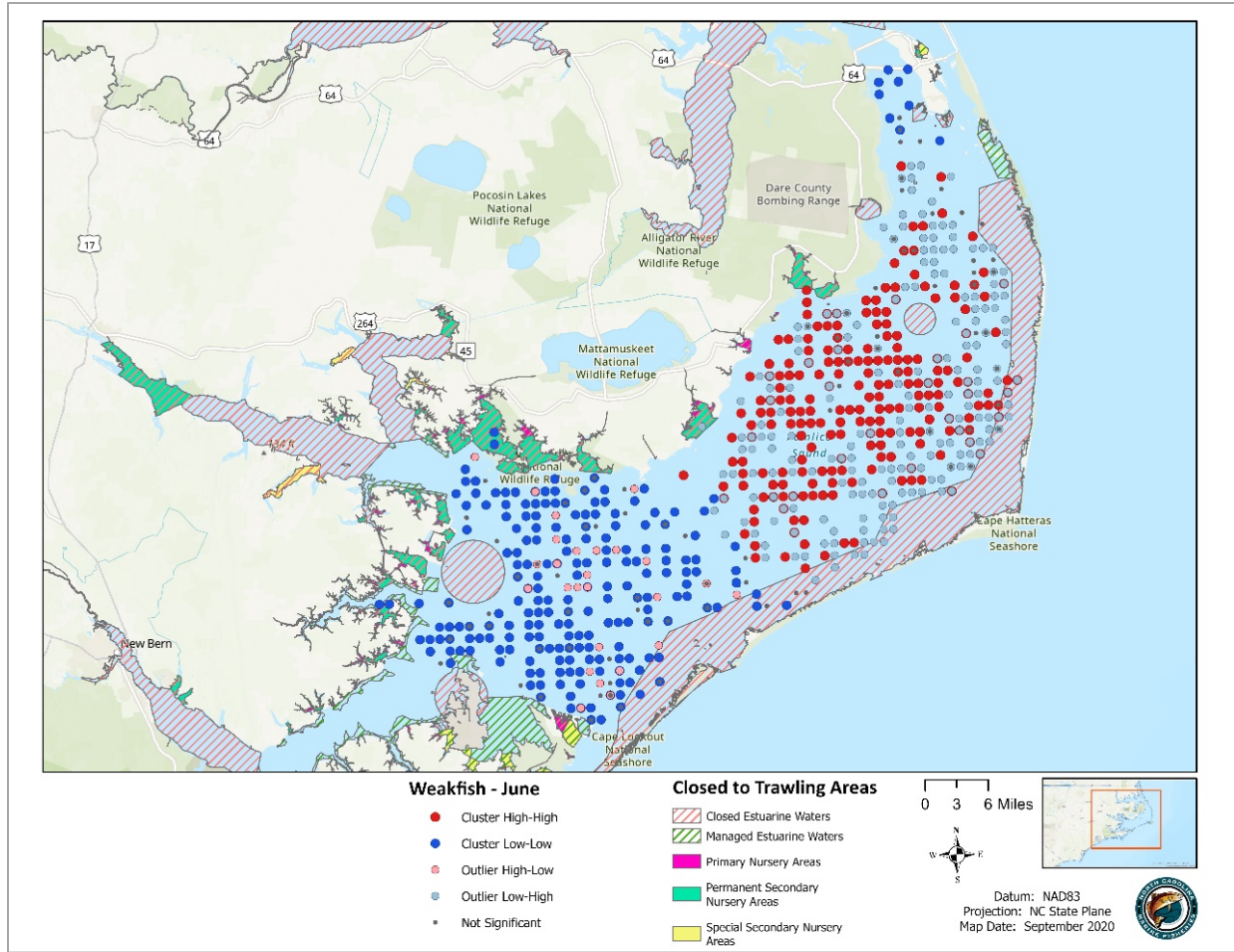
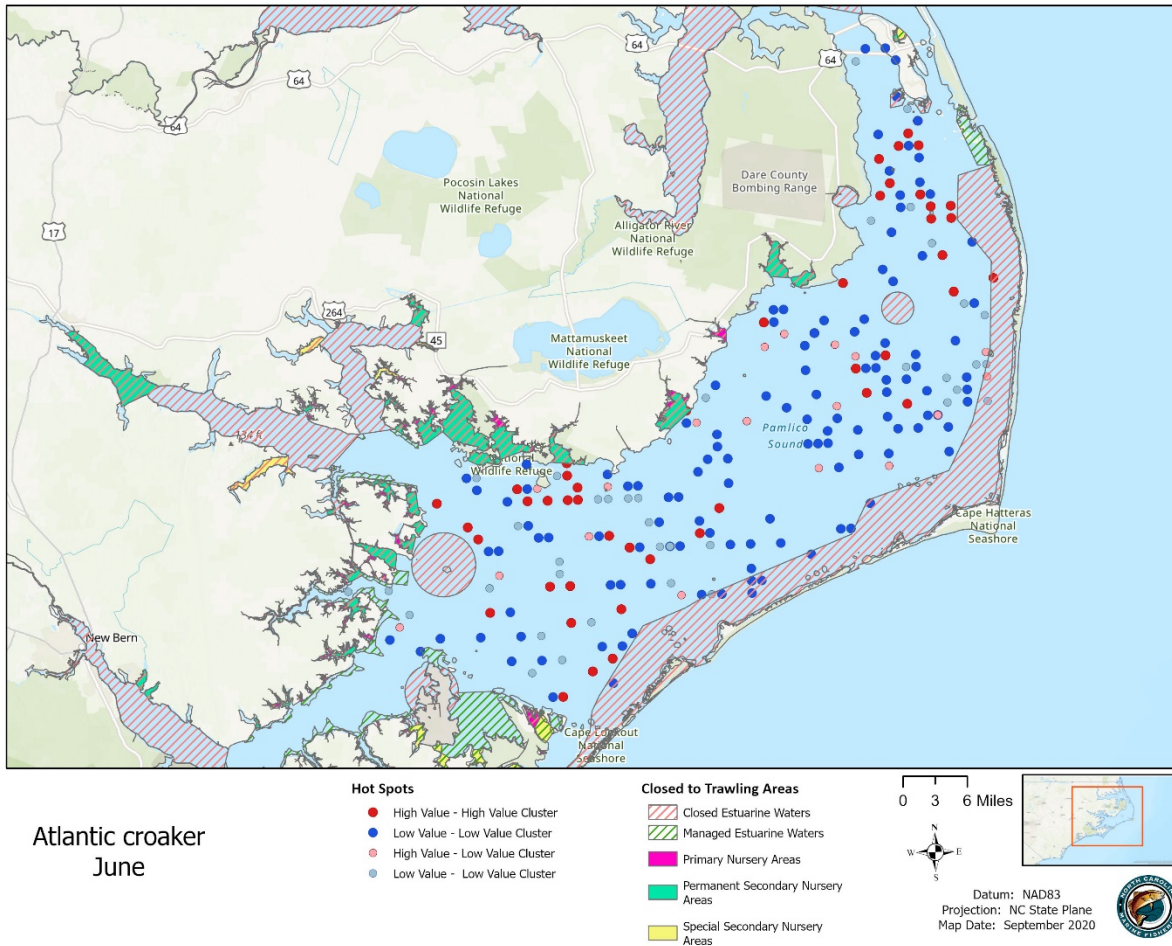


Figure 2.3.A.3. Results of Optimized Outlier Analysis (OOA) tool (ArcGIS) using weakfish data from June, between the years 1987-2019.

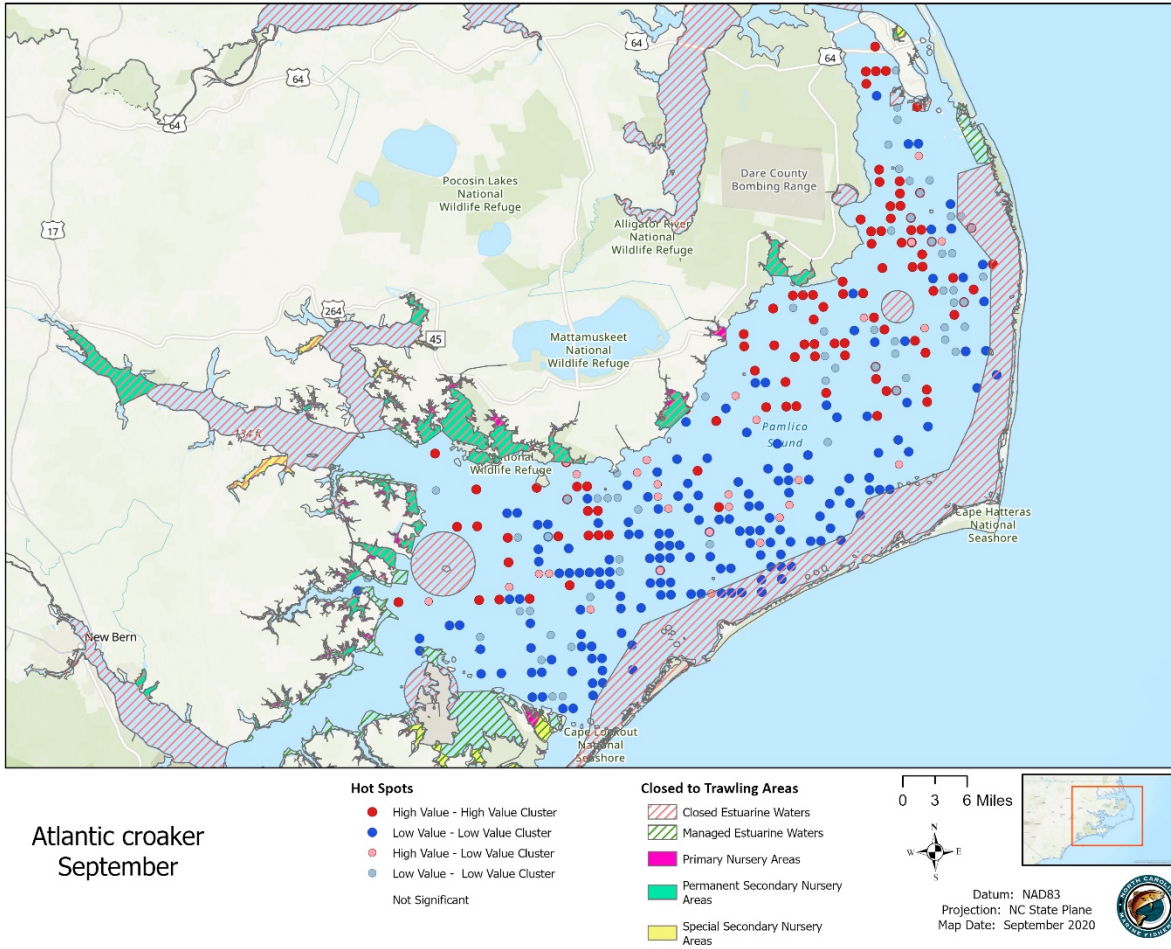
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APPENDIX 2.3.B. MAPS OF HOT SPOTS OF ABUNDANCE IN PAMLICO SOUND



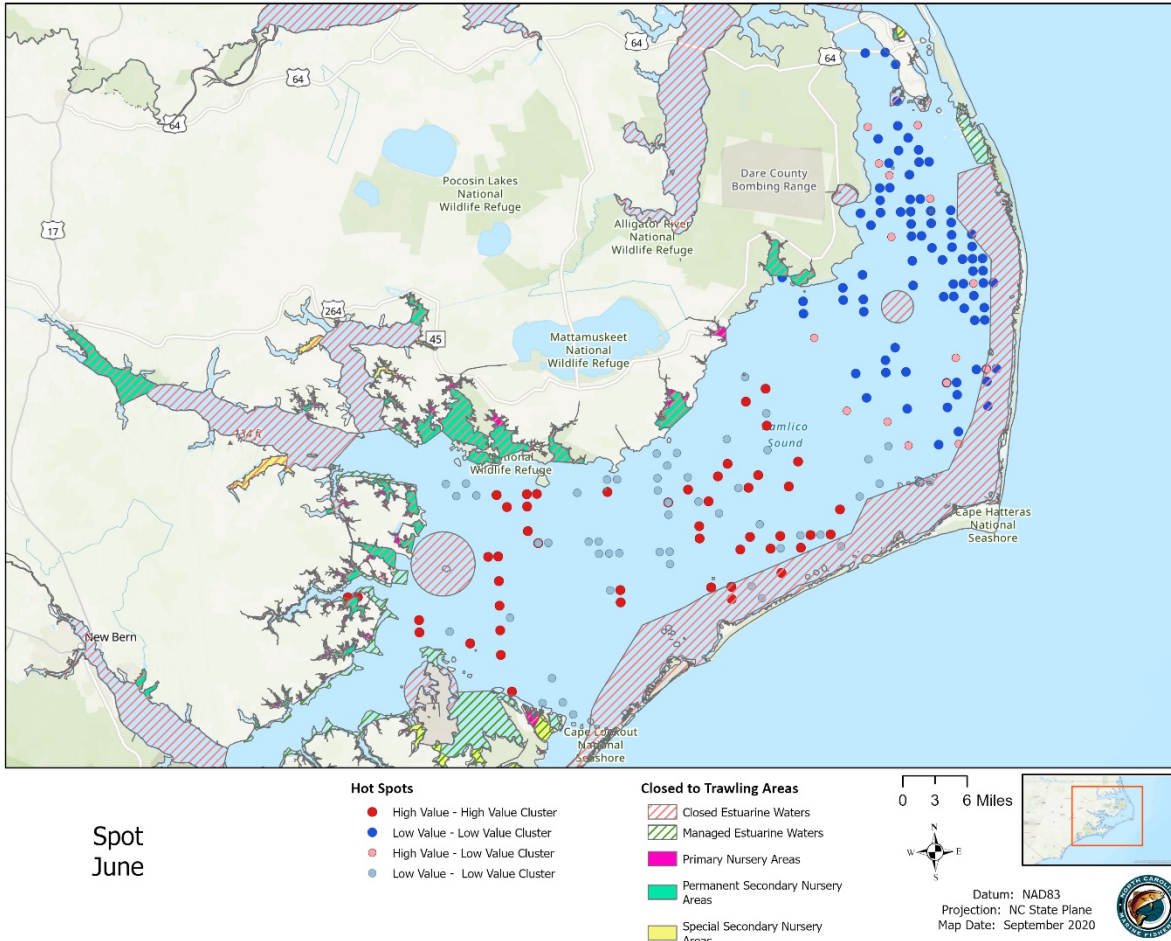
Map 2.3.B.1. Hot spots of abundance for Atlantic croaker in the Pamlico Sound during June using aggregate data from Program 195, 1987-2019.

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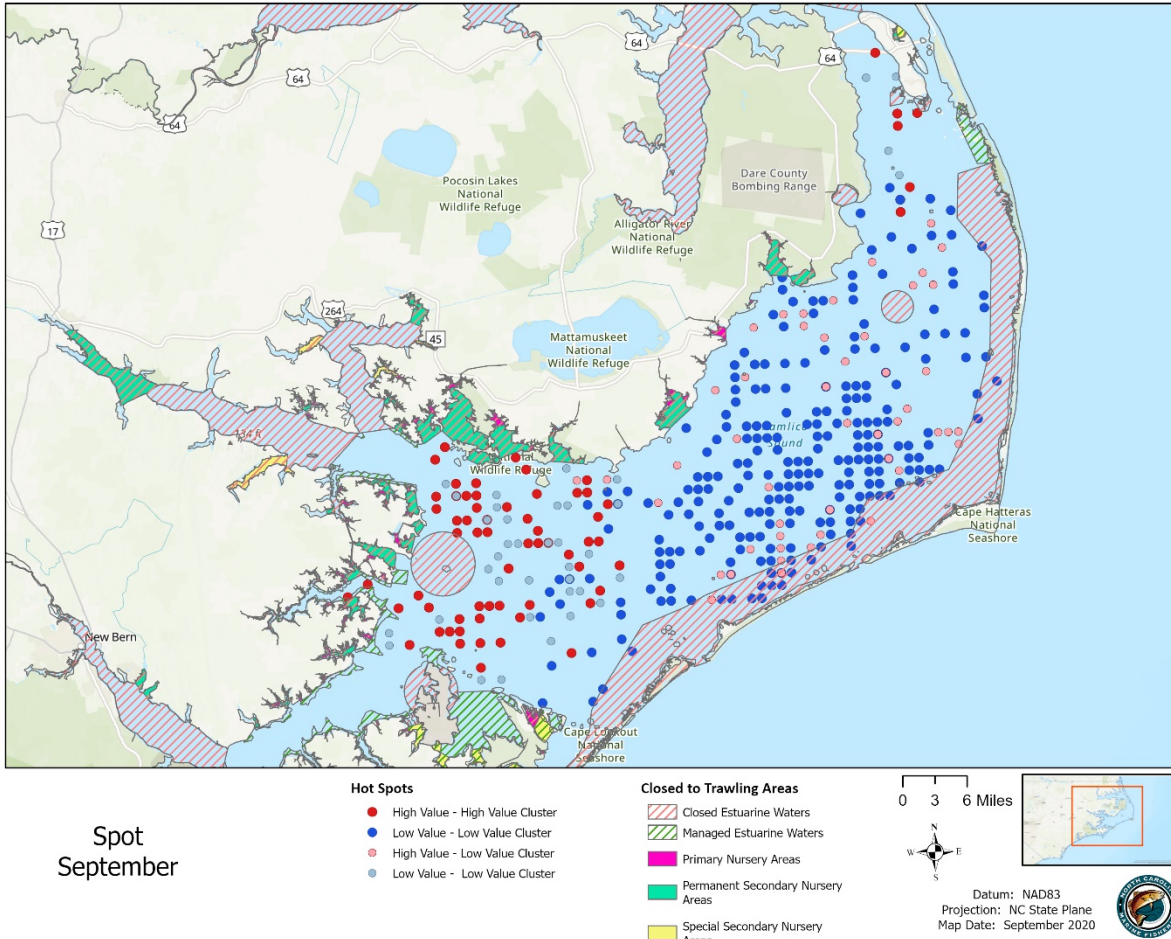
Map 2.3.B.2. Hot spots of abundance for Atlantic croaker in the Pamlico Sound during September using aggregate data from Program 195, 1987-2019.

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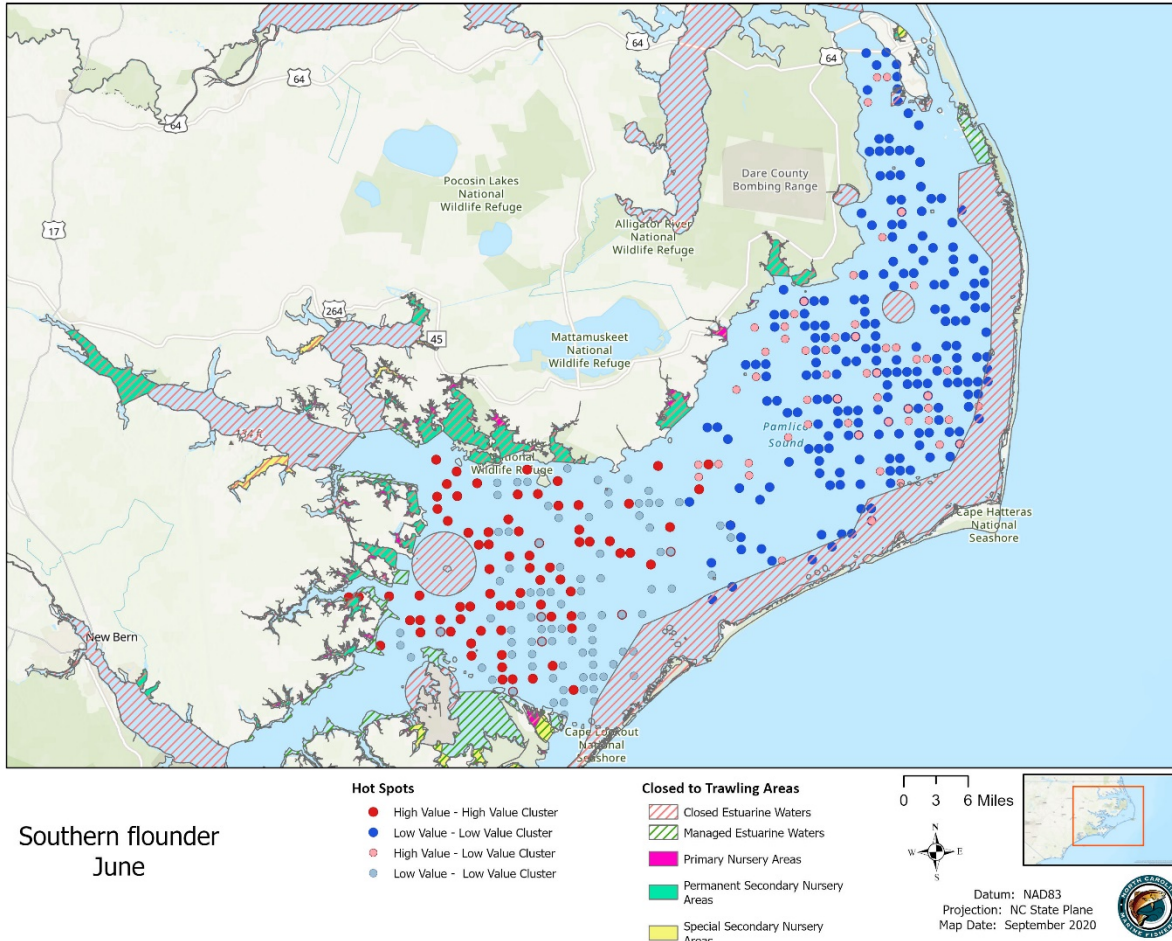
Map 2.3.B.3. Hot spots of abundance for spot in the Pamlico Sound during June using aggregate data from Program 195, 1987-2019.

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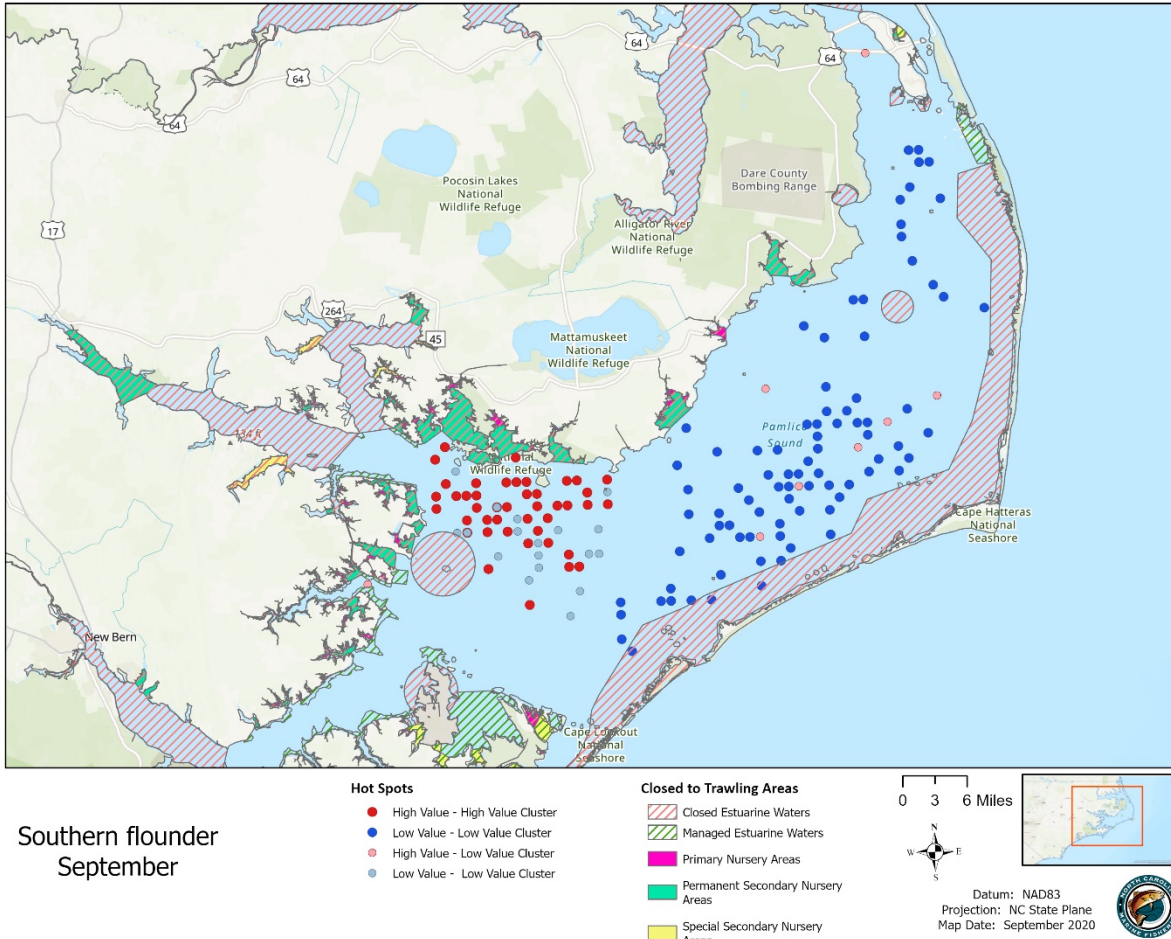
Map 2.3.B.4. Hot spots of abundance for spot in the Pamlico Sound during September using aggregate data from Program 195, 1987-2019.

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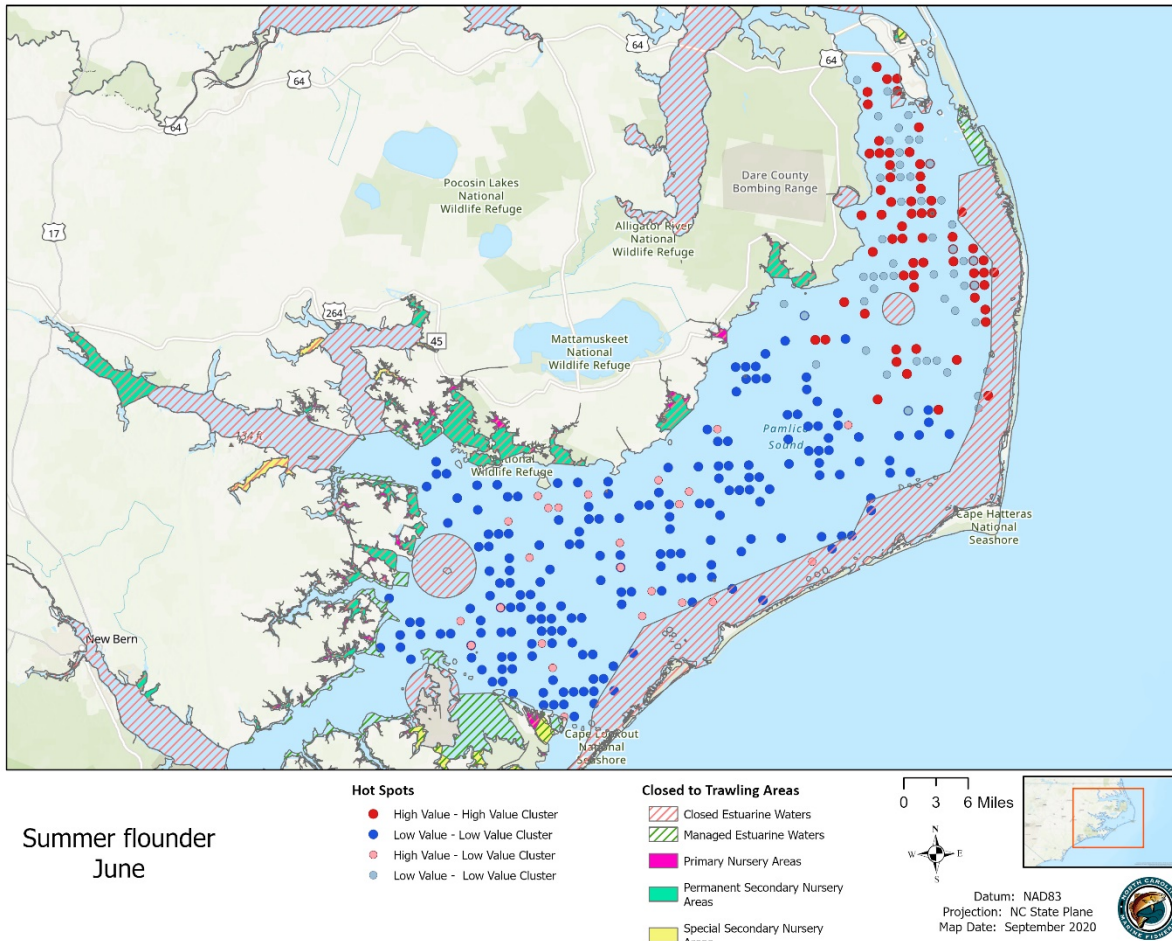
Map 2.3.B.5. Hot spots of abundance for southern flounder in the Pamlico Sound during June using aggregate data from Program 195, 1987-2019.

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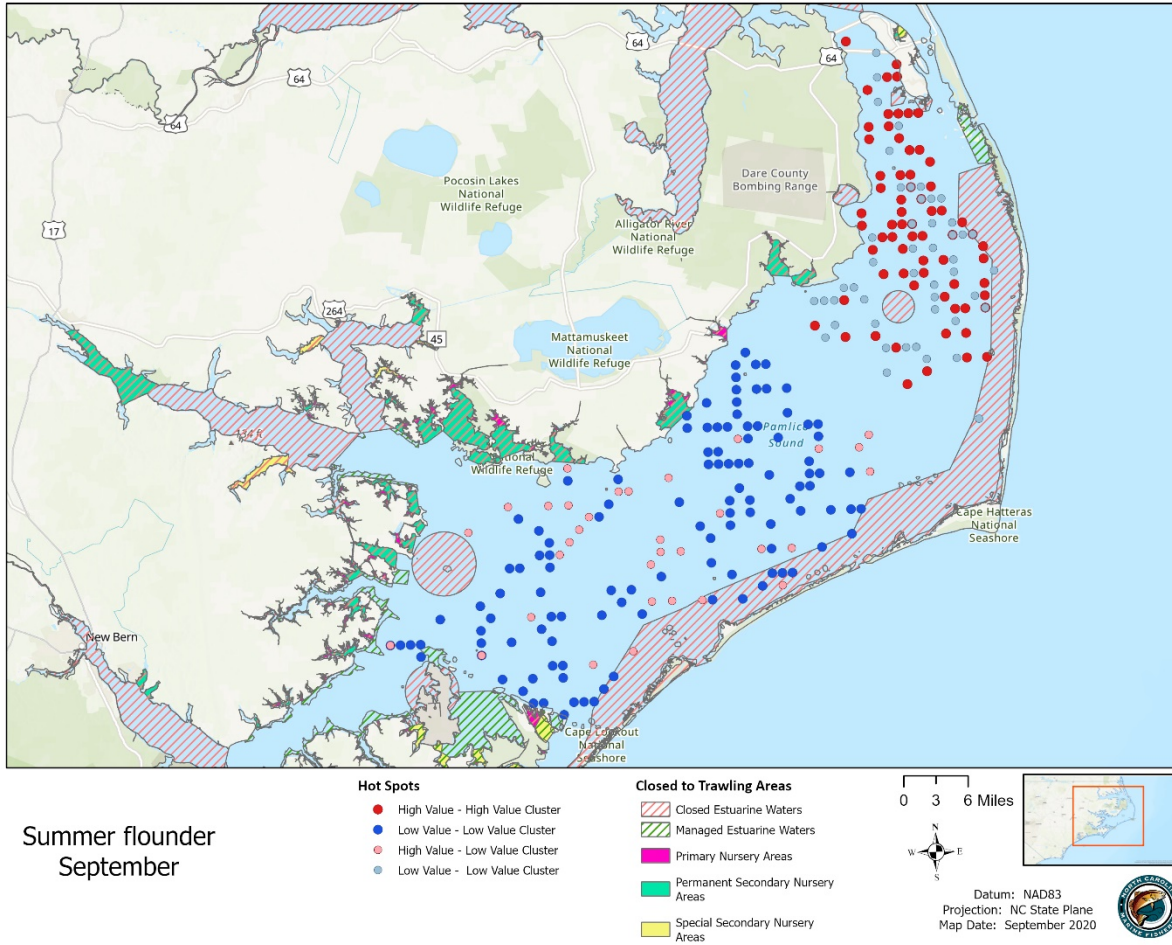
Map 2.3.B.6. Hot spots of abundance for southern flounder in the Pamlico Sound during September using aggregate data from Program 195, 1987-2019.

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Map 2.3.B.7. Hot spots of abundance for summer flounder in the Pamlico Sound during June using aggregate data from Program 195, 1987-2019.

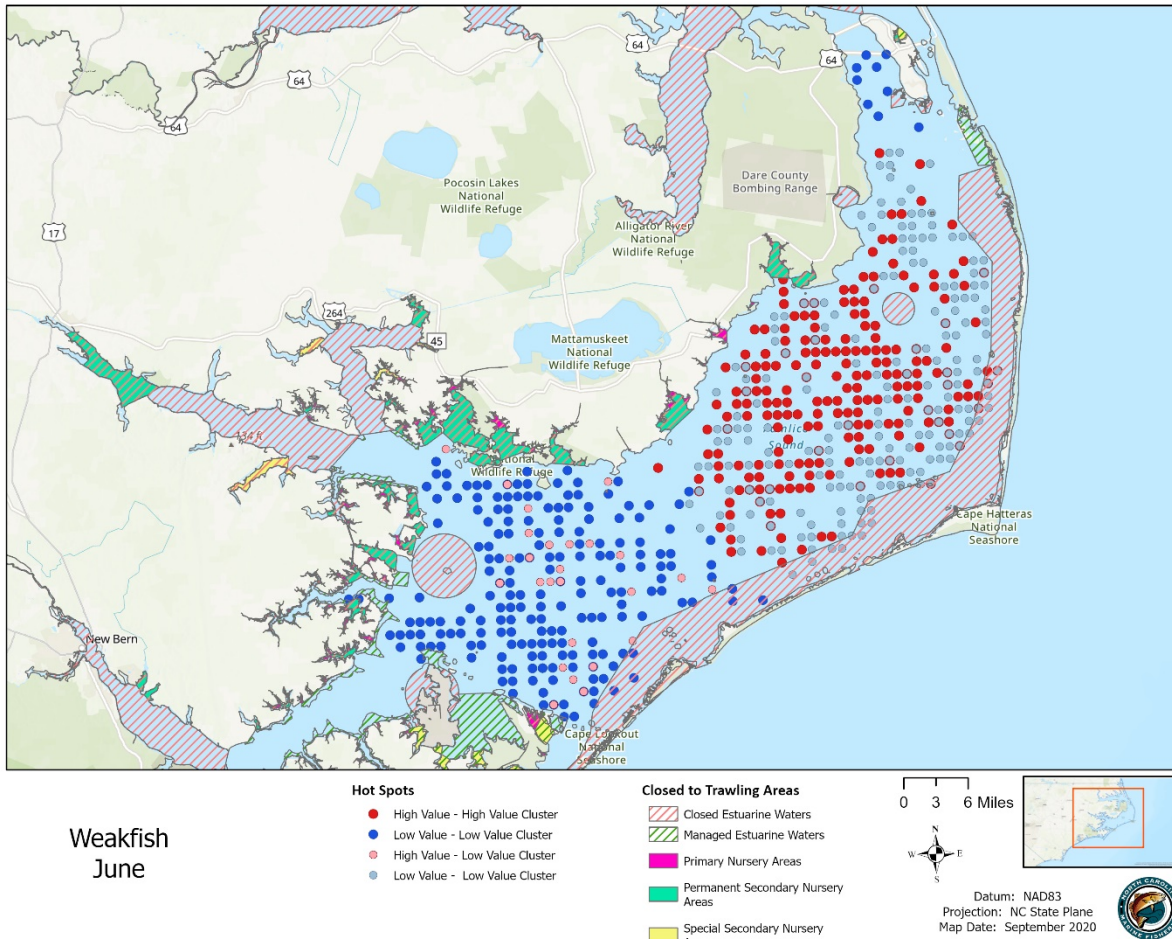
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Summer flounder
September

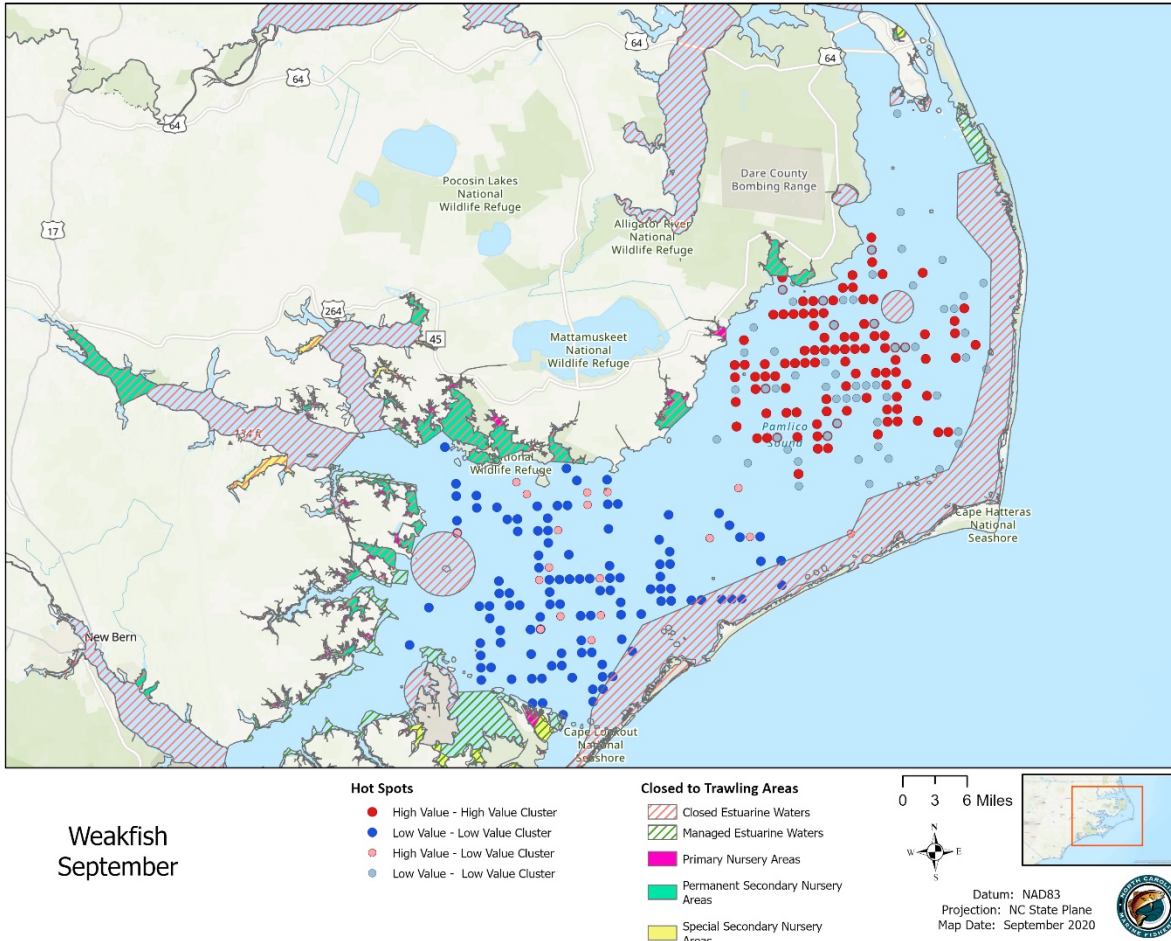
Map 2.3.B.8. Hot spots of abundance for summer flounder in the Pamlico Sound during September using aggregate data from Program 195, 1987-2019.

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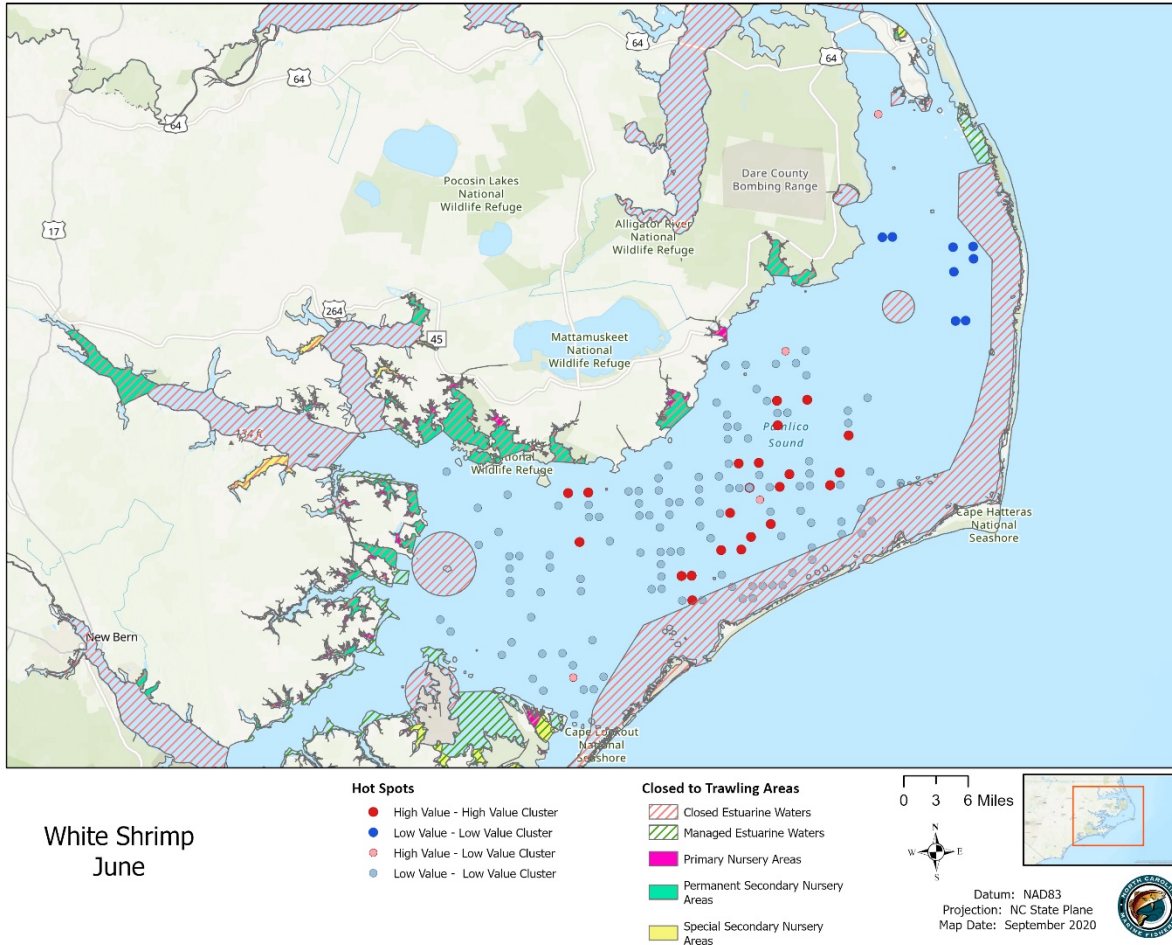
Map 2.3.B.9. Hot spots of abundance for weakfish in the Pamlico Sound during June using aggregate data from Program 195, 1987-2019.

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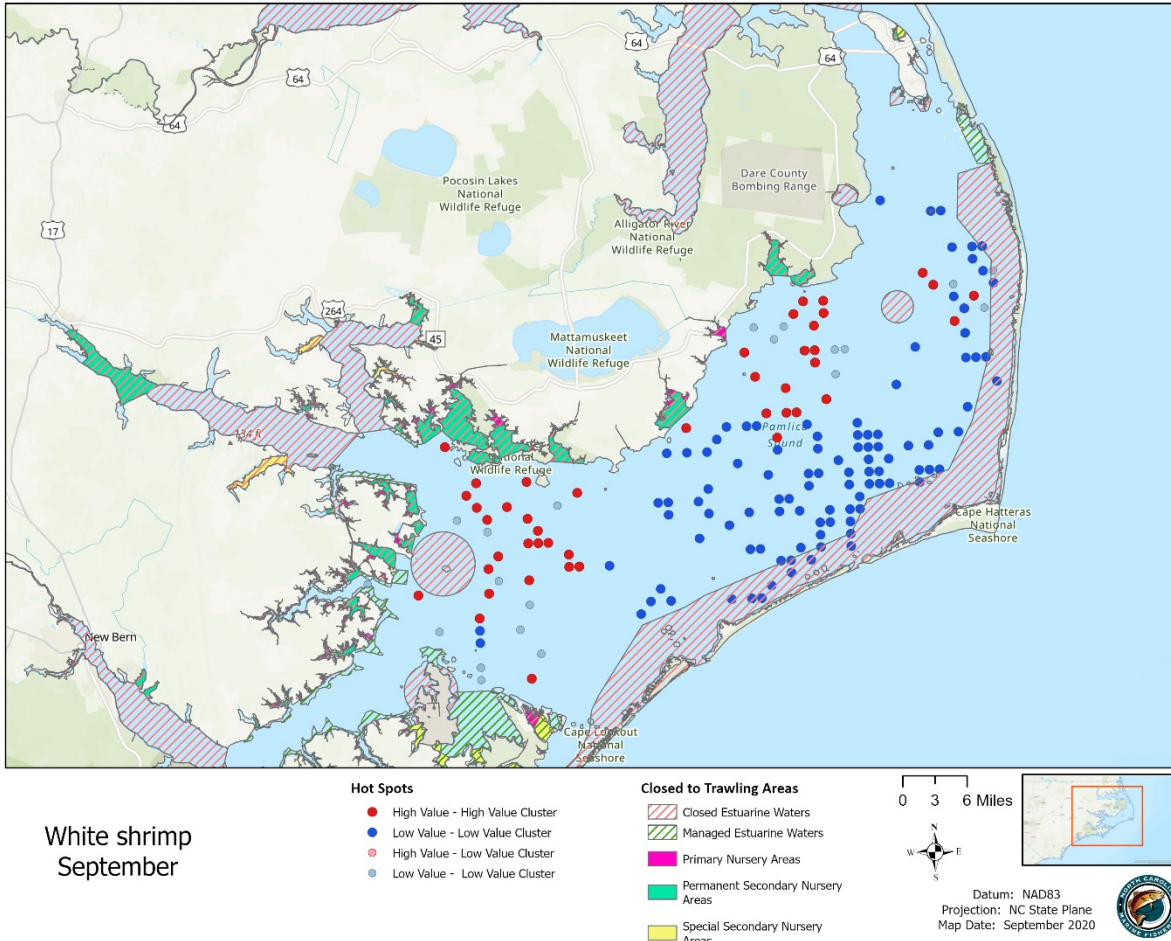
Map 2.3.B.10. Hot spots of abundance for weakfish in the Pamlico Sound during September using aggregate data from Program 195, 1987-2019.

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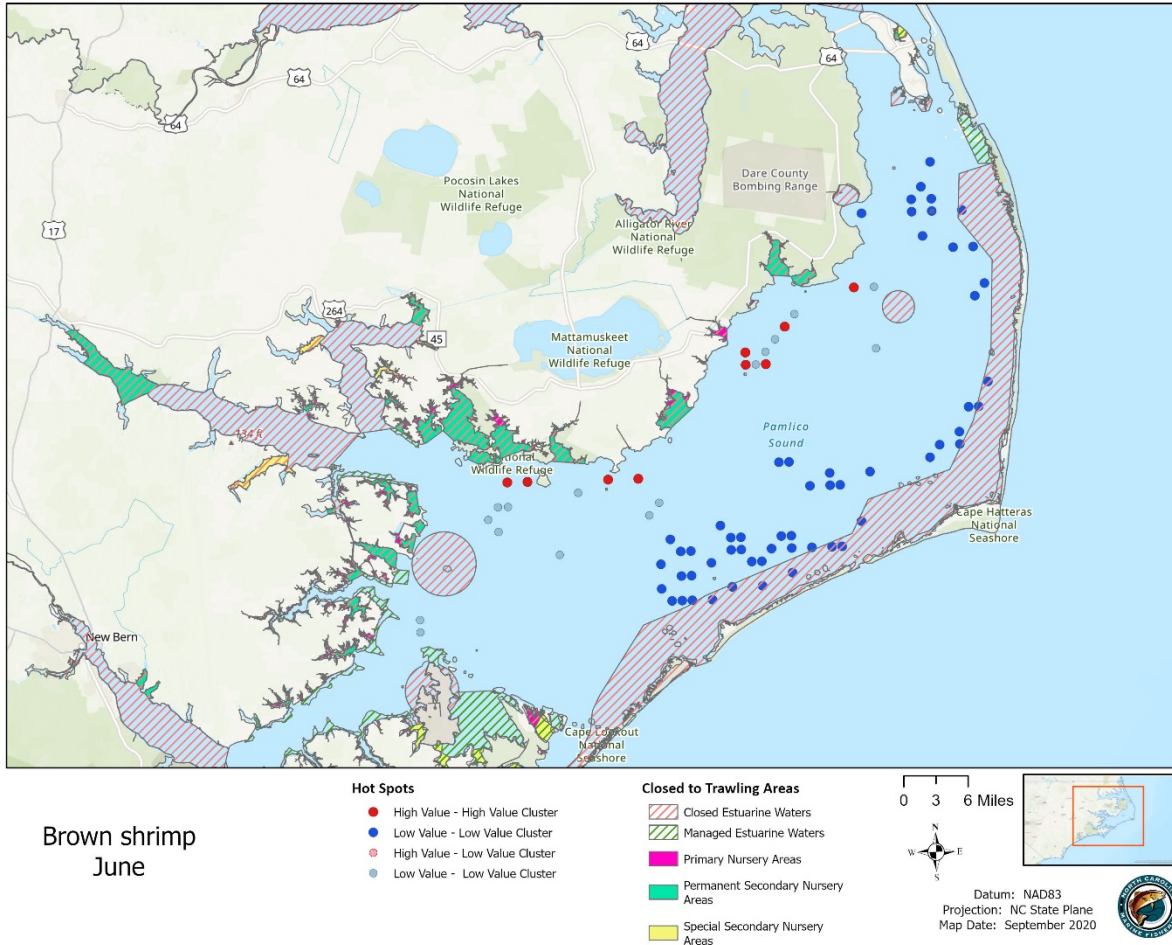
Map 2.3.B.11. Hot spots of abundance for white shrimp in the Pamlico Sound during June using aggregate data from Program 195, 1987-2019.

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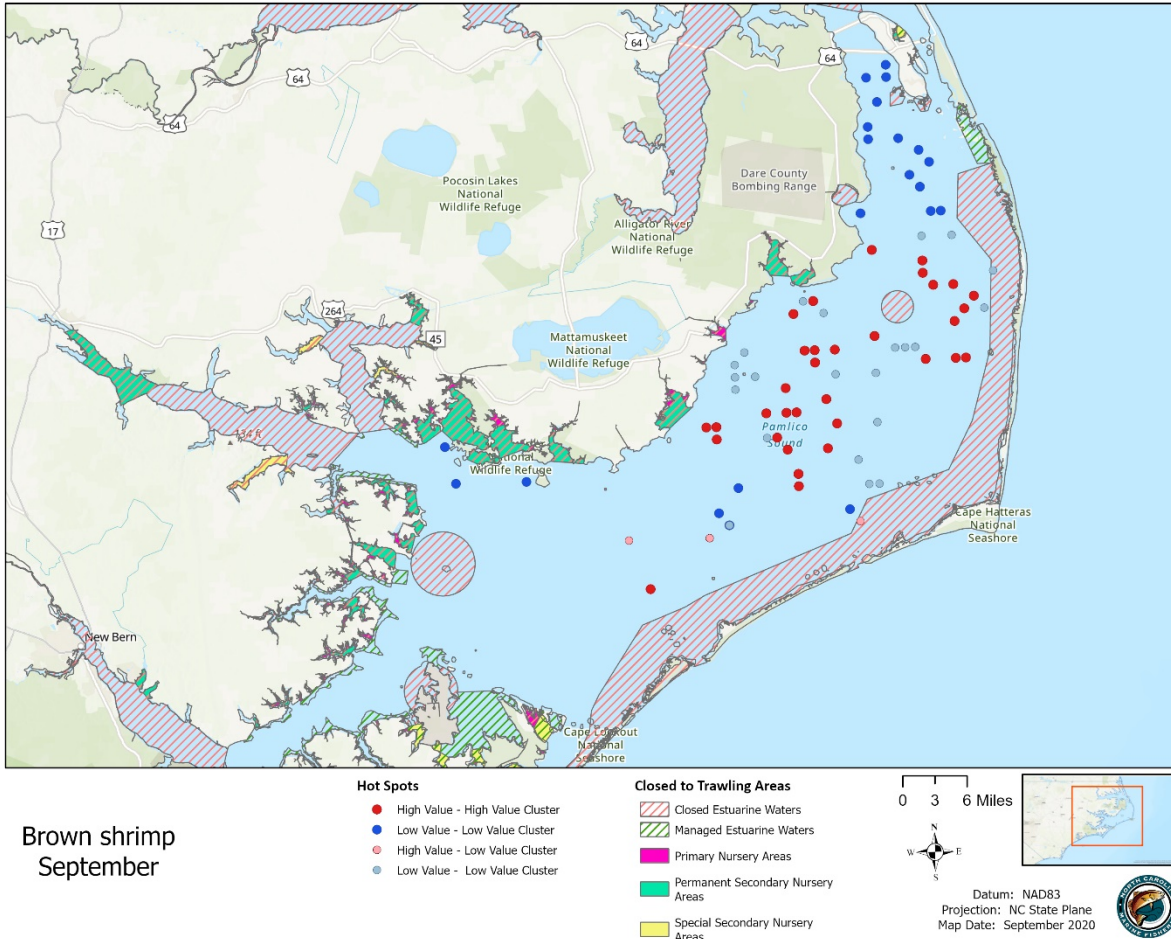
Map 2.3.B.12. Hot spots of abundance for white shrimp in the Pamlico Sound during September using aggregate data from Program 195, 1987-2019.

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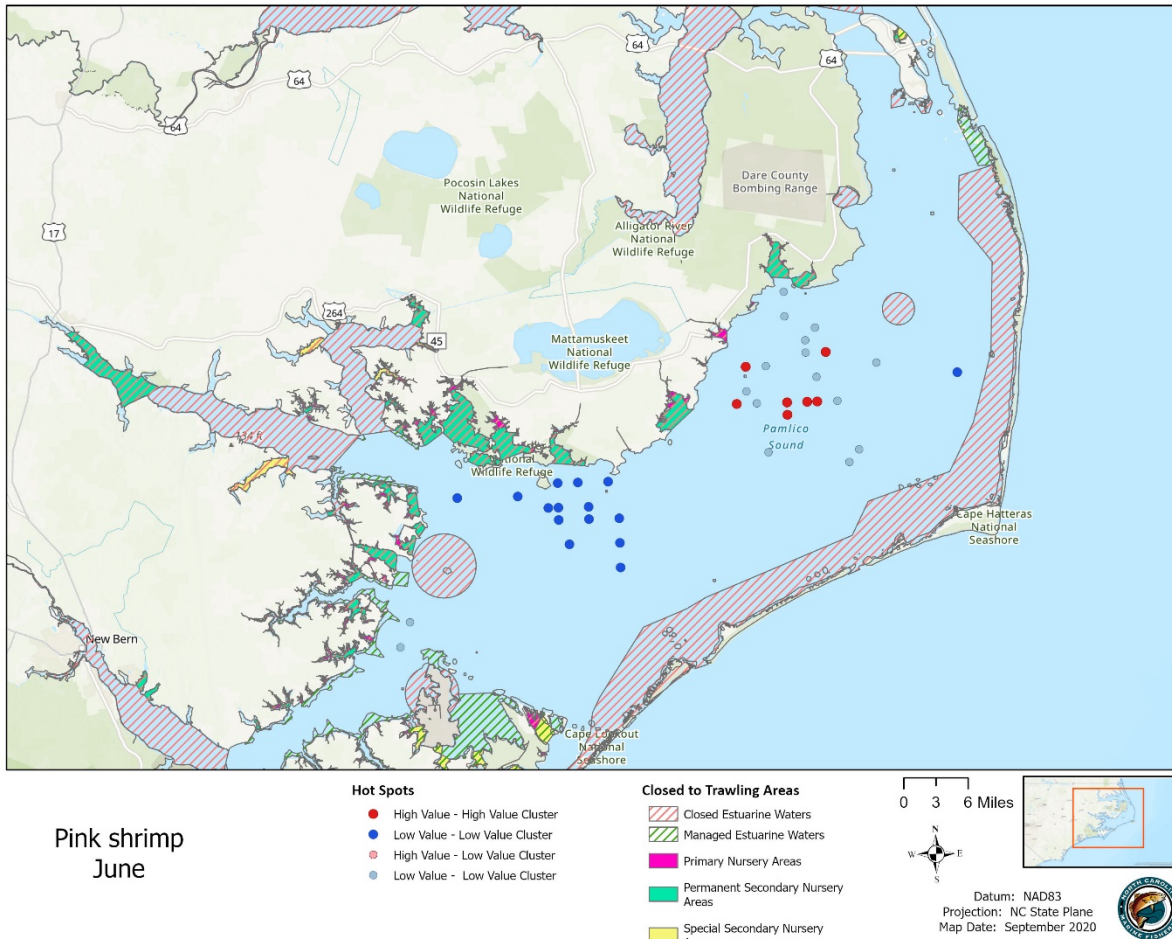
Map 2.3.B.13. Hot spots of abundance for brown shrimp in the Pamlico Sound during June using aggregate data from Program 195, 1987-2019.

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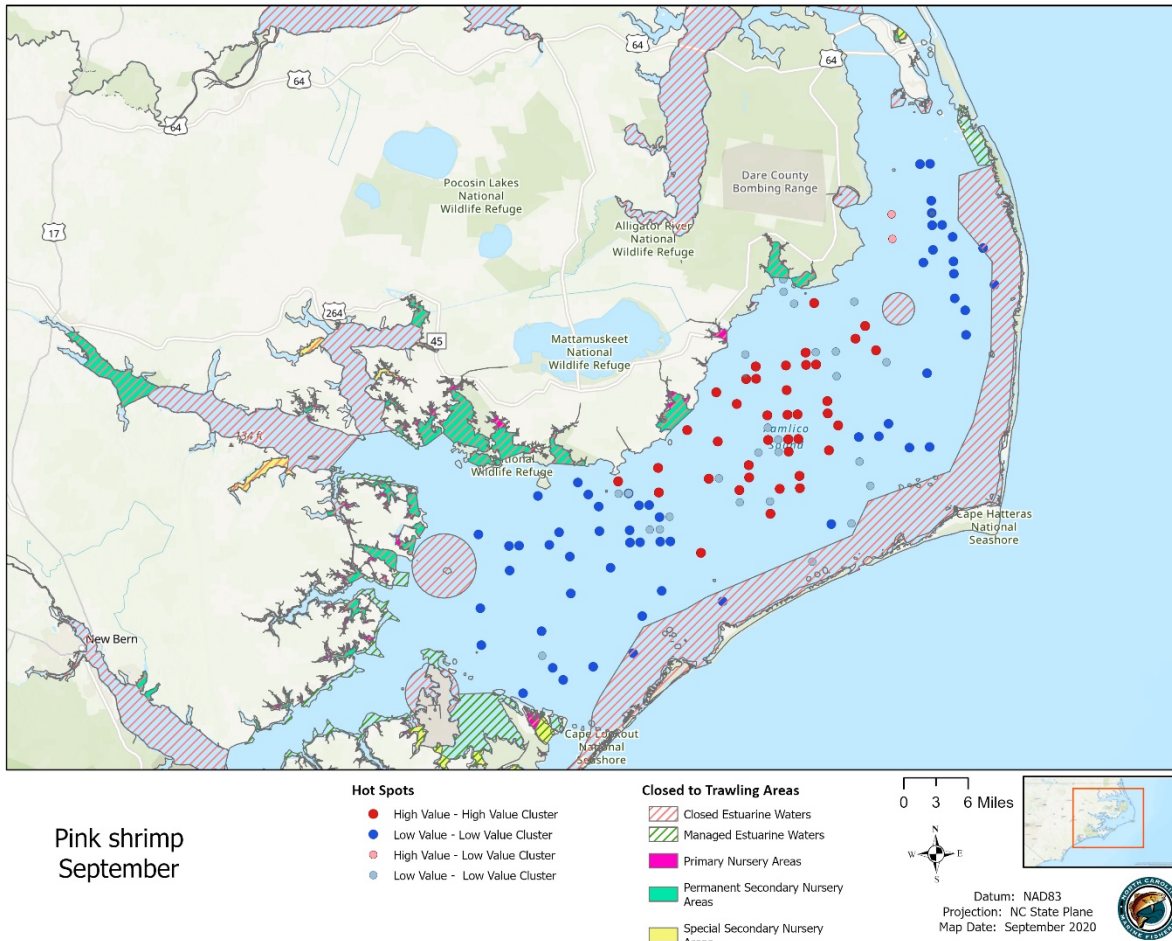
Map 2.3.B.14. Hot spots of abundance for brown shrimp in the Pamlico Sound during September using aggregate data from Program 195, 1987-2019.

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Map 2.3.B.15. Hot spots of abundance for pink shrimp in the Pamlico Sound during June using aggregate data from Program 195, 1987-2019.

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Map 2.3.B.16. Hot spots of abundance for pink shrimp in the Pamlico Sound during September using aggregate data from Program 195, 1987-2019.

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APPENDIX 2.4. MANAGING EFFORT AND GEAR IN THE NORTH CAROLINA SHRIMP FISHERY TO REDUCE BYCATCH

I. ISSUE

Examine potential management measures to reduce bycatch in the North Carolina shrimp fishery through effort reductions and gear management.

II. ORIGINATION

This issue originated from concerns brought forth by the public, conservation groups, and the North Carolina Marine Fisheries Commission.

III. BACKGROUND

General Background on Bycatch

Bycatch is defined by the Atlantic States Marine Fisheries Commission (ASMFC) as “the portion of a catch taken incidentally to the targeted catch because of non-selectivity of the fishing gear to either species or size differences” (ASMFC 1994). In the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), bycatch is defined as “fish which are harvested in a fishery, but which are not sold or kept for personal use.” Fish in the MSFCMA is defined as finfish, mollusks, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds. Bycatch can generally be divided into two components: incidental catch and discarded catch. Incidental catch refers to retained catch of non-target species. Discarded catch is that portion of the catch returned to the sea because of economic, legal, or personal considerations. Differences in market prices for a given size-class of a species or limited storage space can also lead to “high grading”, where less valuable species and size classes are discarded to make space for more valuable fish (Bellido et al. 2011). The biological significance of bycatch can be judged from a number of different perspectives, including those of the populations (e.g., of a particular species), of the fishery or fisheries that target or otherwise encounter the species, and of the general biological community or ecosystem (Murawski 1995).

Through the years, interest in bycatch has shifted from its potential commercial use to concerns about impacts on finfish and other populations, biodiversity, and ecosystem trophic structure (Murray et al. 1992; Hall et al. 2000; Davies et al. 2009). Despite increased public awareness, greater management scrutiny, and significant research efforts, many basic questions remain unanswered. The biggest unanswered question in most fisheries is simply: *How much bycatch is there?* Given this situation, it is not surprising little is known about the impacts of bycatch on specific fisheries, fish populations, and marine communities. Although more information is needed to fully assess the effect of bycatch on fish populations and the ecosystem, continued concern and public policy dictates that bycatch be either eliminated or reduced to insignificant levels (Crowder and Murawski 1998). A prime example of this point can be found in the 1996 reauthorization of the MSFCMA which contained National Standard (#9) requiring bycatch minimization. National Standard 9 states: “Conservation and management measures shall, to the extent practicable, (A) minimize bycatch and (B) to the extent bycatch cannot be avoided, minimize the mortality of such

DRAFT – SUBJECT TO CHANGE

bycatch.” This has been maintained in each subsequent reauthorization of the MSFCMA [16 U.S.C. 1801 - 1891(d)]. Additionally, in 1991 the North Carolina Marine Fisheries Commission (NCMFC) adopted a policy directing the division to establish the goal of reducing bycatch losses to the absolute minimum and to consciously incorporate this goal into all management considerations (Murray et al. 1992).

It is apparent to scientists, natural resource managers, fishermen, and much of the public that bycatch is an important issue and must be addressed. However, characterizing the nature and extent of bycatch has proven difficult. These difficulties are generally attributed to inadequate monitoring of many pertinent fishery characteristics including actual bycatch levels, effort of the directed fishery, distribution of bycatch species, and the mortality rate of discarded species. The problem is exacerbated by the patchy distribution of effort and juvenile finfish in both time and space. The amount of bycatch generally varies from tow to tow (and depends on many factors), with many tows having some bycatch and fewer tows with high bycatch (Diamond 2003). Additionally, available effort data are often insufficient. Although research indicates tow duration is often a significant factor when estimating bycatch losses (e.g., mortality), the division and most other agencies typically record effort data by trip, without any accompanying information on tow duration or the number of tows made during a trip; although a few fisheries use logbooks to record effort metrics like tow time (Broadhurst et al. 2006; A. Bianchi, NCDMF, personal communication). Mortality of bycatch captured in shrimp trawls varies considerably, not only by species, but also in response to factors such as tow time and time out of water (Johnson 2003) as well as water temperature, fishing location, time of year, and gear configuration.

Several methods have been used to estimate shrimp trawl bycatch. One popular method of estimating bycatch is the ratio method. This method uses some information about the ratio of bycatch to the target catch caught by a gear or fishery and uses the reported landings of the target species multiplied by the ratio to estimate the total amount of bycatch (Diamond 2003). Typically, bycatch to catch ratios have been used to support or deny claims about how “clean” a fishery or gear is operated. As an example, if a particular gear or fishery has a bycatch to catch ratio of 1:5 it may be perceived to be a cleaner fishery than one with a 5:1 or even a 1:1 ratio. However, if the actual amount of bycatch is relatively equal in all these cases, then the variability in the ratio is caused by either differing target species or variations in the population of the target species. If the primary concern is the impact to the bycatch species, all the examples above have the same impact regardless of the bycatch to catch ratio. Therefore, the bycatch to catch ratio is not as informative as the actual catch rate (or total catch) of the bycatch species. A comparison among several ratio methods and a catch-per-unit-effort (CPUE) method found the four ratio methods tested were more biased than the CPUE method. Additionally, the four ratio methods were more influenced by the mean or variance of the catch, observer coverage, and correlation between the bycatch and target catch (Diamond 2003). However, in most cases the data needed to calculate reliable CPUE estimates for bycatch species is lacking.

The lack of reliable discard estimates has not stopped researchers from investigating stock assessment impacts, but it has prevented increases in precision. Most stock assessments address the impact of bycatch through sensitivity analyses by comparing the basic stock assessment results over a range of bycatch estimates and assumptions [see 2010 Atlantic croaker stock assessment for an example of this approach (ASMFC 2010)]. If none of the results seem plausible, the stock

DRAFT – SUBJECT TO CHANGE

assessment may proceed without bycatch estimates included but with the caveat that results may be biased or contain additional uncertainties due to unknown levels of missing catch. However, the omission of discard data may result in underestimating fishing mortality and lead to a biased stock assessment (Bellido et al. 2011).

Incidental Landings from Shrimp Trawls

The incidental landings of non-target species by shrimp trawls have declined significantly since 1994 (NCDMF Trip Ticket Program; Figure 2.4.1). On average, 125,402 pounds of incidental finfish catch were landed and sold annually from shrimp trawls from 2010 to 2019; representing 83.3% of all incidental landings sold during this period. Species where the effects of incidental landings and bycatch in shrimp trawls on their sustainability has been raised as a concern include spot (*Leiostomus xanthurus*), flounder (*Paralichthid* spp.), Atlantic croaker (*Micropogonias undulatus*), sheepshead (*Archosargus probatocephalus*), and weakfish (*Cynoscion regalis*). These species on average accounted 44% of the incidental landings annually from shrimp trawls from 1994 through 2009 (Figure 2.4.2). However, this has decreased substantially to only 17% from 2010 through 2019. Additionally, the magnitude of incidental landings has decreased significantly over time (Figure 2.4.3). The largest decreases in incidental landings have been seen for weakfish (98%), Atlantic croaker (97%), flounder (93%), and spot (90%) when comparing the average landings for the 1994 through 1999 period to the 2015 through 2019 period. Incidental landings of kingfishes have declined (34%), but since their decrease has been less dramatic than other species their overall proportion of incidental bycatch landings has increased over time (Figures 2.4.2 and 2.4.3). Sheepshead landings have generally remained consistently low, averaging less than 4,000 pounds annually. Incidental landings of crabs [blue crab (*Callinectes sapidus*); Florida stone crab (*Menippe mercenaria*), horseshoe crab (*Limulus Polyphemus*)] have declined since the 1990s (Figure 2.4.1), averaging 17,750 pounds annually and making up 12% of the total landings for 2010 through 2019. Incidental landings of mollusks (conch/whelks, squid, octopus spp.) have generally declined (Figure 2.4.1), averaging 7,426 pounds annually and 5% of the total landings for 2010 through 2019. Additional species-specific landings information is included in the species sections below.

Discarded Bycatch in Shrimp Trawls

Over 200 species of finfish and crustaceans have been identified in the North Carolina shrimp trawl fishery in recent years (Brown 2009, 2010, 2015, 2016, 2017, 2018; Brown et al. 2017, 2018, 2019). In both estuarine and ocean waters, Atlantic croaker and spot were the most abundant bycatch species. While southern flounder (*Paralichthys lethostigma*), summer flounder (*P. dentatus*), and weakfish typically make up the largest portion of regulatory discards, they only account for a small portion of the total catch by weight. Additional species-specific information for discarded bycatch is included in the species sections below.

Shrimp Trawl Bycatch Impacts on Stock Assessments

Discards are a significant source of mortality that must be accounted for to estimate total removals from a population (Alverson and Hughes 1996; Nance 1998; Bellido et al. 2011). Most quantitative stock assessment techniques involve statistical analysis of catch data that require an accurate

DRAFT – SUBJECT TO CHANGE

record of the entire catch to reliably estimate stock parameters such as recruitment, abundance, and selectivity. Therefore, it is not only important to know the magnitude of discarded bycatch, but the age composition as well (Alverson et al. 1994; Murawski 1995). Omitting discard data can underestimate recruitment and mortality at age and further lead to biased stock assessments (Punt et al. 2006) and stock predictions (Alverson et al. 1994). Recently, discard estimates from the shrimp trawl fishery were incorporated into stock assessments for Atlantic croaker (ASMFC 2017a), spot (ASMFC 2017b), and southern flounder (Flowers et al. 2019), and was attempted for weakfish (ASMFC 2016).

While stock assessment models can help fisheries managers evaluate the relative impact of natural and fishing mortality on a stock, it is difficult to quantify how finfish stocks will improve or change in response to management measures put in place to reduce bycatch due to the many unpredictable human and natural factors that affect fish stock abundance. Habitat quality and fish stock abundance is not only influenced by directed fishing but is also influenced by factors that cannot be controlled through fishery management strategies, such as environmental fluctuations (e.g., pH, temperature, dissolved oxygen, storms), habitat loss due to land development, water quality, and natural mortality rates specific to each species. Furthermore, it is not possible to estimate net changes in fishing effort, temporal and geographic shifts in fishing patterns, and changes in gear and targeted species that could affect fishing mortality and bycatch both positively and negatively. Additional species-specific information regarding stock assessment impacts is included in the species sections below.

Bycatch Management in North Carolina

Concerns about bycatch in North Carolina began in the 1950s after serious declines in the catch of commercial fish were observed in North Carolina waters with attention focused on the shrimp fishery in Pamlico Sound (NCDMF 2015). In the 1960s and early 1970s, directed finfish trawling in the ocean for bait and pet food led to the NCMFC establishing rules to prohibit directed scrap fishing (taking the young of edible fish before they are of sufficient size to be valuable as individual food fish). In 1977, the NCMFC began designating nursery areas to protect both the physical habitat, as well as juvenile finfish and crustaceans. The Albemarle Sound was closed to trawling in 1987 due to conflicts with crab pot and gill net fishermen as well as concerns about bycatch and habitat. North Carolina was the first state to mandate the use of bycatch reduction devices (BRDs) in all shrimp trawls in 1992. The use of BRDs installed in penaeid shrimp trawls can reduce total bycatch by 30 to 70% (McHugh et al. 2017).

The National Marine Fisheries Service first mandated the use of turtle excluder devices (TEDs) in shrimp trawls for inshore (unless following tow time restrictions) and offshore waters in 1987 [Sea Turtle Conservation; Shrimp Trawling Requirements, 50 C.F.R §217, 222, and 227 (1987)]. The use of TEDs has not only been shown to reduce the number of sea turtle stranding's and takes in the shrimp trawl fishery but has also been shown to reduce finfish bycatch (Brewer et al. 2006; Broome et al. 2011; Price and Gearhart 2011). In 1993, NCDMF wrote a comprehensive report on estuarine trawling that addressed bycatch, overfishing, and habitat and water quality concerns. Based on the findings of this report, rules were established in 1994 that prohibited trawling in seagrass beds in eastern Pamlico Sound, eliminated weekend trawling, and established special

DRAFT – SUBJECT TO CHANGE

secondary nursery areas (SSNA) which could be opened by proclamation from August 16 through May 14.

In 2006, the first Shrimp FMP implemented several management measures to address bycatch concerns which included effort controls and gear modifications (NCDMF 2006). Gear modifications and effort controls included: 1) prohibiting the use of otter trawls upstream of the Highway 172 Bridge in the New River; therefore, limiting trawling to skimmer trawls which have been shown to minimize and increase survivability of bycatch (Coale et al. 1994; Hein and Meier 1995) and 2) a maximum combined 90 ft headrope length limit was established for all internal waters except Pamlico Sound and the mouths of the Pamlico and Neuse rivers. This measure was meant to reduce conflict between small and large vessels but may have also helped to reduce bycatch of juvenile finfish and crustaceans as well as protect habitat.

In February 2015, the NCMFC adopted Amendment 1 to the Shrimp FMP which contained management measures to reduce bycatch in the commercial and recreational shrimp trawl fishery (NCDMF 2015). It increased the number of certified BRDs available for use, required two BRDs in shrimp otter trawls and skimmer trawls, and established a maximum combined headrope length of 220 feet in all internal coastal waters where no maximum combined headrope limit previously existed. An industry workgroup was also formed to test gear modifications to reduce finfish bycatch in the shrimp trawl fishery by an additional 40%. Four of the gear configurations tested reduced bycatch an additional 40 to 57% (Brown et al. 2019). In July 2019, the use of these gear configurations was mandated in all shrimp otter trawls operating in Pamlico Sound and portions of Pamlico, Bay, and Neuse rivers through the May 2018 Revision to Amendment 1 (NCDMF 2018). These gear modifications reduce finfish bycatch in shrimp otter trawls by approximately 60% when compared to a net without a TED and any BRDs.

NCDMF Shrimp Trawl Bycatch Characterization Studies

Six commercial shrimp trawl bycatch characterization studies were conducted from July 2007 to December 2017 (Table 2.4.1; Brown 2009, 2010, 2015, 2016, 2017, 2018). The studies observed catches from commercial shrimp trawls (skimmer and otter) in a variety of estuarine waters inside and outside of Pamlico Sound, as well as the nearshore ocean waters (0-3 miles) of North Carolina. Observations were made on a total of 756 fishing days, consisting of 2,068 tows. Additional species-specific information for the characterization studies is included in the species sections below.

Bycatch Species Information

The species included in this section are either commonly caught as bycatch in shrimp trawls and their stock status is either unknown or they are overfished and/or overfishing is occurring (e.g., Atlantic croaker, southern flounder, spot, and weakfish), there are concerns over increased bycatch due to recent shifts in effort by the shrimp trawl fishery (e.g., sheepshead), or they are protected under the Endangered Species Act or Marine Mammal Protection Act (e.g., sea turtle species, Atlantic sturgeon, bottlenose dolphin).

DRAFT – SUBJECT TO CHANGE

ATLANTIC CROAKER

Harvest from Shrimp Trawls

Harvest of Atlantic croaker in the ocean otter trawl fishery from 1994 through 2019 averaged 41,781 pounds and ranged from three to 545,123 pounds. Harvest in the ocean skimmer trawl fishery occurred in only two years of the time series and averaged less than 10 pounds. Harvest in the estuarine (excluding Pamlico Sound) otter trawl fishery averaged less than 200 pounds and ranged from 0 to 1,057 pounds. Harvest in the estuarine (excluding Pamlico Sound) skimmer trawl fishery averaged 9 pounds and ranged from 0 to 58 pounds. Harvest in the Pamlico Sound otter trawl fishery averaged 1,948 pounds and ranged from 19 to 10,678 pounds. Harvest in the Pamlico Sound skimmer trawl fishery occurred in only three years during the time series and averaged less than 10 pounds.

Characterization Studies

In the six characterization studies conducted from July 2007 to December 2017, Atlantic croaker was the most abundant finfish bycatch, representing between 5% (Study 4) and 42% (Study 3) of the catch by weight. The observed at net mortality ranged from 0% (Study 4, fall season) to 57% (Study 4, spring season). Across all studies, most Atlantic croaker ranged from 100 to 180 mm (Table 2.4.1).

Stock Assessment/Status

In 2017, a benchmark stock assessment was completed (ASMFC 2017a). This assessment used a stock synthesis model to address a major source of uncertainty from previous assessments – the magnitude of Atlantic croaker bycatch in South Atlantic shrimp trawl fishery (North Carolina through Florida). However, due to conflicting trends in abundance and harvest, as well as other uncertainties, this assessment was not recommended for management use (ASMFC 2017a). A traffic light approach is used to evaluate Atlantic croaker fishery trends and develop management actions when harvest and abundance thresholds are exceeded (ASMFC 2020a).

The 2017 assessment did show most annual removals of Atlantic croaker were discards from the South Atlantic shrimp trawl fishery, followed by commercial landings and recreational harvest. Annual discards from the South Atlantic shrimp trawl fishery ranged from 180 million pounds to 1.1 billion pounds with a long term mean of 396 million pounds. Shrimp trawl bycatch accounted for 81 to 99% of annual Atlantic croaker removals and averaged 91.6% of all removals. The peer reviewers recognized that discard/bycatch estimates are unusually uncertain due to data insufficiencies, but agreed the method used to develop estimates of Atlantic croaker bycatch from the South Atlantic shrimp trawl fishery was current, supported, and similar (or identical) to methods used in Southeast Data, Assessment, and Review (SEDAR) assessments of South Atlantic king mackerel (*Scomberomus cavalla*), Gulf of Mexico red snapper (*Lutjanus campechanus*), gray triggerfish (*Balistes capricus*), and domestic sharks (ASMFC 2017a).

DRAFT – SUBJECT TO CHANGE

SPOT

Harvest from Shrimp Trawls

Harvest of spot in the ocean otter trawl fishery from 1994 through 2019 averaged 17,218 pounds and ranged from 1,807 to 52,662 pounds. Harvest in the ocean skimmer trawl fishery occurred in only two years of the time series and averaged 45 pounds. Harvest in the estuarine (excluding Pamlico Sound) otter trawl fishery averaged 1,793 pounds and ranged from 105 to 7,511 pounds. Harvest in the estuarine (excluding Pamlico Sound) skimmer trawl fishery averaged 135 pounds and ranged from 0 to 822 pounds. Harvest in the Pamlico Sound otter trawl fishery averaged 12,695 pounds and ranged from 293 to 52,037 pounds. Harvest in the Pamlico Sound skimmer trawl fishery averaged 34 pounds.

Characterization Studies

In the six characterization studies conducted from July 2007 to December 2017, spot represented between 0.7% (Study 6, otter trawls in the ocean) and 23% (Study 3) of the catch by weight. The observed at net mortality ranged from 66% (Study 3) to 82% (Study 4). Across all studies, most spot ranged from 100 to 180 mm (Table 2.4.1).

Stock Assessment/Status

In 2017, the first coastwide benchmark stock assessment was completed for spot (ASMFC 2017b). The assessment used a catch survey model to estimate population parameters (e.g., stock status, natural mortality, discard rates, and mortality) and biological reference points. However, due to conflicting trends in abundance and harvest, as well as other uncertainties, this assessment was not recommended to be used for management advice (ASMFC 2017b). A traffic light approach is used to evaluate spot fishery trends and develop management actions when harvest and abundance thresholds are exceeded (ASMFC 2020b).

Most fishery removals of spot were discards in the South Atlantic shrimp trawl fisheries, followed by commercial landings and recreational harvest. The panelists recognized discard/bycatch estimates are unusually uncertain due to data insufficiencies, but agreed the method used to develop estimates of spot bycatch from the southern shrimp trawl fishery was current, supported, and similar (or identical) to methods used in SEDAR assessments of South Atlantic king mackerel, Gulf of Mexico red snapper, gray triggerfish, and domestic sharks (ASMFC 2017b).

WEAKFISH

Harvest from Shrimp Trawls

Harvest of weakfish in the ocean otter trawl fishery from 1994 through 2019 averaged 2,008 pounds and ranged from 29 to 26,644 pounds. Harvest in the ocean skimmer trawl fishery occurred in only one year of the time series and averaged less than 10 pounds. Harvest in the estuarine (excluding Pamlico Sound) otter trawl fishery averaged 276 pounds and ranged from zero to 1,956 pounds. Harvest in the estuarine (excluding Pamlico Sound) skimmer trawl fishery averaged two

DRAFT – SUBJECT TO CHANGE

pounds and ranged from zero to six pounds. Harvest in the Pamlico Sound otter trawl fishery averaged 5,847 pounds and ranged from 36 to 43,600 pounds. Harvest in the Pamlico Sound skimmer trawl fishery averaged six pounds.

Characterization Studies

In the six characterization studies conducted from July 2007 to December 2017, weakfish represented between 0.1% (Study 5, in skimmer trawls in estuarine waters) and 6% (Study 2) of the catch by weight. The observed at net mortality ranged from 87% (Study 3) to 100% (Study 5). Across all studies, most weakfish were less than 305 mm (12 inches; Table 2.4.1).

Stock Assessment/Status

The 2016 Weakfish Stock Assessment attempted to include estimates of shrimp trawl discards from the South Atlantic (ASMFC 2016). However, the final estimates of weakfish bycatch were very small relative to total commercial removals. The catch from shrimp trawls consisted of mainly age-0 fish which were not included in the model. There was also high uncertainty in the data set due to low sample size, the lack of mandatory observer coverage prior to 2008, and uncertainty in extrapolating catch estimates further into the past. For these reasons, estimates of shrimp trawl bycatch were not included in the assessment. They also explored the NCDMF shrimp trawl observer dataset, but due to the limited temporal and spatial coverage, estimates of weakfish bycatch were not developed. Both the 2016 stock assessment and an updated stock assessment conducted in 2019 found the weakfish stock was depleted (ASMFC 2019).

SOUTHERN FLOUNDER

Harvest from Shrimp Trawls

The NCDMF Trip Ticket Program does not distinguish between summer and southern flounder species and therefore designates southern flounder as being harvested from estuarine waters (hence no ocean landings are produced). Harvest in the estuarine (excluding Pamlico Sound) otter trawl fishery averaged 2,419 pounds and ranged from 83 to 17,024 pounds. Harvest in the estuarine (excluding Pamlico Sound) skimmer trawl fishery averaged 114 pounds and ranged from 0 to 365 pounds. Harvest in the Pamlico Sound otter trawl fishery averaged 18,393 pounds and ranged from 449 to 88,967 pounds. Harvest in the Pamlico Sound skimmer trawl fishery averaged 12 pounds.

Characterization Studies

In the six characterization studies conducted from July 2007 to December 2017, southern flounder represented between 0.01% (Study 6) and 1.6% (Study 3, in 2013 season in estuarine otter trawls) of the catch by weight. The observed at net mortality ranged from 0% (Study 3, in 2012) to 88% (Study 5, in 2015). Across all studies, most southern flounder ranged from 80 to 300 mm (Table 2.4.1).

DRAFT – SUBJECT TO CHANGE

Stock Assessment/Status

The assessment model estimated a value of 0.35 for $F_{35\%}$ (fishing mortality target) and a value of 0.53 for $F_{25\%}$ (fishing mortality threshold; Flowers et al. 2019). The estimate of F in 2017 is 0.91, which is above the threshold ($F_{25\%} = 0.53$) and suggests overfishing is currently occurring. The estimate of spawning stock biomass target ($SSB_{35\%}$) was 5,452 mt and the estimate of $SSB_{25\%}$ (threshold) was 3,900 mt. The model estimate of SSB in 2017 was 1,031 mt, which is below the threshold and suggests the stock is currently overfished (Flowers et al. 2019).

The shrimp trawl fishery was modeled as a bycatch-only fleet and the input landings included only dead discards. No live discards were assumed for the shrimp trawl fishery. Estimates of southern flounder bycatch in the shrimp trawl fishery have shown a general decline over time and were not a major source of fishing mortality (Flowers et al. 2019).

SHEEPSHEAD

Harvest from Shrimp Trawls

Harvest of sheephead in the ocean otter trawl fishery from 1994 through 2019 averaged 3,048 pounds and ranged from 201 to 13,894 pounds. Harvest in the ocean skimmer trawl fishery occurred in only one year of the time series and averaged less than 10 pounds. Harvest in the estuarine (excluding Pamlico Sound) otter trawl fishery averaged 166 pounds and ranged from 10 to 1,098 pounds. Harvest in the estuarine (excluding Pamlico Sound) skimmer trawl fishery averaged 18 pounds and ranged from 0 to 117 pounds. Harvest in the Pamlico Sound otter trawl fishery averaged 916 pounds and ranged from 89 to 2,561 pounds. Harvest in the Pamlico Sound skimmer trawl fishery averaged 6 pounds.

Characterization Studies

In the six characterization studies conducted from July 2007 to December 2017, sheephead represented between 0% (Study 2) and 0.2% (Study 1) of the catch by weight. Across all studies, sheephead ranged from 182 to 388 mm (Table 2.4.1).

Stock Assessment/Status

No formal stock assessment has been completed for sheephead in North Carolina; however, one is being prepared by researchers at North Carolina State University with results expected sometime in the near future.

PROTECTED SPECIES

Protected species (sometimes referred to as “protected resources”) is a broad term that encompasses a range of organisms protected by federal or state statutes because their populations are at risk or are vulnerable to risk of extinction. Federal statutes include the Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA), and the Migratory Bird Treaty Act (MBTA). Of federally protected species found in North Carolina, only sea turtles, sturgeon species,

DRAFT – SUBJECT TO CHANGE

and the common bottlenose dolphin (*Tursiops truncatus*) are known or suspected to be incidentally taken in the shrimp fishery. Due to their protected status, harvest of these species is prohibited.

Sea Turtles

Common sea turtles in North Carolina include the Kemp's ridley sea turtle (*Lepidochelys kempii*), hawksbill sea turtle (*Eretmochelys imbricate*), leatherback sea turtle (*Dermochelys coriacea*), green sea turtle (*Chelonia mydas*), and the loggerhead sea turtle (*Caretta caretta*). After a decline in sea turtle populations and their listing under the endangered species act in 1977, it was determined that the primary cause of sea turtle mortality was the incidental capture as bycatch in the southeast U.S. shrimp fishery (Henwood and Stuntz 1987; National Research Council 1990). This was addressed through regulatory decisions and the development and use of a TED. TEDs in trawls are estimated to have a 97% exclusion rate with minimal shrimp loss (Watson 1981; Murray 2020). Recent studies have shown that sea turtles can exhibit symptoms of decompression sickness, commonly known as "the bends" from forced submergence in bottom trawls which can be greatly reduced through the use of a TED (García-Párraga et al. 2014; Fahlman et al. 2017). In August 2021, the National Oceanic and Atmospheric Administration (NOAA) Fisheries is expected to require the use of TEDs in all skimmer trawls over 40 feet.

Bottlenose Dolphin

While bottlenose dolphins are commonly seen feeding behind shrimp trawlers in North Carolina (Fleming 2004; Johnson 2006; Brown 2009), very few takes have been observed in the shrimp trawl fishery. However, in the Gulf of Mexico, otter trawls have been identified as a significant source of mortality and serious injury for several species of dolphin (Soldevilla et al. 2015).

Atlantic Sturgeon

The bycatch of Atlantic sturgeon (*Acipenser oxyrinchus*) from a variety of fisheries (gill nets, pound nets, trawls, etc.) is thought to be the primary source of mortality and biggest threat to the species recovery (ASMFC 2017c). Results from the 2017 Atlantic Sturgeon Stock Assessment indicate the total and dead bycatch of Atlantic sturgeon from otter trawls has declined since 2002 and the stock is showing signs of recovery (ASMFC 2017c). It should be noted that bycatch estimates from the South Atlantic shrimp trawl fishery was not evaluated for inclusion in the stock assessment for several reasons (i.e., under-reporting of takes, inappropriate survey methods, time series limitations). Continued bycatch monitoring and development of new BRD and TED configurations should further aid in their recovery. In an evaluation of TED designs used in the Mid-Atlantic Atlantic croaker flynet fishery, Atlantic sturgeon were observed escaping through TED openings (Gearhart 2010) and may further be excluded from shrimp trawls.

Characterization Studies

In the six characterization studies conducted from July 2007 to December 2017, there were 16 total protected species interactions observed. The interactions comprised 13 sea turtles, two Atlantic sturgeon, one bird, and zero marine mammals. Details about specific interactions for each study are found in Table 2.4.1.

DRAFT – SUBJECT TO CHANGE

Effort in the Shrimp Fishery

OTTER TRAWL

Effort in the otter trawl sector of the North Carolina shrimp fishery based on the number of participants and vessels has been relatively steady since 2005 (Figure 2.4.4) and has averaged 381 participants and 416 vessels annually in the shrimp otter trawl fishery for 2010 through 2019. Similarly, the number of trips and total number of trip days have remained relatively steady since 2005 (Figure 2.4.5) and has averaged 5,762 trips and 10,499 trip days in the shrimp otter trawl fishery for 2010 through 2019. However, from 2015 through 2019, the number of trips and trip days have been increasing, although they are still well below the highs seen in the early 2000s. The pounds of shrimp harvested by otter trawls fluctuates annually, sometimes by millions of pounds from one year to the next; the value of the fishery also follows a similar pattern (Figure 2.4.6). However, landings and value from 2016 through 2019 are among the highest in the time series, driven largely by increased landings of white shrimp in the Atlantic Ocean north of Cape Hatteras. From 2010 through 2019, landings have averaged 7.7 million pounds with an ex-vessel value of \$17.0 million.

Otter trawl effort by area (Pamlico Sound, other inshore waters, and ocean) shows a similar pattern as the overall trend (Figure 2.4.7). Participants, vessels, trips, and trip days for all three areas declined in the early 2000s and then stabilized from 2006 to 2019 in most cases. The average length of commercial otter trawl trips (Figure 2.4.8) has remained relatively stable throughout the time series for all areas. The average trip length in Pamlico Sound ranged from 2.5 to 3 days, while in other inshore waters trip length averaged about one day per trip. Trip lengths in the ocean averaged about 1.5 days for most of the time series but in recent years increased to an average of about two days per trip. When looking at trip days keep in mind this does not equate to fishing days. Trip days includes travel time, lay days, bad weather days, etc. in addition to fishing days.

SKIMMER TRAWL

Effort in the skimmer trawl sector of the North Carolina shrimp fishery based on the number of participants and vessels has been relatively steady since 2005 (Figure 2.4.9) and has averaged 64 participants and 69 vessels annually in the shrimp skimmer trawl fishery for 2010 through 2019. However, from 2018 through 2019, both participants and vessels have declined sharply. Similarly, the number of trips and total number of trip days have remained relatively steady since 2005 (Figure 2.4.10) and has averaged 806 trips and 851 trip days in the shrimp skimmer trawl fishery for 2010 through 2019. However, from 2016 through 2019, the number of trips and trip days have decreased sharply and are well below the highs seen in the early 2000s. The amount of shrimp harvested by skimmer trawls fluctuates annually, sometimes by hundreds of thousands of pounds from one year to the next, the value of the fishery also follows a similar pattern (Figure 2.4.11). Landings and value from 2018 through 2019 are among the lowest in the time series. From 2010 through 2019, landings have averaged 345,779 pounds with an ex-vessel value of \$534,808.

Further examination of skimmer trawl effort trends by area (Pamlico Sound and other inshore waters). shows a similar pattern as the overall trend (Figure 2.4.12). Participants, vessels, trips, and trip days declined in the early 2000s and then stabilized around 2006 until recent years when

DRAFT – SUBJECT TO CHANGE

there was a sharp decline in all effort metrics. In Pamlico Sound, effort was stable (though at a much lower level than other inshore areas) from the mid-2000s until the past few years when there was a sharp increase in effort (presumably due to increased white shrimp abundance). The average length of commercial skimmer trawl trips (Figure 2.4.13) has remained relatively stable throughout the time series in other inshore waters at roughly 1 day per trip and in Pamlico Sound the average trip length ranged from 1.5 to two days. Ocean data (as well as Pamlico Sound data in some years) was not included because there were no trips or trip data were considered confidential (< 3 trips). When looking at trip days keep in mind this does not equate to fishing days. Trip days includes travel time, lay days, bad weather days, etc. in addition to fishing days.

CHANNEL NETS, CAST NETS, AND OTHER GEARS

Effort in the shrimp fishery from non-trawl gears (i.e., channel nets, cast nets, etc.) is relatively low compared to trawl gears. The number of participants using non-trawl gears fluctuates annually and the number of participants using channel nets, cast nets, and other gears has averaged 62, 11, and 17 participants, respectively for 2010 through 2019 (Figure 2.4.14A). Similarly, the number of trips using non-trawl gears fluctuates annually and the number of trips using channel nets, cast nets, and other gears has averaged 903, 52, and 157 trips, respectively, for 2010 through 2019 (Figure 2.4.14B). Shrimp landings from non-trawl gears is relatively low compared to shrimp trawls. Landings from channel nets, cast nets, and other gears has averaged 166,157,818, and 10,959 pounds, respectively for 2010 through 2019 (Figure 2.4.14C). Similar to landings, the value of the harvest from non-trawl gears is relatively low compared to the value of shrimp trawl harvest. The ex-vessel value of landings from channel nets, cast nets, and other gears has averaged \$266,279, \$4,025, and \$23,034, respectively for 2010 through 2019 (Figure 2.4.14D).

Current Gear Modifications and Effort Reduction Management Measures

HEADROPE LIMIT

The size of gear allowed in North Carolina's shrimp fishery has been the subject of debate, particularly with respect to trawls. Prior to the 2006 Shrimp FMP, there were size limits on channel nets and on recreational shrimp trawls (26 ft headrope length) used by Recreational Commercial Gear License (RCGL) holders, but no restriction on the size of trawls used in the commercial shrimp fishery. At the time, many fishermen felt there should be a maximum limit placed on the size of trawls particularly in some smaller water bodies. They cited it was unfair to allow larger vessels into these areas especially on opening days when many boats would crowd into an area. Small vessel operators thought the larger vessels took most of the shrimp, rendering areas unproductive for several days, and then left to fish in more open waters unworkable by the smaller vessels. Currently, it is unlawful to use shrimp trawls (otter and skimmer) with a combined headrope length greater than 90 feet in internal coastal waters of North Carolina, except in the Pamlico Sound and mouths of the Pamlico and Neuse rivers where up to 220 feet of combined headrope may be used [NCMFC Rule 15A NCAC 03L .0103(c)(d)]. There is no limit on the amount of headrope that can be fished in the state ocean waters. The 90 feet headrope areas were primarily established due to conflicts between small and large trawlers, not to limit or reduce bycatch in those areas. The 220 feet headrope limit in Pamlico Sound was established to cap fleet capacity and not to limit or reduce bycatch.

DRAFT – SUBJECT TO CHANGE

MESH SIZE

For all net types, it is unlawful to use nets with an inner or outer mesh liner. Net material used as chaffing gear must have a mesh length of at least four inches, except smaller mesh may be used along the bottom half of the tailbag. Chaffing gear may not be tied in a way that forms an additional tailbag [NCMFC Rule 15A NCAC 03L. 0103L(b)].

Otter and Skimmer Trawls

The minimum mesh size for otter and skimmer trawls is one and one-half inches stretch mesh [NCMFC Rule 15A NCAC 03L. 0103L(a)(1)]. Except, in areas where up to 220 feet of headrope is allowed (Pamlico Sound and portions of the Pamlico and Neuse rivers), the minimum tailbag mesh size is one and three-quarter inches stretch mesh (Proclamation SH-3-2019).

Channel Nets, Float Nets, Butterfly Nets, Hand Seines, and Cast Nets

The minimum mesh size for channel nets, float nets, butterfly nets, and hand seines is one and one-quarter inches [NCMFC Rule 15A NCAC 03L. 0103L(a)(2)]. There is no minimum mesh size for cast nets [NCMFC Rule 15A NCAC 03L. 0103L(a)(3)].

Other Shrimp Trawl Gear Modifications

BYCATCH REDUCTION DEVICES

Bycatch reduction devices are required to be used in all trawls used to harvest shrimp. Proclamation SH-3-2019 describes the BRD requirements for otter trawls in Pamlico Sound and the mouths of the Pamlico and Neuse rivers. Allowable BRDs in these areas include: 1) two Federal Fisheyes placed inline or 2) the Virgil Potter BRD and one Florida Fish Excluder. Otter trawls in all other waters and skimmer trawls statewide are required to have two BRDs installed on each net. The primary BRD must be one of the following: 1) Florida Fish Excluder, 2) Federal Fisheye, 3) Gulf Fisheye, 4) Eight Inch PVC “Sea Eagle” Fish Excluder, 5) General Eight Inch and Ten Inch Large Mesh and Extended Mesh Funnel BRD, 6) Eight Inch and Ten Inch Inshore Large Mesh and Extended Funnel BRD, 7) Large Mesh Funnel Excluder, 8) Jones-Davis BRD, 9) Modified Jones-Davis BRD, 10) Cone Fish Deflector Composite Panel, or a 11) Square Mesh Composite Panel. The secondary BRD may include: 1) a second BRD listed above, 2) Reduced Bar Spacing TED (<3 inches), or 3) a T-90 or Square Mesh (T-45) tailbag. The BRD requirements in all areas do not apply to single test trawls (also called a try net) with a headrope of 12 feet or less provided: 1) the net is pulled immediately in front of another net or is not connected to another net in any way, 2) no more than one net is used at a time, and 3) the net is not towed as a primary net.

TURTLE EXCLUDER DEVICES

The use of a federally approved TED is required in all trawls in accordance with federal rules and are adopted by reference through NCMFC Rule 15A NCAC 03L 0103(h). Currently all otter trawl nets are required to have a federally approved TED if using mechanical retrieval methods. Skimmer trawl vessels 40 feet and greater must have a federally approved TED installed in each

DRAFT – SUBJECT TO CHANGE

net. The TED requirement for skimmer trawls state the bar spacing may not be greater than three inches (compared to otter trawls which are allowed bar spacings up to four inches). Skimmer trawl vessels less than 40 feet will not be required to use TEDs and instead are allowed to use minimum tow times in accordance with federal rules.

FISHING DAYS RESTRICTIONS

The present 9:00 p.m. Friday through 5:00 p.m. Sunday evening closure for Internal Coastal Waters [NCMFC Rule 15A NCAC 03J. 0104(b)(1)] evolved from a February 1984 petition from fishermen to close Core Sound from 8:00 a.m. Saturday to 6:00 a.m. Monday by proclamation so they had time to rest, make boat and gear repairs, etc. Although some fishermen and dealers complained that they needed shrimp for the Monday morning market and there was a fear of effort shifting to adjacent open areas, there was some support for a Sunday night closure. A proposal to close from Saturday morning through Monday morning by rule failed. Fishermen continued to request a weekend closure, and this was tried in July 1984 by proclamation. Core Sound, North, South, and Newport rivers, and Turnagain, Rataan, Cedar, Long, and West bays, and Adams Creek were closed on the weekend from July 15 through December 31, 1984, and this was continued from that time on in some fashion. In 1993 the weekend closure was adjusted to begin one hour after sunset on Fridays and end one hour before sunset on Sundays. A 1993 effort by the NCMFC to extend the closure through Monday morning failed. Actual times (9:00 p.m. and 5:00 p.m.) were implemented in 2004 to avoid confusion with varying times found on sunrise/sunset tables.

DAILY FISHING TIME RESTRICTIONS

In North Carolina it is unlawful to trawl for shrimp in the Atlantic Ocean off Brunswick County, 9:00 p.m. to 5:00 a.m. [NCMFC Rule 15A NCAC 03J .0202 (8)]. This management measure was implemented in large part to reduce the bycatch of finfish in this gear. Ingraham (2003) examined this question by conducting a study of shrimp and finfish catch rates (day vs. night) in state waters from Topsail Inlet to Little River Inlet. Data from the study showed that finfish bycatch was higher at night than during the day. Of the nine commercially important finfish species caught, southern flounder, spot, Atlantic croaker, and southern kingfish (*Menticirrhus americanus*) catch rates were significantly higher at night. The catch of shrimp did not vary significantly between nighttime and daytime trawling, although catches were slightly higher during the day. Additionally, it is unlawful to use trawl nets from December 1 through February 28 from one hour after sunset to one hour before sunrise in portions of the Pamlico, Pungo, Bay, Neuse, and New rivers [15A NCAC 3J .0104 (b) (5)(A)(B)(C)(D)(E)]. This was originally put in place to protect juvenile southern flounder that were being harvested from crab trawls (K. West, NCDMF, personal communication).

In 1997, many Sneads Ferry trawl fishermen requested opening the New River to daytime shrimp trawling only. This was not based on any biological information. Many of the local shrimpers preferred to fish during the daytime and wanted to keep trawlers from neighboring areas out of New River at night. NCMFC Rule 15A NCAC 03J .0208, effective in 1998, makes it unlawful to use trawl nets upstream of the Highway 172 Bridge over New River from 9:00 p.m. through 5:00 a.m. when opened by proclamation from August 16 through November 30.

DRAFT – SUBJECT TO CHANGE

TOW TIME RESTRICTIONS

Skimmer trawls less than 40 feet are exempt from TED requirements in lieu of tow time restrictions (55 minutes from April to October and 75 minutes from March to November). However, skimmer trawls 40 feet and greater in length are required to use a TED with a bar spacing of no more than three inches in each net. Similarly, try nets are exempt from TED requirements in lieu of tow time restrictions (55 minutes and 75 minutes, seasonally). This exemption is also contingent on: 1) the net is pulled immediately in front of another net or is not connected to another net in any way, 2) no more than one net is used at a time, and 3) the net is not towed as a primary net.

TRIP/CREEL LIMITS

Currently, there are no trip limits for the commercial shrimp fishery. However, there are creel limits for the recreational shrimp fishery. In areas open to shrimp harvest, recreational fishermen are limited to no more than 48 quarts (heads on) or 30 quarts (heads off) of shrimp per person per day or per vessel per day if a vessel is used [NCMFC Rule 15A NCAC 03L .0105(1)]. However, if more than one RCGL holder is aboard a vessel they are limited to no more than 96 quarts (heads on) or 60 quarts (heads off) of shrimp per vessel per day [NCMFC Rule 15A NCAC 03O .0303(e)(f)]. In areas closed to the harvest of shrimp, no more than four quarts (heads on) or two and one-half quarts (heads off) of shrimp per person per day may be taken by cast net only [NCMFC Rule 15A NCAC 03L .0105(2)]. Although it should be noted no areas are completely closed to shrimp harvest; however, enforcement of this rule has used the areas closed to taking shrimp with nets as defined in proclamation as areas closed to the taking of shrimp under this rule.

OTHER GEARS

In addition to trawls, several other gears are used to harvest shrimp, these include but are not limited to channel nets, seines, cast nets, shrimp pots, and shrimp pounds. Current management measures, implemented through proclamation, restrict the commercial and recreational harvest of shrimp (therefore effort) with nets to shrimp trawls, crab trawls, seines, and cast nets to specific areas and times. Areas are open to harvest with seines and cast nets at the same time they open to shrimp and crab trawls, so the use of these non-trawl nets is limited to when areas are opened to trawling. The use of shrimp pounds, shrimp pots, channel nets, fyke nets, and other non-net gears used to harvest shrimp are not limited to areas and times open to shrimp trawls, crab trawls, seines, and cast nets. Harvest of shrimp with other types of nets not specifically listed above (such as gill nets) is prohibited regardless of the area or time. These restrictions on harvest with other gears were primarily put in place due to issues of fairness over access to the shrimp resource raised by shrimp trawl fishermen as well as some fishermen wanting to delay harvest of shrimp until they were larger and more valuable.

Channel nets are also managed with area closures (Proclamation M-10-2007). Permanently closed areas are: 1) all waters bound on the north by the site of the old N.C. Highway 210-50 swing bridge at Surf City and on the south by a line beginning on the east side of the Intracoastal Waterway (IWW) at 34° 25.6049' N, 77° 33.4116' W running to a point on the west side of the IWW at 34° 25.7193' N, 77° 33.4649' W to include all areas on either side of the IWW channel and 2) the New River marked navigation channel from Marker #17 to New River Inlet. While some areas are

DRAFT – SUBJECT TO CHANGE

permanently closed to channel nets, others are closed unless they are open to shrimping with other gears by proclamation. These areas include: 1) New River above a line beginning at a point on the north shore 34° 34.9000'N – 77° 24.1740' W running southerly through Marker # 25 to a point on the south shore 34° 34.2700' N – 77° 24.4770' W, 2) areas adjacent to the IWW from the site of the old Highway 210-50 Surf City swing bridge to IWW Marker #49, and 3) the Cape Fear River. Closures (permanent or conditional) for channel nets were typically put in place to address user conflict issues.

AREA RESTRICTIONS

Area restrictions for trawling have been used to deal with allocation, resource, habitat, and safety issues in North Carolina. During the late 1980s trawling was prohibited in Albemarle Sound and its tributaries [15A NCAC 3J .0104 (b) (3)]. This action was implemented to protect the flounder fishery in this area (allocation issue) and to reduce conflicts with crab pot fishermen. Since 1978 over 124,000 acres of estuarine nursery areas have been closed to trawling to protect juvenile fish and crustaceans. NCMFC Rule 15A NCAC 3N .0102 (a) defines Nursery Areas “as those areas in which for reasons such as food, cover, bottom type, salinity, temperature and other factors, young fish and crustaceans spend the major portion of the initial growing season.” There are approximately 77,000 acres of Primary Nurseries (PNAs), 55,000 acres of Secondary Nursery Areas (SNAs), and 28,000 of Special Secondary Nursery Areas (SSNAs). PNAs and SNAs are permanently closed to trawling, while SSNAs may only be opened to trawling by proclamation from August 16 through May 15. In the mid-1990s the seagrass beds along the Outer Banks were closed to trawling to protect this critical habitat. Over 78,000 acres of military danger zones and restricted areas are also closed to trawling for safety reasons. In all, approximately 47% of estuarine waters are closed to trawling and 53% are open or managed. In state ocean waters, approximately 8% are closed and 92% are open or managed for trawling. Although, it should be noted that not all these open, closed, and managed areas are ideal for shrimp trawling. For additional discussion of area closures for shrimp trawls see *Appendix 2.2: Shrimp Management in Special Secondary Nursery Areas* or *Appendix 2.3: Reducing Shrimp Trawl Bycatch Through Area Closures that Increase Connectivity Between Closed Areas*.

SEASON RESTRICTIONS

Harvest seasons have been used to reduce bycatch by relegating fishing activity to times of maximum target species abundance, or by limiting activity during times of high bycatch. Currently shrimp trawling is permitted all year in North Carolina. However, some areas are only opened to shrimp trawling for limited time periods. These include SSNAs, other managed shrimp trawl areas, and Crab Spawning Sanctuaries. For additional discussion of season closures see *Appendix 2.2: Shrimp Management in Special Secondary Nursery Areas* or *Appendix 2.3: Reducing Shrimp Trawl Bycatch Through Area Closures that Increase Connectivity Between Closed Areas*.

IV. AUTHORITY

North Carolina General Statutes
G.S. 113-134 RULES

DRAFT – SUBJECT TO CHANGE

G.S. 113-173 RECREATIONAL COMMERCIAL GEAR LICENSE

G.S. 113-182 REGULATION OF FISHING AND FISHERIES

G.S. 113-182.1 FISHERY MANAGEMENT PLANS

G.S. 143B-289.52 MARINE FISHERIES COMMISSION – POWERS AND DUTIES

North Carolina Marine Fisheries Commission Rules

15A NCAC 03J .0104 TRAWL NETS

15A NCAC 03L .0101 SHRIMP HARVEST RESTRICTIONS

15A NCAC 03L .0102 WEEKEND SHRIMPING PROHIBITED

15A NCAC 03L .0103 PROHIBITED NETS, MESH LENGTHS AND AREAS

15A NCAC 03L .0105 RECREATIONAL SHRIMP LIMITS

V. DISCUSSION

The management options presented in this paper are a starting point for discussion on reducing effort in the shrimp trawl fishery to limit or reduce bycatch. Public input could provide additional options.

Carry Forward Items from Amendment 1

There are a few effort reduction management measures that will be carried forward from Amendment 1 and the 2018 Revision to Amendment 1 to the N.C Shrimp Fishery Management Plan (NCDMF 2015, 2018). These include: 1) requiring shrimp trawls, with the exception of skimmer trawls, to use BRDs or gear configurations that reduce finfish bycatch by at least 40% over a standard shrimp trawl consisting of a Florida fisheye BRD, a federally approved TED, and a 1.5-inch stretch mesh tailbag, 2) allowing any federally certified BRD to be used in areas where new BRD or gear configurations have not been established, and 3) requiring two approved BRDs to be used in shrimp trawls in areas where new BRD or gear configurations have not been established.

Limited Entry

Limited entry methods of management restrict access to a fishery. Capping or reducing fishing effort can protect the biological viability of a species and the economic integrity of the fishery. The species is protected by preventing overfishing and depletion of the stocks. The fishery is enhanced by reducing costs and increasing earnings, effectively increasing efficiency. Other benefits of limited entry programs include an incentive to conserve, more efficient management, bycatch minimization, and habitat protection. However, piecemeal implementation of limited entry programs can easily displace fishing effort from one fishery to create new problems in other areas and fisheries (Buck 1995). For bycatch reduction, limited entry systems are often used in conjunction with other management measures, such as quotas or trip limits to achieve management objectives.

North Carolina General Statute 113-182.1 states the NCMFC can only recommend the General Assembly limit participation in a fishery if the commission determines sustainable harvest in the fishery cannot otherwise be achieved. As shrimp in North Carolina are managed as an annual crop,

DRAFT – SUBJECT TO CHANGE

due to the strong influence of environmental factors on population size, sustainable harvest is not currently a concern. Therefore, limited entry is not considered a realistic option for managing shrimp at this point due to the statutory constraints on its use. However, several bycatch species in the shrimp trawl fishery are currently classified as either overfished, overfishing is occurring, or both (e.g., weakfish and southern flounder). An amended state FMP for southern flounder (NCDMF 2019) has recently been adopted to recover the stock. Weakfish (ASMFC 2002, 2009a) is an interjurisdictional stock managed by the ASMFC and has an FMP in place to monitor and recover the stock. If it chose to do so, the NCMFC may ask the legislature to limit participation in the shrimp trawl fishery to potentially reduce bycatch of these species. To be effective in reducing bycatch, any limited entry program should not simply “freeze” participation in the shrimp trawl fishery to those currently in the fishery. It would have to reduce the number of participants/vessels to some number below those currently in the shrimp trawl fishery. Although, no clear link has been established between shrimp trawl discards and the status of these species and it will be impossible to attribute any population increases of these species with this type of action due to the many unpredictable human and natural factors that affect fish stock abundance.

If the areas where shrimp trawls can be used are significantly reduced, then limited entry may become more important as fishing effort will become concentrated in smaller areas. This concentration of effort may increase the detrimental effects on the habitat and bycatch species in those areas that remain open. It may also lead to increased conflict among fishermen in these areas competing for resources in limited space.

NCDMF Shrimp Trawl Observer Data Analysis

In order to determine if any trawl gear parameters influenced the catch rate of bycatch in otter and skimmer trawls, NCDMF shrimp trawl observer data from 2012 through 2017 were examined using two different modelling approaches, catch-per-unit-effort (CPUE) and presence/absence models. Observations from 1,567 individual tows were used in the analyses. The results of the analyses generally varied depending on the species or species group included in the model as well as how areas were delineated in the different model scenarios (see *Appendix 2.4.A: Shrimp Trawl Bycatch Effort Analysis* for more details).

There was some variation in the significant predictor variables dependent on the species or species group, scenario, and sub-model. For example, for the CPUE sub-model, there are consistent results for multiple species and species groups across scenarios. Specifically, of the 65 possible combinations of scenarios and species or species groups; year, net type, and season are significant for 80%, 66%, and 52% of the sub-models. Gear parameters such as headrope per boat, wing mesh, and tailbag mesh were not significant factors in any of the CPUE sub-models; however, potentially valuable species-specific information was still extracted from the analysis. For example, spot and weakfish were encountered in shrimp trawls more frequently than other key bycatch species, present in 93% and 54%, respectively, of all trawl samples and present in 99% and 73%, respectively, in trawl samples from Pamlico Sound where the majority of estuarine shrimp harvest and effort occurs. For spot, net type was a significant factor in the 3-area (Pamlico, inshore, offshore), 2-area (inshore, offshore), and inshore models with tongue style nets having more spot bycatch than two-seam and four-seam nets. Similarly, net type was also a significant factor for weakfish in the 3-area, 2-area, inshore, offshore, and Pamlico models with tongue nets having

DRAFT – SUBJECT TO CHANGE

more weakfish bycatch. While not entirely surprising, this does suggest net type may be important to consider when discussing gear modifications to reduce bycatch for these species. Season was also consistently a significant factor for weakfish in all models. With summer having higher rates of weakfish bycatch in the 3-area, 2-area, inshore, and offshore models, and the fall having higher rates of weakfish bycatch in the Pamlico model. This suggests for weakfish that season should be considered when discussing methods to reduce weakfish bycatch and that one approach may not work for all areas.

The presence/absence sub-models provided less clearly distinct generalizations yet, there is still valuable species-specific information. In the presence/absence models used for zero-inflated species (those with high numbers of zero catches), total headrope per boat (summer flounder), wing mesh size (Atlantic croaker and summer flounder), and tailbag mesh size (summer flounder) were selected as significant factors and may provide some direction for future research.

Due to the onboard observations being made opportunistically and inconsistently across years, months, and areas many had few or no observations. Modelling efforts were further hampered by the high number of zero catches for some species as well as variations in the level of data collected for each tow. Due to these limitations the results should be viewed as exploratory and inconclusive. However, some factors were repeatedly selected as significant among models including year, net type (typically indicating increased bycatch in tongue nets), and season (typically indicated increased bycatch in the fall). Although the results of these analyses are inconclusive, it does provide some direction for future research efforts. The significant data gaps also highlight the need for consistent monitoring of discards in the shrimp trawl fishery through a dedicated onboard observer program. This will allow managers to better quantify shrimp trawl bycatch and its impact on bycatch species as well as provide additional data that can be used to research and implement more constructive and focused means to reduce bycatch in the shrimp trawl fishery.

Headrope Limit

In early 2020, the NCDMF surveyed active shrimp trawlers to gather information on the characteristics of gear currently used in the shrimp trawl fishery (Stewart and Dietz 2021). Of the 521 active shrimp trawlers, headrope length data were received for 212 gear configurations (197 otter and 15 skimmer) from 146 shrimp trawlers (135 otter and 11 skimmer) active in the shrimp trawl fishery. The headrope data came from a representative cross section of the shrimp trawl fishery. The highest percentage of vessels in the shrimp otter and skimmer trawl fleets occur in the 20-29-ft vessel size category and likewise survey responses were highest from this group (Figures 2.4.15 and 2.4.16). For both the otter trawl (Figure 2.4.17) and skimmer trawl (Figure 2.4.18) fleets, the total amount of headrope fished increased with vessel size. Vessels 60 feet and greater in length were found to fish up to the maximum amount of headrope allowed to be fished (220 feet in Pamlico Sound), though not all vessels do so. The median total amount of headrope fished by vessels in the 60-ft category was 180 feet, 200 feet in the 70-ft category, and 220 feet in both the 80 and 90-ft categories. The most common net type being fished by the shrimp trawl fleet is tongue nets (51%), followed by two-seam (25%), four-seam (16%), and skimmer (7%; Figure 2.4.19).

In the analysis of NCDMF shrimp trawl observer data (described above), total headrope per boat was not a significant factor influencing the amount of bycatch in any of the CPUE sub-models. In

DRAFT – SUBJECT TO CHANGE

the presence/absence models used for zero-inflated species, total headrope per boat was a significant factor influencing bycatch of summer flounder. This analysis suggests the effects of total headrope per boat on bycatch catch rates may be an important factor for some species and should be investigated further.

Shrimp trawl design has evolved to improve the efficiency of the gear to capture shrimp and maximize area swept. Regulations limiting total headrope length will likely reduce the efficiency of both large and small vessels using trawls with headropes larger than 35 feet. Thus, overall effort will likely be reduced due to a loss of fishing power and fishermen leaving the fishery because it is no longer economically feasible. Not only will the current gear configuration used by many fishermen become obsolete, but operating costs may begin to exceed the value of their catch. Shifts in effort may also occur putting more pressure on already overburdened fishing locations, leading to increased conflict and potentially local increases in bycatch. Fishermen attempting to compensate for lost catches because of being forced to use less efficient gear may make more or longer tows, potentially generating as much or more bycatch. Reductions in bycatch may also be minimal if crews of larger vessels begin operating multiple smaller vessels, not only increasing effort (participants and trips) but the total amount of headrope being fished by the fleet. Additionally, some fishermen may begin towing at a faster speed to attempt to cover more area or increase the depth (height) of their nets to maintain shrimp numbers. This could increase bycatch by reducing the efficiency of existing BRDs. There is also the potential for shifts in the species and size makeup of the bycatch. If larger vessels are forced out of the internal coastal waters into the ocean due to regulations that reduce total headrope length, more pressure may be put on the winter ocean spawners (e.g., spot, Atlantic croaker, sheepshead, and southern flounder). While reducing headrope length has the potential to reduce bycatch associated with inshore trawling (Watson et al. 1984), the issue is extremely complex making it difficult to quantify its total impact on bycatch species and the fishery beyond a reduction in effort.

If the areas where shrimp trawls can be used are significantly reduced, then reducing the amount of headrope allowed in Internal Coastal Waters may be needed as fishing effort will be further concentrated into smaller areas. This concentration of effort may have detrimental effects on the habitat and bycatch species in those areas. It may also lead to increased conflict among fishermen in these areas competing for resources in limited space.

Otter Trawl Headrope/Footrope Regulations in Other States

All states in the U.S. South Atlantic have enacted various regulations limiting maximum headrope length, which often varies by area, fleet (commercial or recreational), and purpose (food or bait; Appendix 4). Estuarine trawling is prohibited in much of South Carolina; however, in designated areas fishermen may use shrimp trawls with a combined footrope length no greater than 220 feet. In Georgia, it is unlawful to fish for shrimp for human consumption with trawls having a total footrope length greater than 220 feet (only allowed in state ocean waters) and commercial and recreational bait shrimpers are restricted to trawls with maximum footrope lengths of 20 feet and 10 feet, respectively in designated bait shrimp areas. In the nearshore and inshore waters of Florida where otter trawls are allowed, fishermen are limited to a single net with a headrope no greater than 10 feet. Two trawls may be used in certain nearshore and inshore regions; however, combined

DRAFT – SUBJECT TO CHANGE

headrope length cannot exceed 20 feet. Outside of these areas trawlers may use a single net with headrope no greater than 20 feet.

States along the Gulf of Mexico have also limited the maximum headrope length and the number of nets fishermen can use (Appendix 4) typically to address conflict issues within the fishery. In Alabama, commercial vessels operating in Mobile Bay and its sounds are limited to two trawls with a maximum combined headrope length of 50 feet. In the offshore waters of Alabama there is no restriction on headrope length. Commercial and recreational bait trawlers are restricted to a single trawl with a maximum headrope length of 16 feet. In Mississippi, commercial shrimp trawlers operating in internal waters can use one trawl with a maximum headrope length of 50 feet or two 25 foot trawls. Recreational fishermen are limited to a 16 foot maximum headrope length. Commercial vessels fishing inshore waters of Louisiana are limited to one net with a headrope length of 50 feet or two 25 foot nets [except in Breton and Chandeleur sounds two nets with a headrope length of 65 feet (130 feet combined) may be used]. Vessels fishing in Louisiana's state ocean waters may use up to 130 feet of headrope. Recreational fishermen are limited to one net with a maximum headrope length of 25 feet. In major bays of Texas, commercial fishermen targeting penaeid shrimp may use a single net with a headrope measuring 40 to 54 feet during the spring (statewide) and winter (south of the Colorado River) seasons and may use a single net with a headrope not exceeding 95 feet during the fall season. Commercial bait fishermen are also limited to a single net with a headrope measuring 40 to 54 feet. Commercial vessels operating in Texas state ocean waters may use two trawls with headrope lengths ranging from 71 to 89 feet based on door size inside three nautical miles and are not limited by number of nets or headrope from three to nine nautical miles offshore.

Skimmer Trawl Headrope Regulations in Other States

While headrope length is most associated with otter trawls, headrope length can also be used to describe the length of the support structure the mesh or webbing attaches to nearest the surface of the water for skimmer trawls. Thus, the headrope length of most skimmer trawls is dictated by the length of the skimmer trawl frame. Very few states have specific regulations for skimmer trawl configuration regarding headrope length and design (Appendix 4). Mississippi's skimmer trawl regulations mirror their otter trawl regulations, limiting vessels to two nets with a 25 foot headrope on each diagonal arm (not to exceed a combined headrope length of 50 feet). In Florida, skimmers must be equipped with rollers and vessels are limited to two unconnected trawls with upper and lower horizontal beams that do not exceed 16 feet in length each net. In most states where skimmer trawl net and frame lengths are not specified, headrope length is defined to include the length of supporting structure that is the nearest to the surface of the water.

Fishing Days Restriction

Adding additional day(s) of the week to the present closed trawling period is another time related bycatch reduction measure to consider. Although an additional day added to the weekend closure, be it Friday or Monday, would reduce shrimp trawling effort, it is not possible to quantify the reduction in bycatch. A uniform number of shrimp, as well as bycatch species, are not caught each available trawling day so an additional closed day may not reduce bycatch significantly. Regardless of the day(s) of the week closed, it has been observed the best catches of shrimp are on

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the night of the opening after the weekend “rest period”. Johnson (2006) noted twice as much shrimp were caught early in the five-day trawling week than later in the week in the coastal shrimp trawl fishery in NC, suggesting extending the weekly closure could further improve the efficiency of the shrimp trawl fishery. Extending the weekend closure would likely reduce effort; however, reducing the number of days available for shrimp trawling does not consider days already lost to wind and weather, unfavorable tides, moon phases, etc. Additional day(s) added to the weekend closure may also disproportionately impact RCGL holders and part-time fishermen who shrimp trawl mainly around the weekends.

Daily Fishing Time Restriction

Reducing the number of hours in a day when shrimp trawling is allowed is another way to potentially reduce bycatch. The habits of North Carolina’s three shrimp species determine when they are targeted. In the central part of the state, brown and pink shrimp usually burrow into the substrate during the day and trawling for them usually occurs at night. Occasionally trawling for brown shrimp can occur during the daytime when waters are murky. These trips usually last one night or one day. Larger trawlers fishing in Pamlico Sound and the Atlantic Ocean with the capacity to store ice usually stay out four or five days and tow day and night. White shrimp are found higher up in the water column and fishing for them occurs mainly during the day with some fishing at night as well.

South Carolina shrimp trawling has been closed at night since the 1970s, but that was enacted to keep North Carolina fishermen from catching brown shrimp at night because South Carolina fishermen wanted to work during the day, not for any biological reason (L. DeLancey, SCDNR, personal communication). Georgia, Mississippi, Louisiana, and Texas also close all or parts of their shrimp trawl fisheries to nighttime trawling (Appendix 4).

Tow Time Restriction

Another way to potentially reduce effort in the shrimp trawl fishery is to restrict individual tow times. A tow time limit of 45 minutes has been mentioned by the public. Although reducing tow times should logically reduce bycatch, in reality that may not necessarily occur as additional tows could be made and result in minimal reductions in the amount of time the trawl is actually fishing. Reduced tow times could likely reduce bycatch mortality for some species by allowing them to be released from the trawl more quickly. Fish aggregations, as well as shrimp aggregations, are not uniformly distributed and each tow is different depending on depth, tide stage, moon phase, bottom type, etc. Carothers and Chittendon (1985) found a significant linear relationship between catch and tow duration (i.e., the longer you tow, the more you catch). Their study examined the catch for tow times of 5, 10, 15, 20, 25, and 30-minute durations.

A tow time requirement would be very difficult to enforce without constant Marine Patrol oversight or costly Vessel Monitoring Systems. Tow times in the ocean were enforced from 1996 through 2005 under a now-expired Incidental Take Permit from NOAA issued to trawlers from Browns Inlet to Rich Inlet due to the presence of brown algae. This involved constant monitoring by observers and was very difficult to enforce. The timing of tows began when the otter trawl doors were lowered into the water and ended when they exited the water. Skimmer trawl tows

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could not be timed in that way since they are towed continuously and the tailbags are pulled in and emptied periodically. Additional tows could be made to make up for the “lost effort” of limited tow times. Although, limiting tow times may be effective in reducing bycatch mortality in individual tows.

Trip/Creel Limits

Another method of reducing effort is to establish commercial trip limits or recreational creel limits. The reasoning behind this method is the expectation that once the limit is reached fishermen will either cease fishing for the day or begin to target another species.

Commercial Fishery

In the commercial shrimp trawl fishery, establishing a trip limit may be effective in reducing overall shrimp trawl effort and therefore presumably reducing the amount of bycatch and dead discards. However, the limit would have to be high enough for a trip to still be profitable but low enough that the vessel would have to cease fishing operations for the day for single day trips or to return to port to offload their catch at least once during the weekly open period if capable of multi-day trips. Establishing vessel limits for annual crop species (such as shrimp) in high volume fisheries that can have large annual fluctuations in abundance due to environmental conditions can be difficult. Adding to the difficulty for shrimp in North Carolina is the wide range in the size of vessels and size of gear used in the fishery and the subsequent range in how many pounds can be stored onboard across vessel sizes. Establishing a trip limit that works for 40 foot vessels may not work for 80 foot vessels in terms of maintaining profitable trips. Waste would also be a potential issue if the trip limit were set too low given the high-volume nature of the fishery. Additionally, enforcement of this type of measure can be difficult to enforce without adequate assets in place (ASMFC 2009b).

Recreational Fishery

As previously discussed, the recreational fishery has different creel limits in place for areas open versus closed to shrimp harvest (keeping in mind no areas are completely closed to shrimp harvest). Increased access could be given to recreational fishermen in areas closed to shrimp harvest with nets (this is how the rule has been enforced) by allowing non-trawl net gears (i.e., seines and other non-trawl nets) to be used to harvest shrimp in areas closed to shrimp harvest with nets (would only be trawl nets if this change is made), increasing the creel limit for areas closed to shrimp harvest with nets, or both. With these gears, discards of bycatch species are not a big concern so allowing them would presumably have little negative impact on bycatch species. Removing the four quarts (heads on) or two and one-half quarts (heads off) creel limit for cast nets in closed areas and allowing recreational harvest limited to 48 quarts (heads on) or 30 quarts (heads off) of shrimp per person per day or per vessel for all gears would simplify regulations and allow additional harvest opportunities for recreational fishermen if additional areas are closed to shrimp harvest with trawls. This could be accomplished by repealing NCMFC Rule 15A NCAC 03L .0105(2).

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Other Gears

As previously stated, the reason for tying the opening of crab trawls, seines, and cast nets and prohibiting harvest with other nets (except for channel nets and fyke nets) with shrimp trawls was done primarily due to fairness issues raised by shrimp trawl fishermen. With the possibility of additional area and/or seasonal closures for shrimp trawls, severing the tie between when areas open to shrimp trawls versus other net gears would eliminate impacts to these gears from additional shrimp trawl closures. Additionally, fishermen holding a RCGL may have the use of shrimp trawl gear severely reduced if additional areas are closed to shrimp trawling (either permanently or seasonally). Having additional harvest opportunities using seines and cast nets may alleviate some of these impacts. Even if additional closures are not adopted for shrimp trawls, removing the connection between non-trawl gears and shrimp trawls will allow additional harvest opportunities for fishermen using these gears, simplify regulations, and ease confusion over what areas are open to which gears.

While some areas are permanently closed to channel nets, others are closed until they are opened to shrimp harvest with other gears. This has been enforced to mean when these areas are open to taking shrimp with nets as defined in proclamation. These areas include: 1) New River above a line beginning at a point on the north shore 34° 34.9000'N – 77° 24.1740' W running southerly through Marker # 25 to a point on the south shore 34° 34.2700' N – 77° 24.4770' W, 2) areas adjacent to the IWW from the site of the old Highway 210-50 Surf City swing bridge to IWW Marker #49, and 3) the Cape Fear River. Removing the dependency on other gears (i.e., shrimp trawls) for these areas to be opened to channel nets will allow increased access to channel net fishermen in these areas. This may be more desirable if the areas where shrimp trawls can be used are significantly reduced or the areas where channel net openings are dependent on other gears become permanently closed to shrimp trawls.

Economic Impacts

Each of the different management measures discussed in this paper would have economic impacts to the shrimp fishery with economic consequences for those operating and working on shrimp trawlers. Any reduction in effort will likely reduce the efficiency of the shrimp trawl fishery and consequently reduce the amount of shrimp harvested and likewise profitability of each trip. This may also lead to reduced employment in the shrimp trawl fishery as operators have to deal with tighter profit margins. However, there is also the possibility for economic gains in other portions of the shrimp fishery as well as other fisheries. Additional opportunities for recreational and commercial fishermen using non-trawl gears may lead to some economic gains for commercial fishermen using these gears and recreational fishery suppliers as fishermen purchase additional gear. Another potential benefit of reduced shrimp trawl effort may be improved habitat and reduced bycatch mortality (hence increased survival) of bycatch and other species and thus have more available for harvest as recruits grow into the fishery (both commercially and recreationally). Additionally, improved habitat may also improve other economic niches like eco-tourism. Although, these types of economic benefits are more abstract, uncertain, and dependent on other external factors.

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Summary

While the management measures presented here have the potential to reduce effort and presumably bycatch and dead discards in the shrimp fishery, the necessary data do not exist to adequately quantify the full impact any of these regulations may have on bycatch reduction and survival as well as on the shrimp fishery and its associated industries. Limited entry would be difficult to implement with the current statutory restrictions but may need to be explored depending on other management measures enacted in this or future FMPs. While no clear connection between headrope length and bycatch has been established, this measure may warrant consideration if the areas open to shrimp trawling are significantly reduced. Reducing the number of days open to shrimp trawling would have some reduction on effort but may disproportionately impact part-time and RCGL fishermen. Daily fishing time restrictions may also reduce effort and would likely impact boats that make multi-day trips. Limiting tow times would likely reduce bycatch mortality but is difficult to enforce. Establishing commercial trip limits may also reduce effort but determining an appropriate trip limit that balances ecological and economic considerations will be difficult. Simplifying recreational creel limits will aid both the fishing public and enforcement actions. Additionally, removing the dependency of other gears on shrimp trawls will help to simplify regulations and potentially create additional opportunities for non-trawl gears. Ultimately, the decision to be weighed will be the potential unquantified gain in some bycatch species versus the losses to an economically important fishery.

VI. PROPOSED RULE(S)

Completed after recommendations are brought forward.

VII. PROPOSED MANAGEMENT OPTIONS

(+ Potential positive impact of action)

(- Potential negative impact of action)

1. *Status quo*: no additional management changes at this time
 - + No additional management changes for fishermen to learn
 - No additional reductions in bycatch
 - Continues disparity between rules and management practices
2. Request the N.C. General Assembly consider limited entry as a means to manage the shrimp trawl fishery
 - + Most effective way to limit effort in the shrimp trawl fishery
 - Current participants may be excluded from the fishery moving forward
3. Reduce the total amount of trawl headrope that may be used per vessel to harvest shrimp in Internal Coastal Waters
 - + May reduce bycatch
 - Effort may increase to make up for loss of efficiency/fishing power
 - Possible financial hardships for fishermen due to loss of fishing power, gear modification, further distance from fishing grounds where headrope limits not imposed

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- May shift effort offshore and further impact other species and/or age classes
4. Reduce the number of days per week shrimp may be harvested using trawls in Internal Coastal Waters
 - + May reduce bycatch
 - + Easy to enforce
 - Effort may increase to make up for loss of fishing days
 - Additional days may be lost due to wind and weather, unfavorable tides, moon phases
 - May impact RCGL holders and part-time fishermen disproportionately
 - May force fishermen to work in unfavorable conditions
 - May increase conflict in more productive areas
 5. Reduce the number of hours during the day trawls may be used to harvest shrimp in Internal Coastal Waters
 - + May reduce bycatch
 - May negatively impact the harvest of brown and pink shrimp
 - May force fishermen to work in unfavorable conditions
 - Increased enforcement responsibilities
 6. Establish a maximum tow time for trawls being used to harvest shrimp in Internal Coastal Waters
 - + Increased survivability of culled bycatch
 - Hard to enforce / increased enforcement
 - Reductions in bycatch offset by additional tows
 - Loss of fishing time due to more haul backs
 7. Establish a trip limit for the commercial shrimp trawl fishery in Internal Coastal Waters
 - + May reduce bycatch
 - May create waste or encourage high grading
 8. Eliminate the four quarts (heads on) or two and one-half quarts (heads off) recreational creel limit for cast nets only in areas closed to shrimping
 - + Increased access to the resource (bait, consumption)
 - + Eliminates confusion over creel limits
 - May increase conflict between recreational and commercial fishermen
 9. Allow non-trawl gears (e.g., seines, channel nets, shrimp pots, shrimp pounds, cast nets, etc.) to harvest shrimp in areas closed to shrimp trawling
 - + Encourages the use of non-bottom distributing gears with less bycatch
 - + Increased access to the resource
 - + Eliminates confusion over what areas are open to shrimp harvest for non-trawl gears
 - Increased conflict over set locations and navigation issues with channel nets

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VIII. RECOMMENDATIONS

Division of Marine Fisheries

- Maintain existing headrope limits for shrimp harvest in Internal Coastal Waters. If needed, implement additional headrope restrictions to resolve user conflicts using current proclamation authority
- Allow non-trawl net gears (e.g., seines, channel nets, cast nets, etc.) to harvest shrimp in areas closed to shrimp trawling (all other existing gear restrictions would remain in place)
- Eliminate the four quarts (heads on) or two and one-half quarts (heads off) recreational creel limit for cast nets only in areas closed to the taking of shrimp

Northern Advisory Committee

- Cannot support these options because there are no quantifiable data or targets to apply to the options.

Southern Advisory Committee

- Cannot support these options because there are no quantifiable data or targets to apply to the options.
- Recommend the NCMFC supports focused studies on the effects of effort and gear restrictions on bycatch.

Finfish Advisory Committee

- Continue to work toward bycatch reduction with gear modification and devices with industry input taking the lead with the support of the division.
- Strongly encourages the NCDMF to enhance data collection to obtain the data to be able to better quantify bycatch in the shrimp trawl fishery, and its impacts on the populations of concern.

Shellfish and Crustacean Advisory Committee

- Continue to work toward bycatch reduction with gear modification and devices with industry input taking the lead with the support of the division.

Habitat and Water Quality Advisory Committee

- No motion or recommendation.

NCMFC Selected Management Strategy

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Tables

Table 2.4.1. Summary of North Carolina commercial shrimp trawl characterization studies performed by the division, 2007-2017.

Study Details			Bycatch Characteristics	Species							
				Atlantic croaker	spot	weakfish	blue crab	southern flounder	sheepshead	protected species	
Study 1 Brown 2009	Study Period	7/2007 – 6/2008	Percent of Catch	25%	7%	2%	<1%	<1%	<1%	sea turtles	3
	Area Fished	Ocean	Size Range	120 – 180 mm	90 – 140 mm	50 – 305 mm	-	<355 mm	-	Atlantic sturgeon	0
	Fishing Days Observed	143 (trips)	At-net Mortality	n/a	n/a	n/a	n/a	n/a	n/a	marine mammals	0
	Trawl Type	Otter								birds	0
	Number of Tows Sampled	314									
Study 2 Brown 2010	Study Period	7/2009 – 12/2009	Percent of Catch	33%	13%	6%	2%	<1%	0%	sea turtles	0
	Area Fished	Pamlico Sound	Size Range	100 – 140 mm	80 – 120 mm	70 – 150 mm	-	130 – 180 mm	n/a	Atlantic sturgeon	0
	Fishing Days Observed	66 (trips)	At-net Mortality	n/a	n/a	n/a	n/a	n/a	n/a	marine mammals	0
	Trawl Type	Otter								birds	0
	Number of Tows Sampled	191									
Study 3 Brown 2015	Study Period	8/2012 – 8/2015	Percent of Catch	34 – 49%	10 – 21%	2%	<1 – 2%	<1 – 2%	<1%	sea turtles	1
	Area Fished	Estuary and Ocean	Size Range	100 – 170 mm	80 – 120 mm	70 – 180 mm	-	100 – 300 mm	-	Atlantic sturgeon	0
	Fishing Days Observed	388	At-net Mortality	23%	66%	87%	-	0 – 88%	-	marine mammals	0
	Trawl Type	Otter								birds	0
	Number of Tows Sampled	1,037									
Study 4 Brown 2016	Study Period	1/2015 – 11/2015	Percent of Catch	5%	1%	1%	2%	<1%	<1%	sea turtles	4
	Area Fished	Estuary	Size Range	100 – 180 mm	60 – 110 mm	140 – 210 mm	-	80 – 130 mm	-	Atlantic sturgeon	0
	Fishing Days Observed	62	At-net Mortality	41%	82%	97%	-	-	-	marine mammals	0
	Trawl Type	Skimmer								birds	1
	Number of Tows Sampled	238									
Study 5 Brown 2017	Study Period	1/2016 – 12/2016	Percent of Catch	8 – 27%	1 – 11%	<1 – 4%	<1%	<1%	0 – <1%	sea turtles	4
	Area Fished	Estuary and Ocean	Size Range	70 – 180 mm	60 – 190 mm	80 – 190 mm	-	-	-	Atlantic sturgeon	2
	Fishing Days Observed	72	At-net Mortality	21%	77%	100%	-	-	-	marine mammals	0
	Trawl Type	Otter and Skimmer								birds	0
	Number of Tows Sampled	218									
Study 6 Brown 2018	Study Period	7/2017 – 12/2017	Percent of Catch	6 – 35%	1 – 7%	<1 – 6%	<1 – 3%	<1 – 1%	0 – <1%	sea turtles	1
	Area Fished	Estuary and Ocean	Size Range	100 – 170 mm	70 – 210 mm	-	-	-	-	Atlantic sturgeon	0
	Fishing Days Observed	25	At-net Mortality	24 – 33%	n/a	-	-	-	-	marine mammals	0
	Trawl Type	Otter and Skimmer								birds	0
	Number of Tows Sampled	70									

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Figures

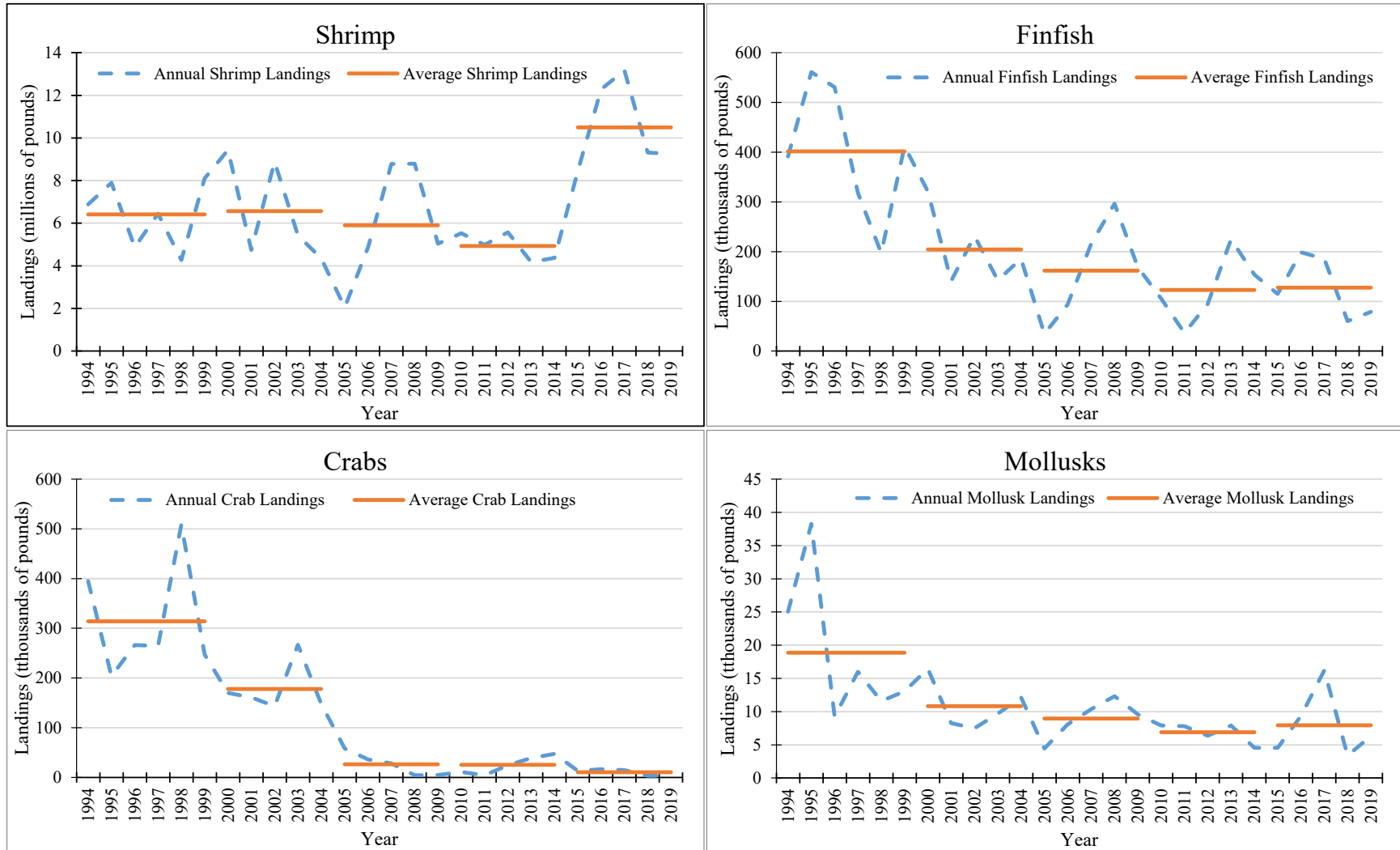


Figure 2.4.1. Annual landings (dashed line) and average landings (solid lines) of shrimp and incidental landings of finfish, crab, and mollusks from the commercial shrimp trawl fishery, 1994-2019. Note: the solid lines represent the average landings for the period covered.

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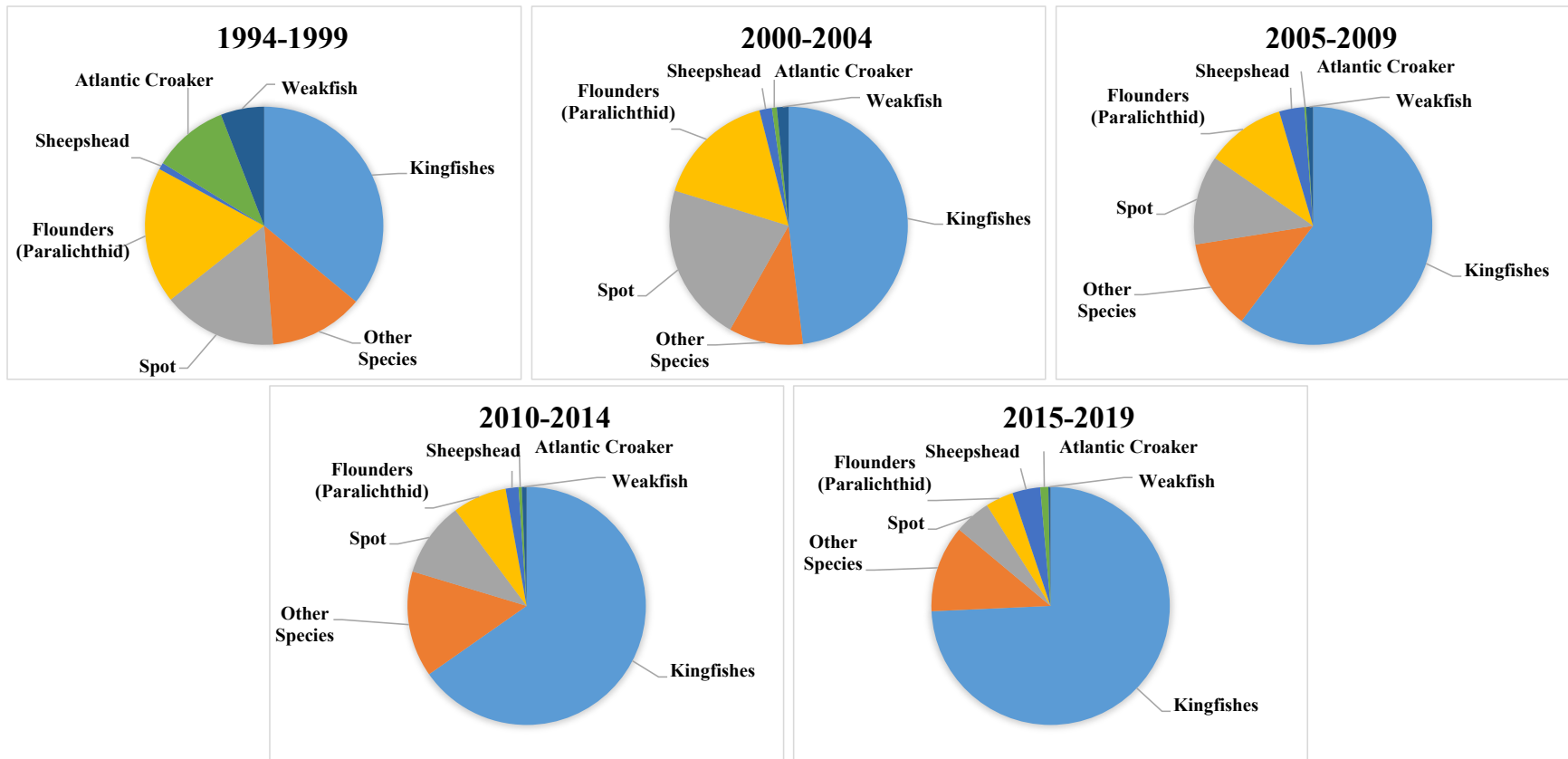


Figure 2.4.2. Proportional species makeup of incidental finfish landings in the shrimp trawl fishery for different periods, 1994-2019.

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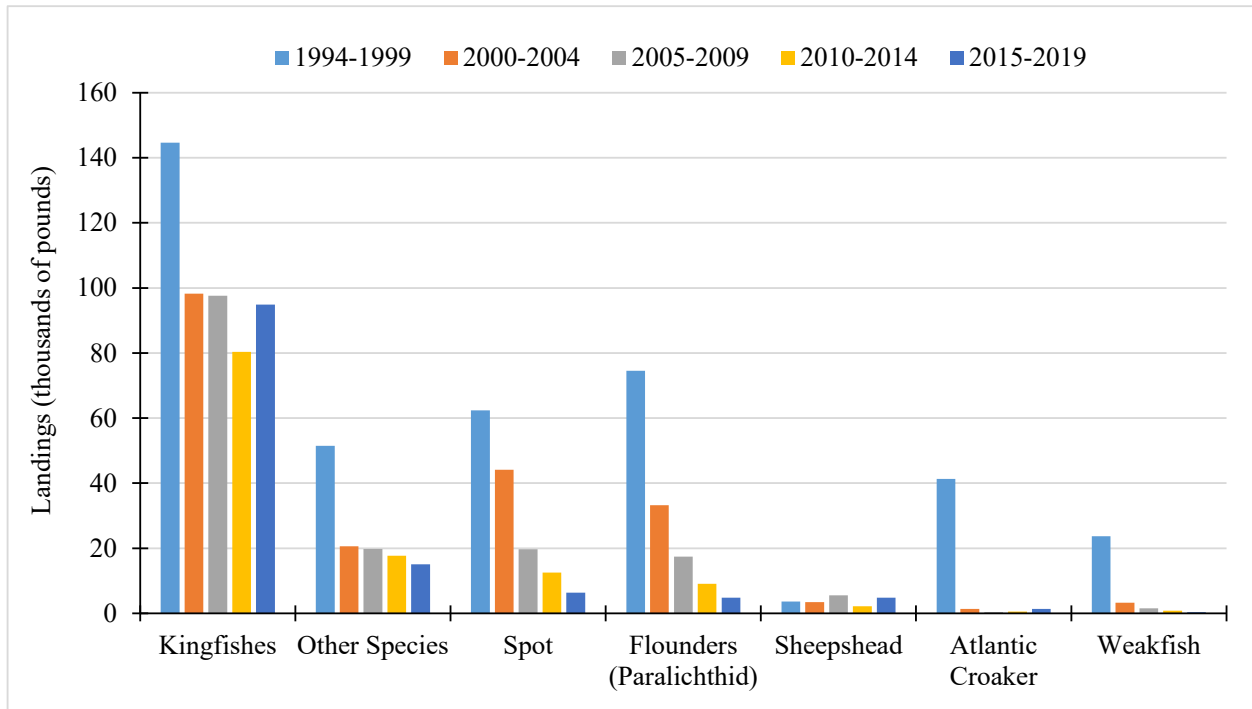


Figure 2.4.3. Average incidental landings of finfish species in the shrimp trawl fishery for different periods, 1994-2019.

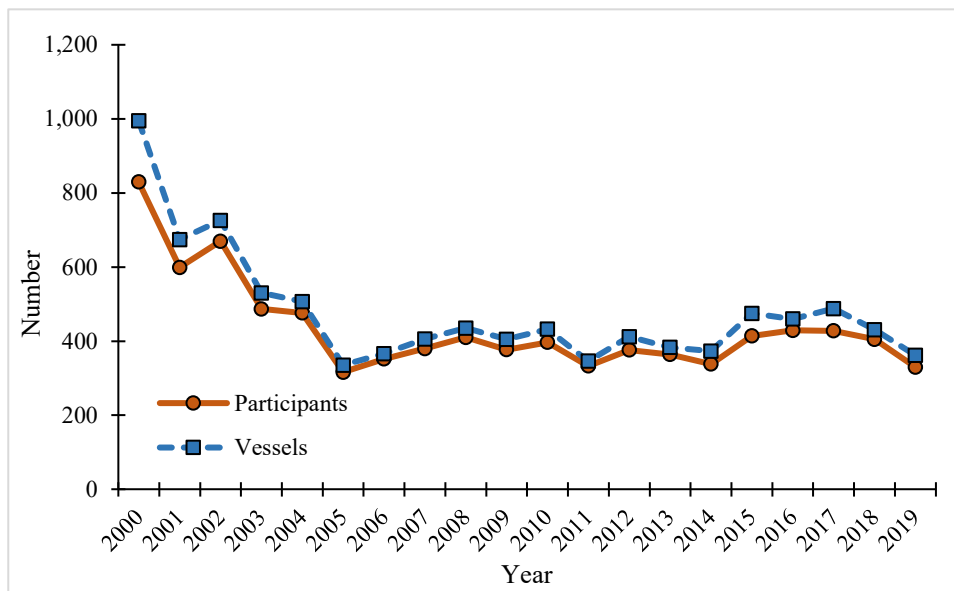


Figure 2.4.4. Number of participants and number of vessels in the North Carolina shrimp otter trawl fishery by year, 2000 – 2019.

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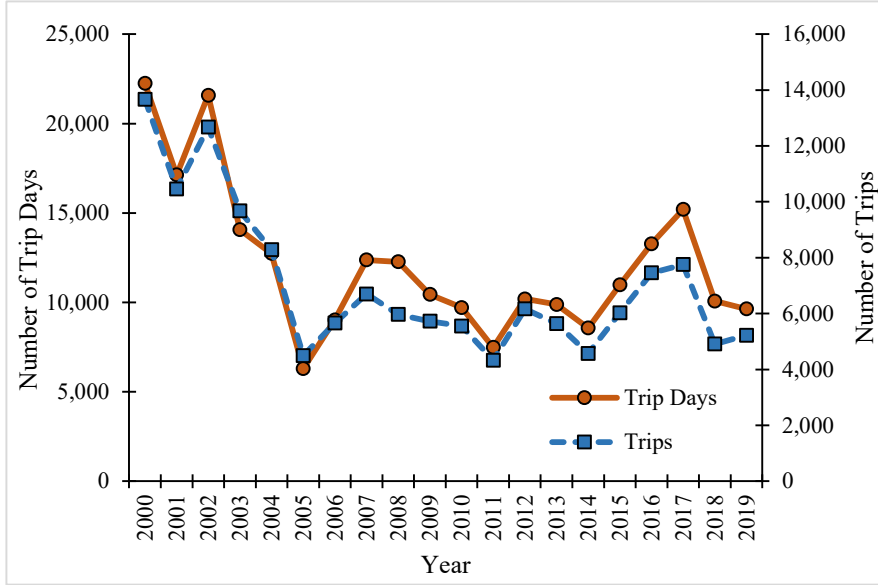


Figure 2.4.5. Number of trip days (number of trips x trip duration) and number of trips in the North Carolina shrimp otter trawl fishery by year, 2000 – 2019.

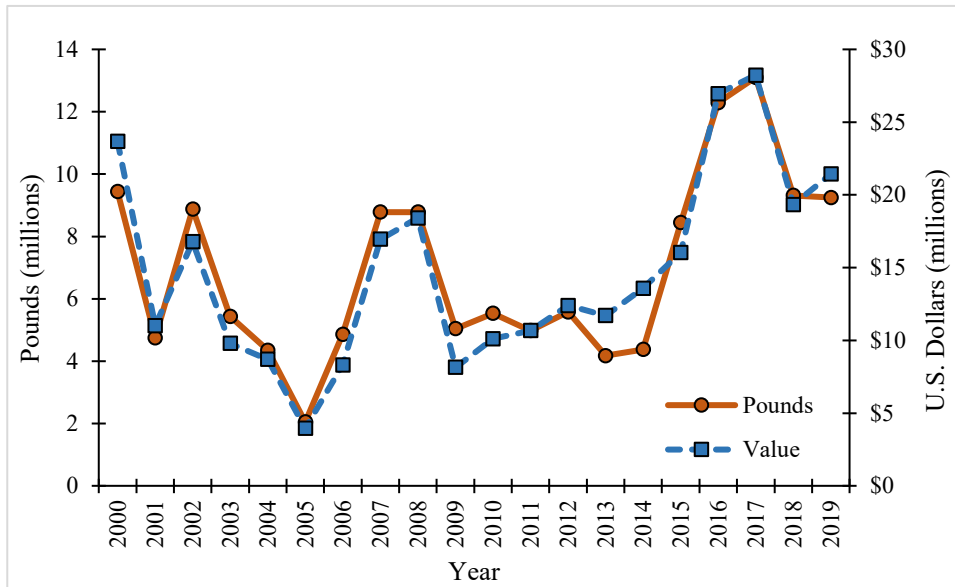


Figure 2.4.6. Pounds of shrimp landed and value for the North Carolina shrimp otter trawl fishery by year, 2000 – 2019.

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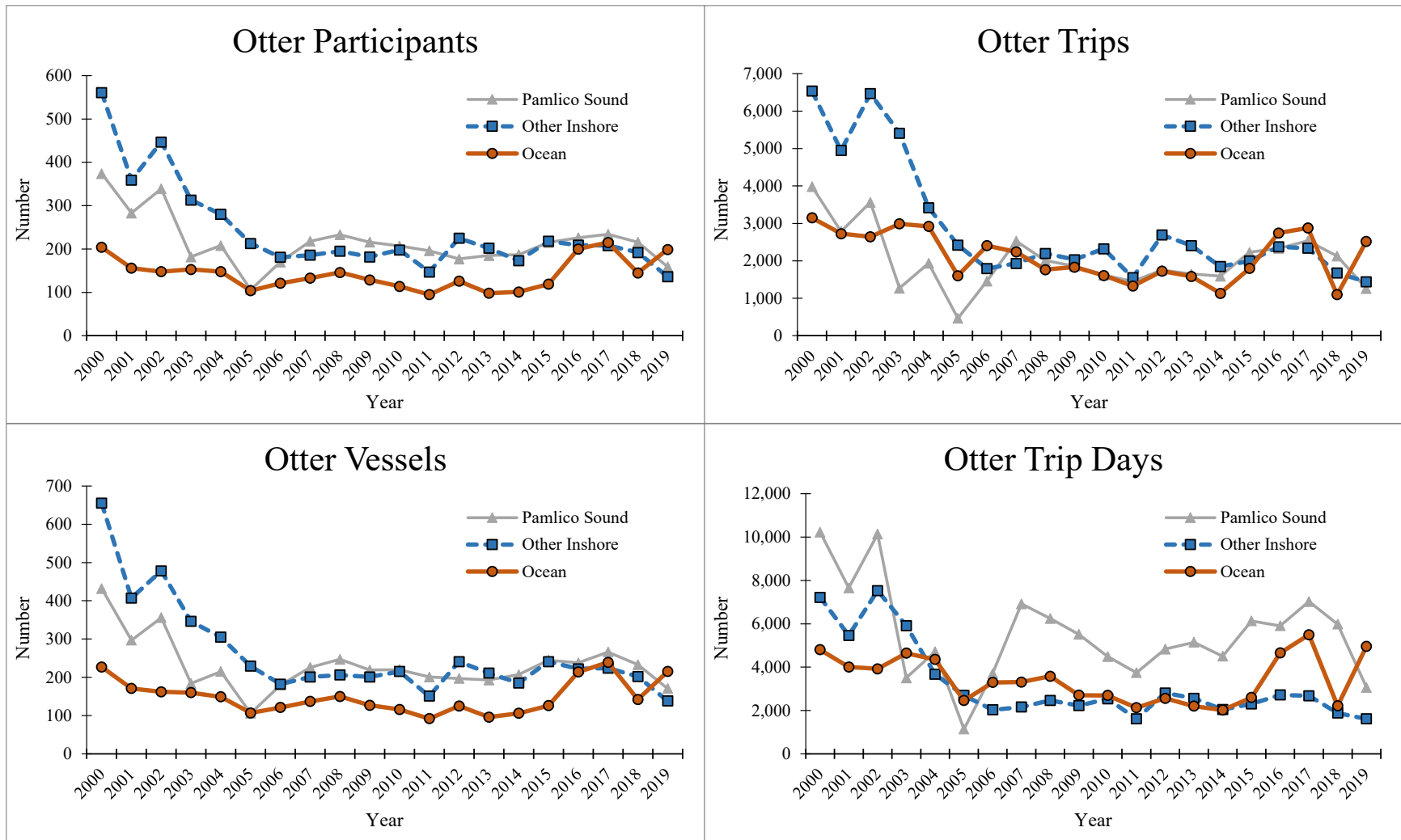


Figure 2.4.7. Number of participants, vessels, trips, and trip days by area for the North Carolina shrimp otter trawl fishery by year, 2000-2019.

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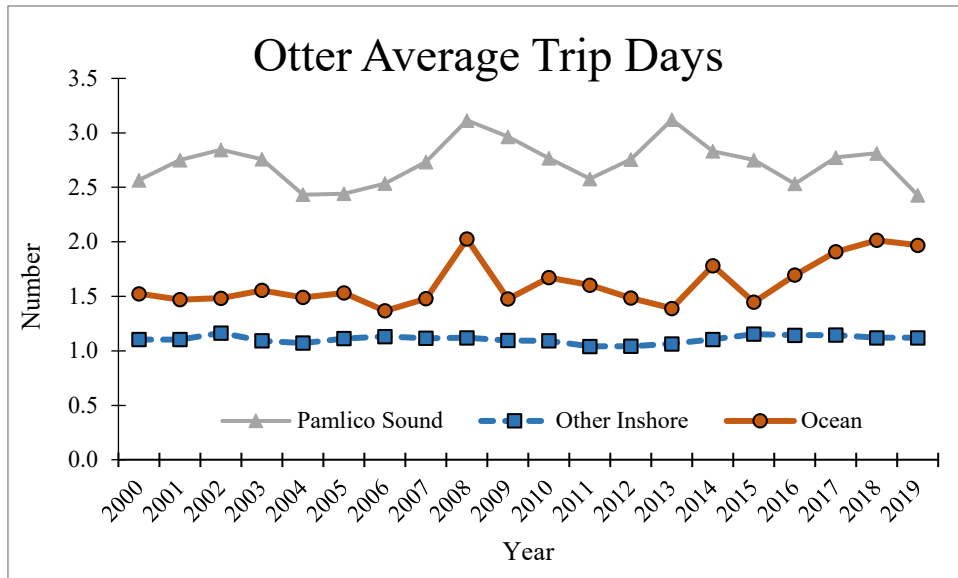


Figure 2.4.8. Average number of trip days by area for the North Carolina shrimp otter trawl fishery by year, 2000-2019.

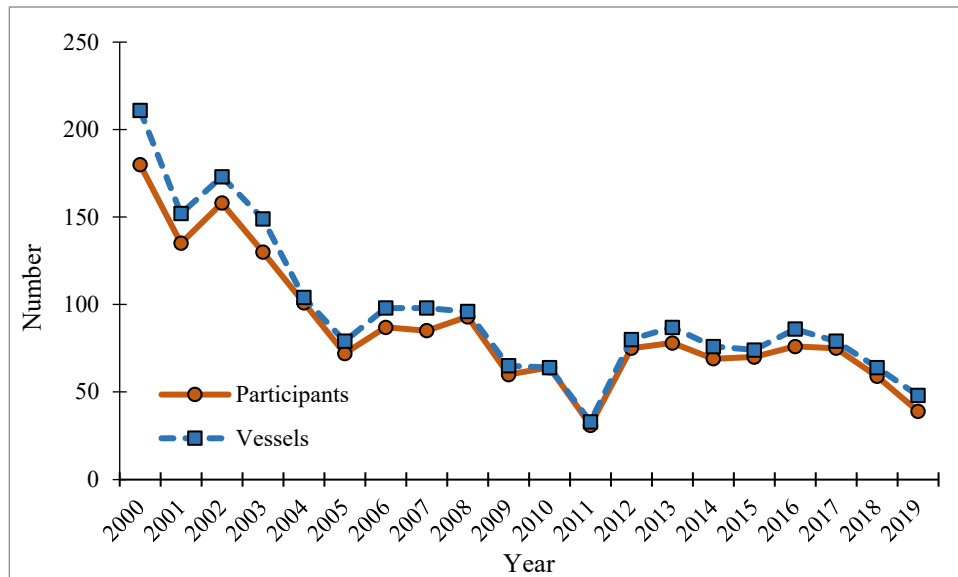


Figure 2.4.9. Number of participants and number of vessels in the North Carolina shrimp skimmer trawl fishery by year, 2000 – 2019.

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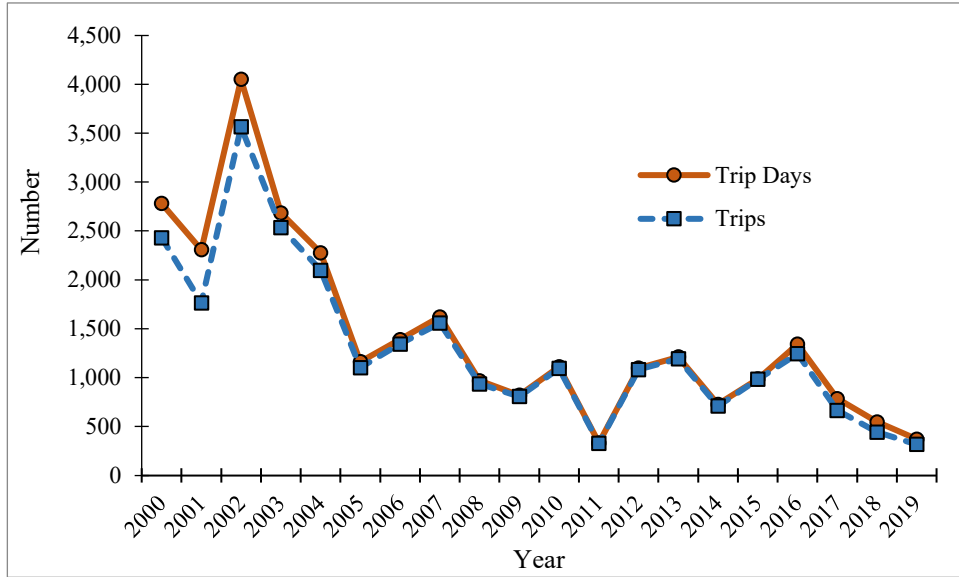


Figure 2.4.10. Number of trip days (number of trips x trip duration) and number of trips in the North Carolina shrimp skimmer trawl fishery by year, 2000 – 2019.

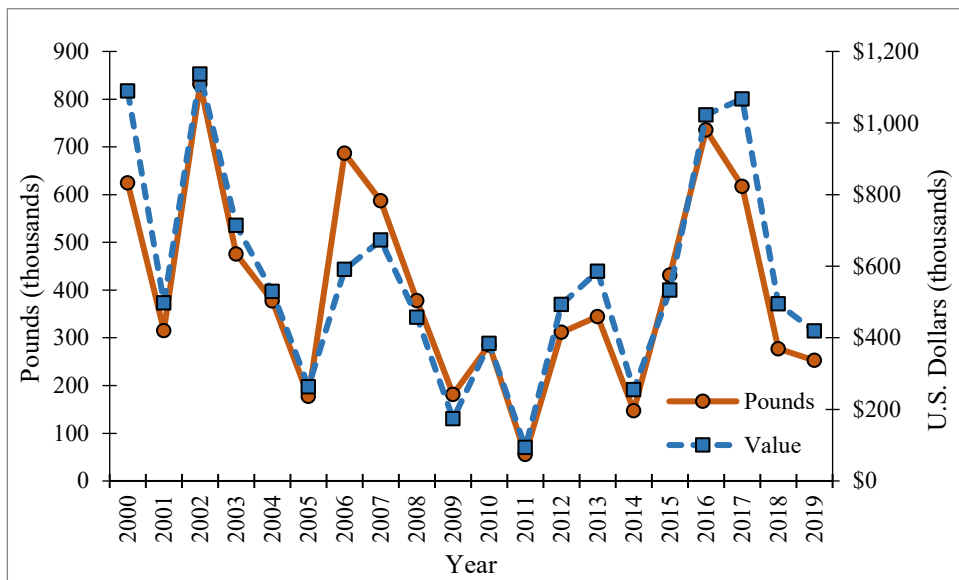


Figure 2.4.11. Pounds of shrimp landed and value for the North Carolina shrimp skimmer trawl fishery by year, 2000 – 2019.

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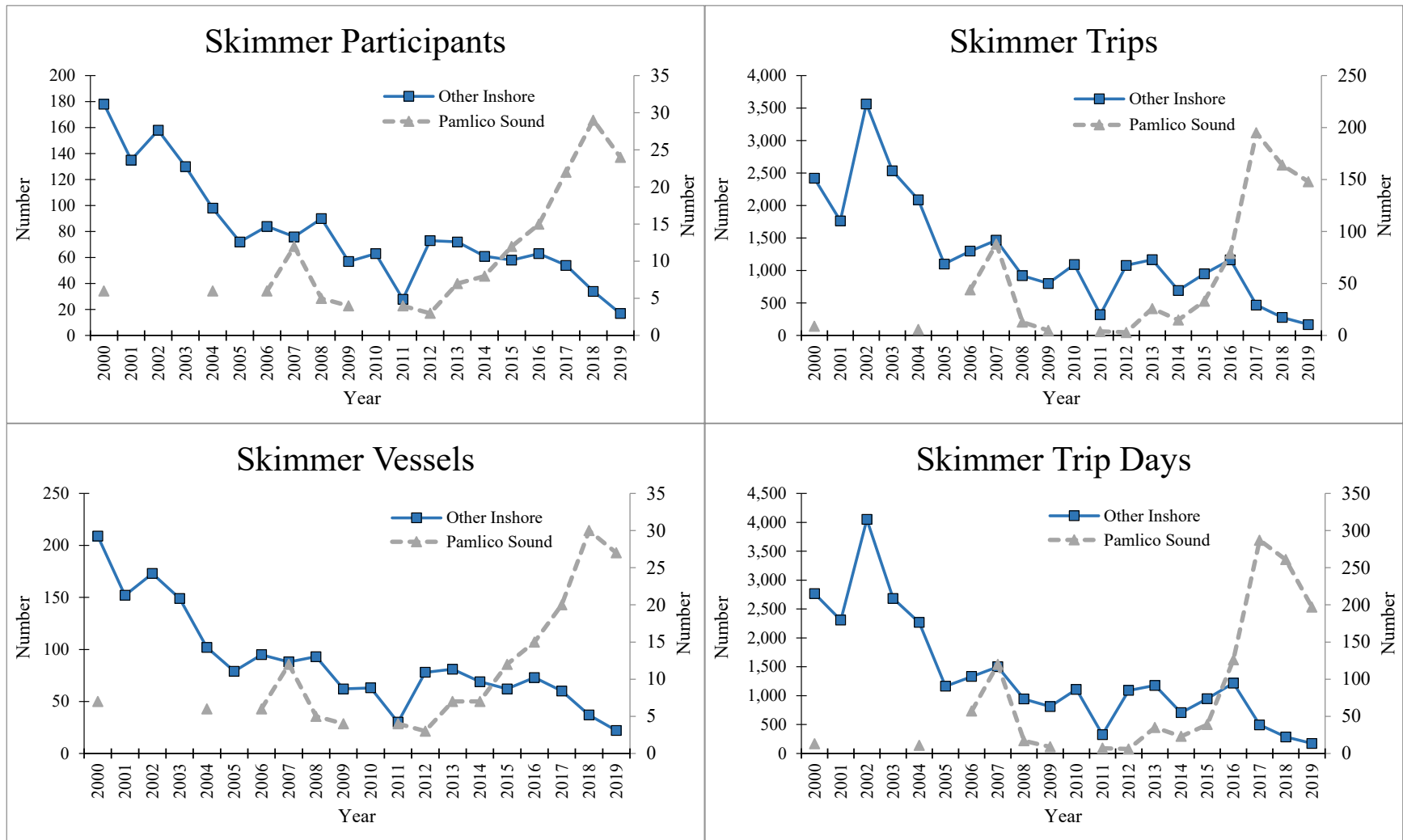


Figure 2.4.12. Number of participants, vessels, trips, and trip days by area for the North Carolina shrimp skimmer trawl fishery by year, 2000-2019.

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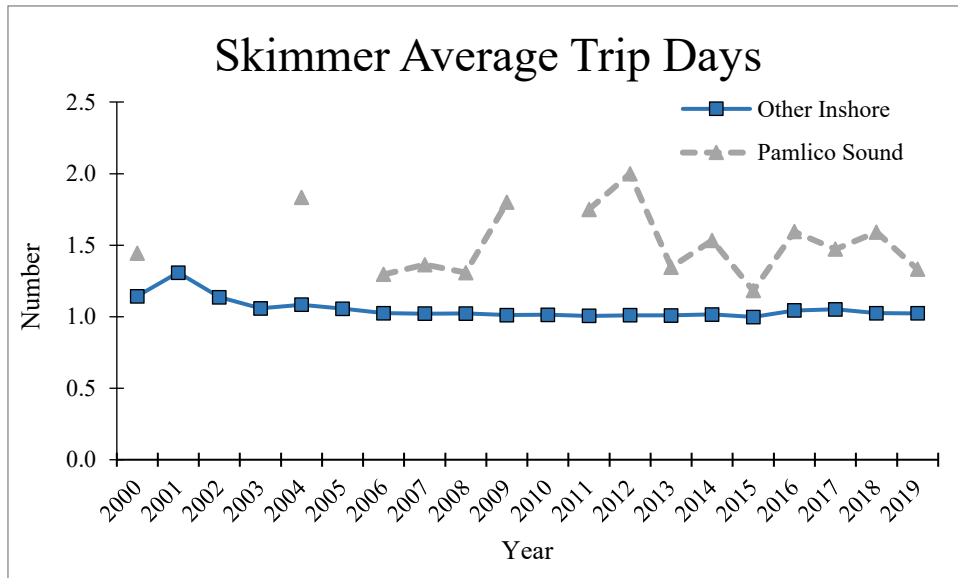


Figure 2.4.13. Average number of trip days by area for the North Carolina shrimp otter trawl fishery by year, 2000-2019.

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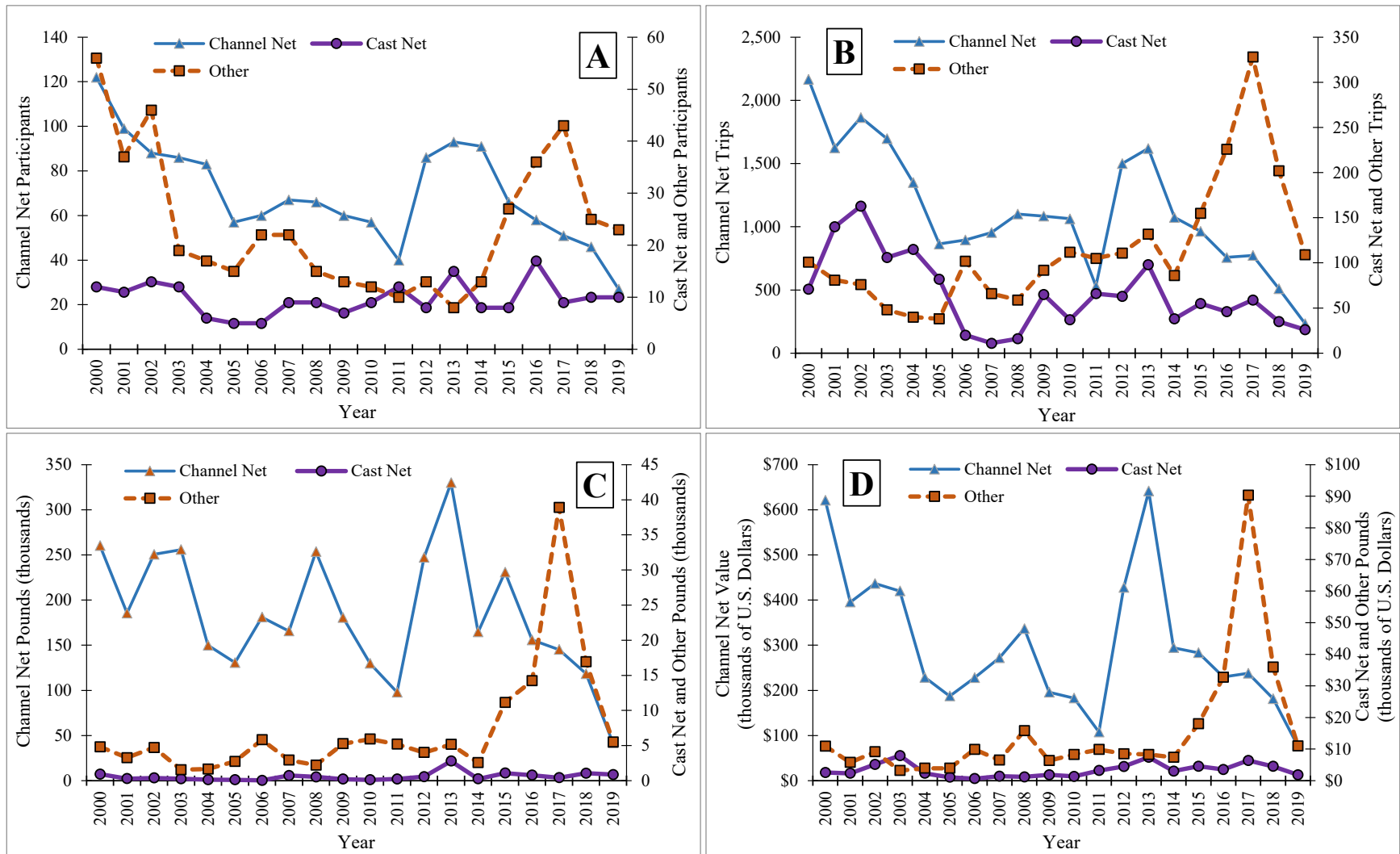


Figure 2.4.14. Commercial shrimp channel net, cast net, and other gear participants (A), trips (B), landings (C), and value (D), 2000-2019.

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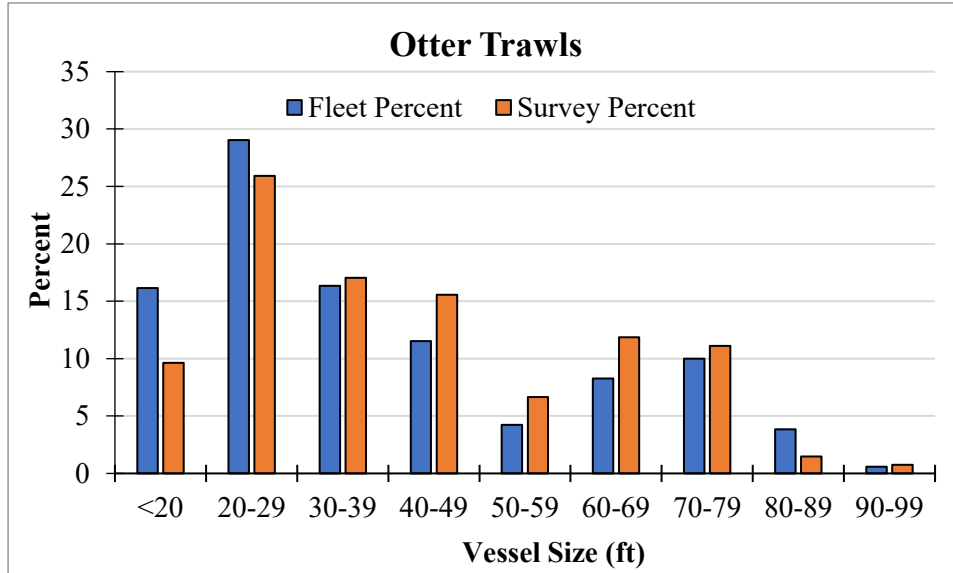


Figure 2.4.15. Commercial shrimp otter trawl fleet vessel size vs. surveyed portion of the fleet in the NCDMF BRD characterization survey.

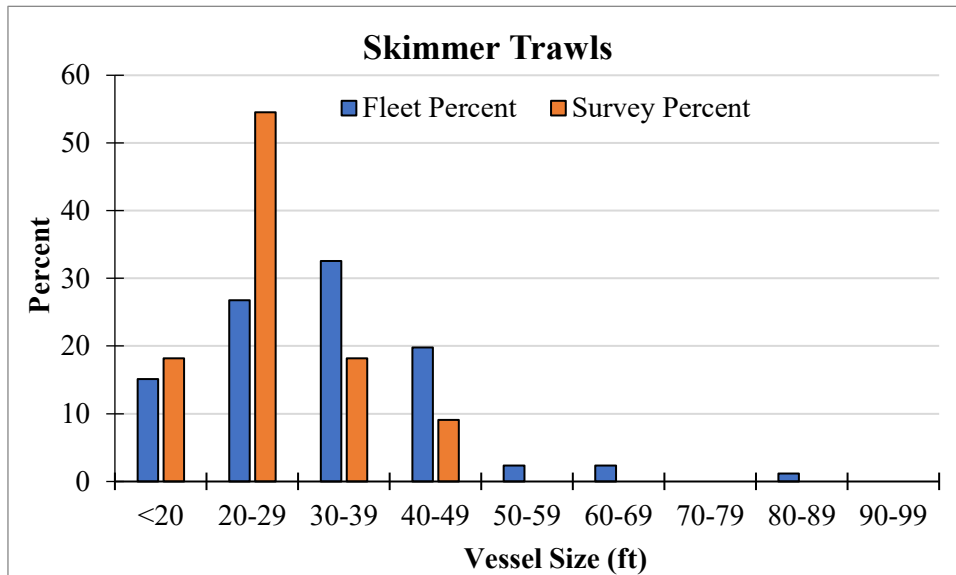


Figure 2.4.16. Commercial shrimp skimmer trawl fleet vessel size vs. surveyed portion of the fleet in the NCDMF BRD characterization survey.

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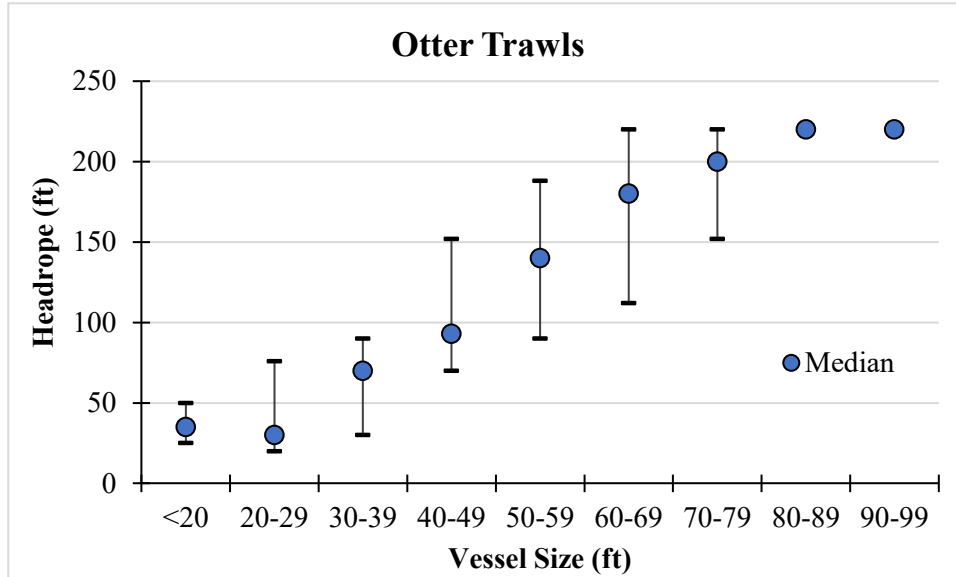


Figure 2.4.17. Commercial shrimp otter trawl median (blue dot), minimum (lower dash), and maximum (upper dash) total headrope per boat by vessel size bin from the NCDMF BRD characterization survey.

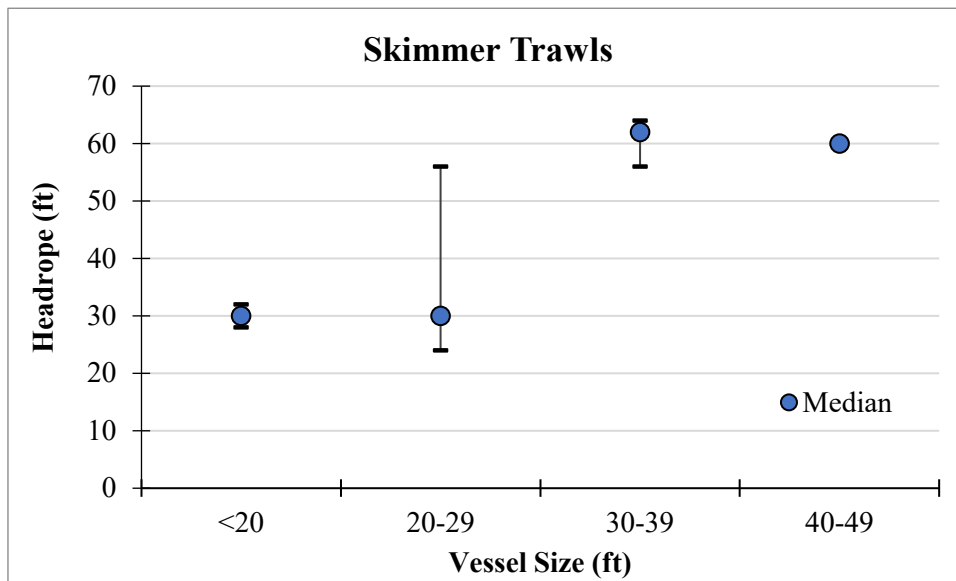


Figure 2.4.18. Commercial shrimp skimmer trawl median (blue dot), minimum (lower dash), and maximum (upper dash) total headrope per boat by vessel size bin from the NCDMF BRD characterization survey.

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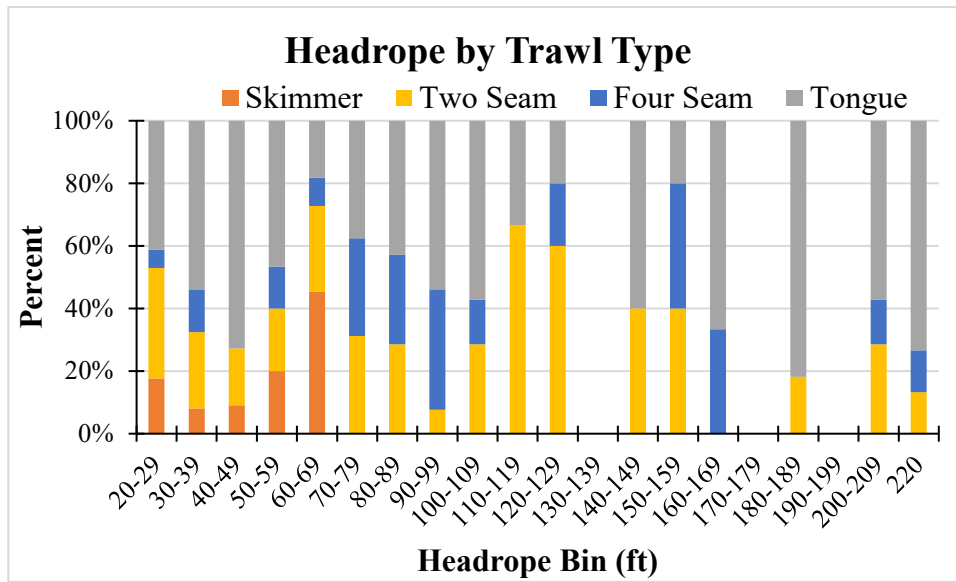


Figure 2.4.19. Proportion of net types by total headrope bin for vessels surveyed in the NCDMF BRD characterization survey.

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APPENDIX 2.4.A. SHRIMP TRAWL BYCATCH EFFORT ANALYSES

Objective

The objective of these analyses was to determine what fishery and gear characteristics significantly affect CPUE of shrimp (brown, pink, and white) and finfish bycatch in the North Carolina shrimp trawl fishery.

Methods

Data sub-setting

The data included species sampled from individual tows ($n = 1,567$) obtained from commercial shrimp trawls in North Carolina waters within 3 areas (Pamlico Sound, offshore and inshore) from 2012 to 2017 (Table 2.4.A1). The data was subset and aggregated by species groups as follows: “finfish” (all finfish), “key shrimp” (brown shrimp, pink shrimp, and white shrimp), “key bycatch” (blue crab, southern flounder, summer flounder, spot, croaker, and weakfish), and “key finfish” (southern flounder, summer flounder, spot, croaker, weakfish). Individual species were also subset as follows: white shrimp, brown shrimp, pink shrimp, blue crab, southern flounder, summer flounder, spot, croaker, weakfish.

Each dataset was analyzed in 5 scenarios with regards to area as follows: “3 areas” (all 3 areas included; 1, 567 individual tows), “2 areas” (Pamlico tows were combined with inshore and then offshore and inshore were both included; 1,567 individual tows), “Pamlico” (Pamlico only; 488 individual tows), “inshore” (inshore only not including Pamlico; 559 individual tows), and “offshore” (offshore only; 520 individual tows).

Potential predictors

Potential categorical predictors included year, day of the week, season, day or night tow, turtle excluder device (TED) position (position 0 = no TED, position 1 = top, position 2 = bottom), net type (net type 1 = two seamed, net type 2 = four seamed, net type 3 = tongue, net type 4 = skimmer), area (levels dependent on scenario as described previously), and management regime (Figure 2.4.A.1). Management regime was defined with two levels as prior and post June 2015 when regulations that were assumed to impact CPUE of catch and bycatch were implemented. Season was defined with three levels as follows: spring was from March 21st to June 21st, summer was from June 22nd to September 22nd, and fall was from September 23rd to December 21st. Day or night was defined with two levels as follows: in spring day was from 6:17 am to 8:04 pm, in summer day was from 6:25 am to 8:13 pm, and in fall day was from 6:41 am to 5:13 pm.

Potential numerical predictors included bycatch reduction device (BRD) placement from centerline (CL) (number of meshes), BRD placement from tailbag ties (TT) (number of meshes), wing mesh (bar mesh length in inches), tailbag mesh (bar mesh length in inches), tow speed (knots), tow duration (minutes), tow distance (nautical miles), TED bar spacing (inside edge to inside edge in inches), number of nets, total head-rope per boat, latitude, longitude, and interaction between latitude and longitude (Figure 2.4.A.2).

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Spatial heterogeneity

Spatial components were an important consideration in determining which variables were the most significant predictors of CPUE. Spatial distribution and density maps were created for each species by area (Figures 2.4.A.3, A.4, and A.5).

Effort metrics

Several metrics were considered as appropriate measures for effort including tow duration (minutes) and distance towed (nautical miles). Distance towed was calculated as tow duration multiplied by tow speed (knots). The natural log of catch weight for each species group was plotted against tow duration and tow distance for visual comparison of the relationships between these metrics to catch weight (Figures 2.4.A.6, A.7, A.8, and A.9). Spearman's rank correlation coefficient (ρ) was calculated for each species group for the natural log of catch weight and tow duration (Table 2.4.A.2) and tow distance (Table 2.4.A.3). Correlations varied based on species group and tow distance had slightly higher correlations for most of the species groups; however, since correlations for both metrics were comparable, tow duration was selected as the unit of effort as this metric would be easier to use for enforcement purposes if future regulations were implemented to limit effort.

Modeling

To determine which variables were correlated with each other, variables were sequentially dropped from the variance inflation factor (VIF) analysis until all VIFs were below a value of 3 (Zuur et al. 2010). Total head-rope per boat and number of nets were found to be correlated (Tables 2.4.A.4, A.5, and A.6). Subsequently, number of nets was dropped as a potential predictor because it was determined that total head-rope per boat would be a more important variable to evaluate as a predictor.

The response variable modeled was the logarithm of CPUE (Y) using generalized least squares with a spatial correlation matrix to account for spatial, non-constant variance. The spatial correlation matrix was only included when it improved the model based on the difference in Akaike's information criterion (ΔAIC). Any model with latitude and/or longitude as predictor variables was not fitted with a spatial correlation matrix. Models were developed as:

$$Y \sim \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \dots + \varepsilon$$

where $\beta_{1,2,3,\dots}$ were the coefficients for the potential predictor variables, $X_{1,2,3,\dots}$ were the potential predictor variables, and ε was random error. Models that included a spatial correlation matrix were modeled as:

$$Y_l \sim \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \dots + \varepsilon_l$$

where Y at location l was modeled as previously with random error specific to location l .

A forward model selection process was implemented using a likelihood ratio test (LRT). Candidate models were developed by adding one predictor variable to the base model ($Y \sim 1$). The candidate

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models were compared to the base model with a LRT and the candidate model with the lowest p-value that was lower than the significance level (α) of 0.01 was adopted as the updated base model. This process was repeated until none of the candidate models were lower than the significance level.

To prevent the overfitting of models, a backward selection process was also incorporated where the resulting model from the forward selection was assigned as the base model and candidate models were developed by removing one predictor variable from the base model. The candidate models were compared to the base model using AIC. If the candidate model had a lower AIC than the base model, then the candidate was accepted as the updated base model. This process was repeated for each predictor variable until the candidate model AIC was no longer lower than the base model AIC.

Zero-inflation

Some species groups were zero-inflated (Table 2.4.A.7) and were modeled using two sub-models; a presence/absence model and the log(CPUE) model as described above. Species groups with the percentage of zeroes $\geq 60\%$ were considered zero-inflated and the presence/absence of the selected species group was modeled using a generalized linear model with a similar model structure as the log(CPUE) model except the response variable was binomially distributed and a spatial correlation matrix was not included.

Results

Plots were developed for each species group of log(CPUE) against each potential variable (Figures 2.4.A.10-A.22). Some variables indicated a relationship for predicting CPUE, for example, in Figure A14 the plot of CPUE against day or night indicates a possible significant difference between day and night for predicting CPUE however, the data was inadequate due to the high number of missing data points (93.2%). These results indicate a possible relationship for predicting CPUE based on the time of day and might be an avenue of further research.

3-area scenario

Results for the 3-area scenario indicate that for the log(CPUE) sub-models (Table 2.4.A.8), the predominant predictors for the various species groups were year (12 species groups), net type (11 species groups), area (8 species groups), and season (5 species groups). Management regime (3 species groups), day of the week (3 species groups), latitude (2 species groups), longitude (2 species groups), and the interaction between latitude and longitude (2 species groups) were each significant but not as frequently. The presence/absence sub-models (Table 2.4.A.9) indicate that of the five zero-inflated species groups with converged models; year (5 species groups), TED position (5 species groups), net type (5 species groups), and area (4 species groups) were the predominant predictors. Season (2 species groups), management regime (2 species groups), wing mesh (1 species group), tailbag mesh (1 species group), and BRD placement TT (1 species group) were each significant less frequently.

2-area scenario

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Results for the 2-area scenario indicate that for the log(CPUE) sub-models (Table 2.4.A.8), the predominant predictors for the various species groups were year (12 species groups), net type (11 species groups), day of the week (4 species groups), season (5 species groups), and management regime (4 species groups). Area (3 species groups), latitude (1 species group), longitude (1 species group), and the interaction between latitude and longitude (1 species group) were each significant but not as frequently. The presence/absence sub-models (Table 2.4.A.9) indicate that of the five zero-inflated species groups with converged models; year (5 species groups), TED position (5 species groups), and net type (4 species groups) were the predominant predictor variables. Area (2 species groups), season (2 species groups), management regime (1 species group), wing mesh (2 species groups), tailbag mesh (1 species group), BRD placement TT (1 species group), latitude (1 species group), longitude (1 species group), and the interaction between latitude and longitude (1 species group) were each significant less frequently.

Inshore scenario

Results for the inshore scenario indicate that for the log(CPUE) sub-models (Table 2.4.A.8), the predominant predictors for the various species groups were year (9 species groups), net type (9 species groups), and season (5 species groups). Day of week, management regime, latitude, longitude, and the interaction between latitude and longitude were each significant for two species groups. The presence/absence sub-models (Table 2.4.A.9) indicate that of the five zero-inflated species groups with converged models; total head-rope per boat and TED bar spacing were significant for three species groups and were the predominant predictor variables. Year (2 species groups), TED position (2 species groups), day/ night (1 species group), season (2 species groups), management regime (1 species group), longitude (1 species group), and the interaction between season and longitude (1 species group) were each significant less frequently.

Offshore scenario

Results for the offshore scenario indicate that for the log(CPUE) sub-models (Table 2.4.A.8), the predominant predictors for the various species groups were year (8 species groups), net type (5 species groups), and season (7 species groups). Day of week was only significant for one species group and latitude, longitude, and the interaction between latitude and longitude were each significant for three species groups. The presence/absence sub-models (Table 2.4.A.9) indicate that of the four zero-inflated species groups with converged models; season (3 species groups) and BRD placement TT (2 species groups) were the two most frequent predictors. Year, management regime, wing mesh, BRD placement CL, TED bar spacing, latitude, longitude, and the interaction between latitude and longitude were each significant for only one species group.

Pamlico scenario

Results for the Pamlico scenario indicate that for the log(CPUE) sub-models (Table 2.4.A.8), the predominant predictors for the various species groups were year (10 species groups), TED position (5 species groups), net type (6 species groups), and season (8 species groups). Management regime (1 species group), latitude (4 species groups), longitude (4 species groups), and the interaction between latitude and longitude (4 species groups) were significant but not as frequently. The presence/absence sub-models (Table A9) indicate that of the four zero-inflated species groups with

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converged models; year, TED position, and TED bar spacing each were significant in 2 species groups and net type, season, management regime, wing mesh, total head-rope per boat and latitude were each significant for only one species group.

Discussion

The data used for these analyses were acquired opportunistically through onboard observations of commercial shrimp trawlers. Consequently, the data have some limitations as some areas have years and months with little or no data (Table 2.4.A.1). These results should be viewed as exploratory in nature and not conclusive.

There is some variation in the significant predictor variables dependent on the species or species group, scenario, and sub-model (Tables 2.4.A.8 and A.9). For example, for the log(CPUE) sub-models, TED position is almost exclusively important for the Pamlico area and the coefficients indicate that for brown shrimp and the key shrimp species group, position 2 (bottom) has the highest increase on CPUE and position 1 (top) has a higher increase on CPUE compared to position 0. However, for the log(CPUE) sub-model, there are consistent results for multiple species and species groups across scenarios. Specifically, of the 65 possible combinations of scenarios and species or species groups; year, net type, and season are significant for 80.0%, 66.2%, and 51.8% of the sub-models. Unfortunately, the presence/absence sub-models provide less clearly distinct generalizations yet, there is still valuable species-specific information.

For example, spot and weakfish were encountered in shrimp trawls more frequently than other key bycatch species, present in 93.3% and 54.1%, respectively, of all trawl samples and present 99.2% and 73%, respectively, in trawl samples from Pamlico Sound where the majority of estuarine shrimp harvest and effort occurs (Table 2.4.A.7). For spot, net type was a significant factor in the 3-area, 2-area, and inshore models with tongue style nets having more bycatch than two-seam and four-seam nets. Similarly, net type was also a significant factor for weakfish in the 3-area, 2-area, inshore, offshore, and Pamlico models with tongue nets having more bycatch. This suggests net type may be important to consider when discussing methods to reduce bycatch for these species. Season was also consistently a significant factor for weakfish in all the models, with summer having higher rates of bycatch in the 3-area, 2-area, inshore, and offshore models, and the fall having higher rates of bycatch in Pamlico model. This suggests for weakfish that season should be considered when discussing methods to reduce bycatch and that one approach may not work for all areas.

Although results of these analyses are inconclusive, this work does provide some direction for future research efforts. The significant data gaps also highlight the need for more consistent monitoring of discards in the shrimp trawl fishery through a dedicated onboard observer program and/or directed experimental research. This will allow more constructive and focused efforts to be made to reduce bycatch in the shrimp trawl fishery.

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Literature Cited

Zuur, A. F., Ieno, E. N., Elphick, C. S. 2010. A protocol for data exploration to avoid common statistical problems: Data exploration. *Methods in Ecology and Evolution* 1, 3–14.
<https://doi.org/10.1111/j.2041-210X.2009.00001.x>

DRAFT – SUBJECT TO CHANGE

Tables

Table 2.4.A.1. Number of individual tows sampled by area, year, and month, 2012-2017.

Area	Year	Month									
		March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
All areas (1,567 tows)	2012	0	0	0	0	0	61	55	61	21	23
	2013	0	6	46	45	54	1	33	30	24	4
	2014	0	0	11	88	128	71	48	50	0	0
	2015	0	0	14	89	50	80	61	85	11	0
	2016	4	20	19	33	41	37	23	27	13	0
	2017	0	10	10	11	0	32	30	7	0	0
	Totals	4	36	100	266	273	282	250	260	69	27
Inshore (559 tows)	2012	0	0	0	0	0	22	21	17	0	6
	2013	0	6	23	4	0	0	0	3	0	0
	2014	0	0	0	5	0	7	5	16	0	0
	2015	0	0	7	46	12	10	61	85	11	0
	2016	0	20	3	17	30	23	20	6	0	0
	2017	0	10	10	3	0	20	28	2	0	0
	Totals	0	36	43	75	42	82	135	129	11	6
Offshore (520 tows)	2012	0	0	0	0	0	14	23	20	21	17
	2013	0	0	23	26	17	1	15	6	15	4
	2014	0	0	11	68	24	8	15	34	0	0
	2015	0	0	4	25	13	32	0	0	0	0
	2016	4	0	16	16	4	0	3	21	13	0
	2017	0	0	0	0	0	0	2	5	0	0
	Totals	4	0	54	135	58	55	58	86	49	21
Pamlico (488 tows)	2012	0	0	0	0	0	25	11	24	0	0
	2013	0	0	0	15	37	0	18	21	9	0
	2014	0	0	0	15	104	56	28	0	0	0
	2015	0	0	3	18	25	38	0	0	0	0
	2016	0	0	0	0	7	14	0	0	0	0
	2017	0	0	0	8	0	12	0	0	0	0
	Totals	0	0	3	56	173	145	57	45	9	0

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Table 2.4.A.2. Correlation results for Ln(catch weight) vs. tow duration.

Species	Spearman ρ
Brown	0.59
Croaker	0.55
Spot	0.53
Key bycatch	0.51
Key shrimp	0.51
Key finfish	0.5
Finfish	0.49
Crab	0.48
Weakfish	0.4
Southern	0.36
Summer	0.36
Pink	0.36
White	0.18

Table 2.4.A.3. Correlation results for Ln(catch weight) vs. distance towed.

Species	Spearman ρ
Brown	0.63
Croaker	0.61
Spot	0.57
Key finfish	0.55
Key bycatch	0.55
Finfish	0.54
Key shrimp	0.53
Pink	0.48
Crab	0.46
Weakfish	0.44
Summer	0.4
Southern	0.38
White	0.14

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Table 2.4.A.4. Correlation variance inflation factors for potential model variables with headrope per boat and number of nets included. Values under 3 are acceptable for modeling.

Variable	Variance Inflation Factors
Wing mesh	1.57
Tailbag mesh	1.40
Tow speed	2.60
BRD placement TT	1.36
BRD placement CL	1.30
TED bar spacing	1.92
Number of nets	9.48
Total head-rope per boat	9.92

Table 2.4.A.5. Correlation variance inflation factors for potential model variables without headrope per boat. Values under 3 are acceptable for modeling.

Variable	Variance Inflation Factors
Wing mesh	1.47
Tailbag mesh	1.35
Tow speed	2.56
BRD placement TT	1.35
BRD placement CL	1.10
TED bar spacing	1.76
Number of nets	2.73

Table 2.4.A.6. Correlation variance inflation factors for potential model variables without number of nets. Values under 3 are acceptable for modeling.

Variable	Variance Inflation Factors
Wing mesh	1.56
Tailbag mesh	1.39
Tow speed	2.52
BRD placement TT	1.33
BRD placement CL	1.13
TED bar spacing	1.90
Total head-rope per boat	2.86

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Table 2.4.A.7. Percentage of tows with zero catches of species group for each area subset.

Species group	All areas	Inshore	Offshore	Pamlico
Finfish	1.8	3.0	1.9	0.2
Key shrimp	1.7	2.7	1.9	0.2
Key bycatch	1.9	3.0	2.1	0.2
Key finfish	1.9	3.2	2.1	0.2
Blue crab	62.5	57.4	89.6	39.5
Spot	6.7	12.9	5.6	0.8
Croaker	47.5	22.4	61.2	61.9
Southern flounder	78.0	87.3	82.3	62.7
Summer flounder	73.1	81.0	71.7	65.4
Weakfish	44.9	63.0	42.1	27.0
White shrimp	74.6	43.1	86.9	97.5
Brown shrimp	38.7	69.1	33.3	9.6
Pink shrimp	88.4	90.5	81.7	93.0

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Table 2.4.A.8. Log(CPUE) model predictor variables for each analysis.

Species/ Group Variable	FF	KF	KB	KS	Bc	Sp	Cr	So	Su	Wf	Ws	Bs	Ps
Year	32POI	32POI	32POI	32POI	32I	32POI	32POI	32PO	32P	32POI	32PI	32P	
TED Pos.		P		P		P	P					P	32
Net Type	32POI	32OI	32POI	32I	32PI	32OI	32I		32P	32POI		32PI	32P
Area	32	3	3	32	3	3				3		32	
Day of Week		2		32OI							32I	32	
Day/ Night													
Season	32PO	P	P	32PI	32P	P	POI	32POI	O	32POI		OI	32O
Manage. Regime			2	32I	P	3	32			2			I
Wing Mesh													
Tailbag Mesh													
Tow Speed													
BRD Place TT													
BRD Place CL													
TED bar spacing													
Headrope / Boat													
Number of Nets													
Latitude					3			I	32PO	P		POI	PO
Longitude					3			I	32PO	P		POI	PO
Lat * Lon					3			I	32PO	P		POI	PO

Abbreviations are as follows:

FF: Finfish, **KF:** Key finfish, **KB:** Key bycatch, **KS:** Key shrimp, **Bc:** Blue crab, **Sp:** Spot, **Cr:** Croaker, **So:** Southern flounder, **Su:** Summer flounder, **Wf:** Weakfish, **Ws:** White shrimp, **Bs:** Brown shrimp, **Ps:** Pink shrimp.

Area symbol coding as follows:

3: 3 areas (inshore, offshore, & Pamlico), **2:** 2 areas (inshore & offshore), **P:** Pamlico, **O:** offshore, **I:** inshore.

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Table 2.4.A.9. Presence/absence model predictor variables for data sets that were zero-inflated.

Species/ Group Variable	FF	KF	KB	KS	Bc	Sp	Cr	So	Su	Wf	Ws	Bs	Ps
Year					32		P	32POI	32I		32		32
TED Pos.					32		P	32	32PI		32	I	32
Net Type					32			32	3		32		32P
Area					32			32	3		3		
Day of Week													
Day or Night										I			
Season								OI	O		32O	I	32P
Season * Lon								I					
Manage. Regime					32						2O		3PI
Wing Mesh							P		3O				
Tailbag Mesh									3				
Tow Speed													
BRD Place TT								O			O		32
BRD Place CL											O		
TED bar spacing							P	I	POI			I	
Headrope / Boat									2PI			I	I
Number of Nets													
Latitude							P		O		2		
Longitude								I	O		2		
Lat * Lon									O		2		

Abbreviations are as follows:

FF: Finfish, **KF:** Key finfish, **KB:** Key bycatch, **KS:** Key shrimp, **Bc:** Blue crab, **Sp:** Spot, **Cr:** Croaker, **So:** Southern flounder, **Su:** Summer flounder, **Wf:** Weakfish, **Ws:** White shrimp, **Bs:** Brown shrimp, **Ps:** Pink shrimp.

Area symbol coding as follows:

3: 3 areas (inshore, offshore, & Pamlico), **2:** 2 areas (inshore & offshore), **P:** Pamlico, **O:** offshore, **I:** inshore.

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Figures

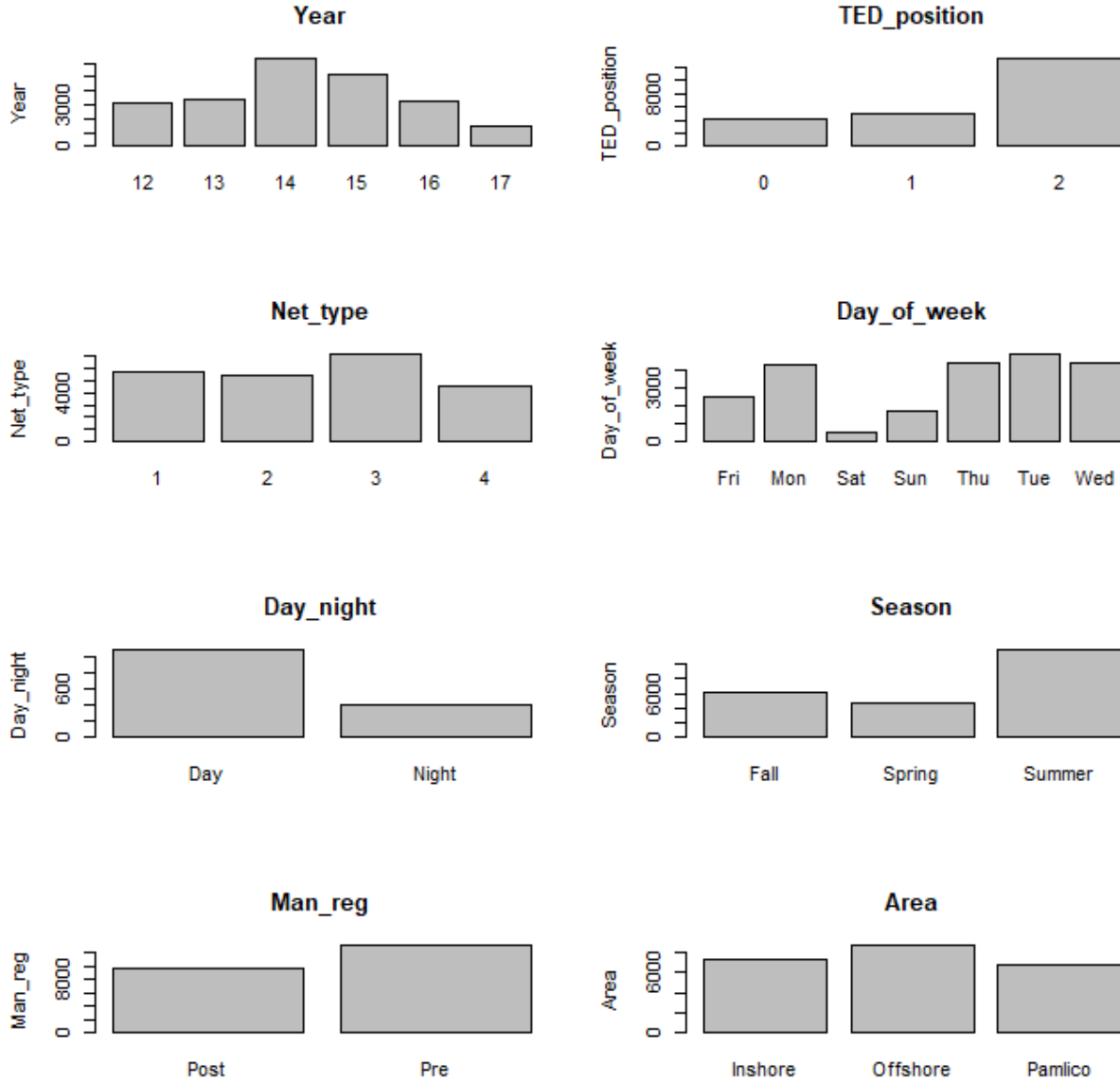


Figure 2.4.A.1. Histograms of potential categorical variables. “Man_reg” refers to management regime.

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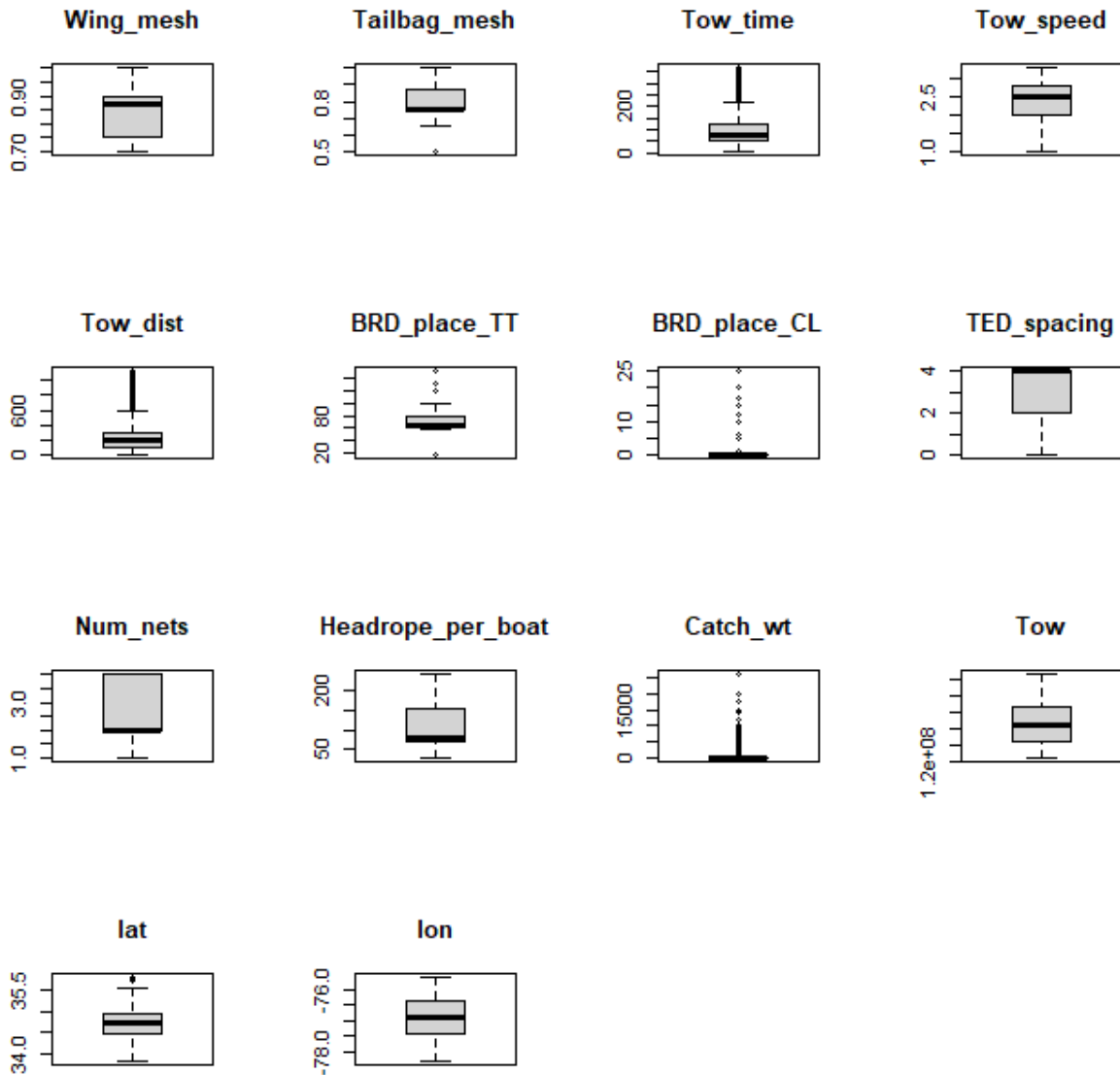


Figure 2.4.A.2. Boxplots of potential numerical variables. “lat”, “lon”, and “Num_nets” refer to latitude, longitude, and number of nets, respectively.

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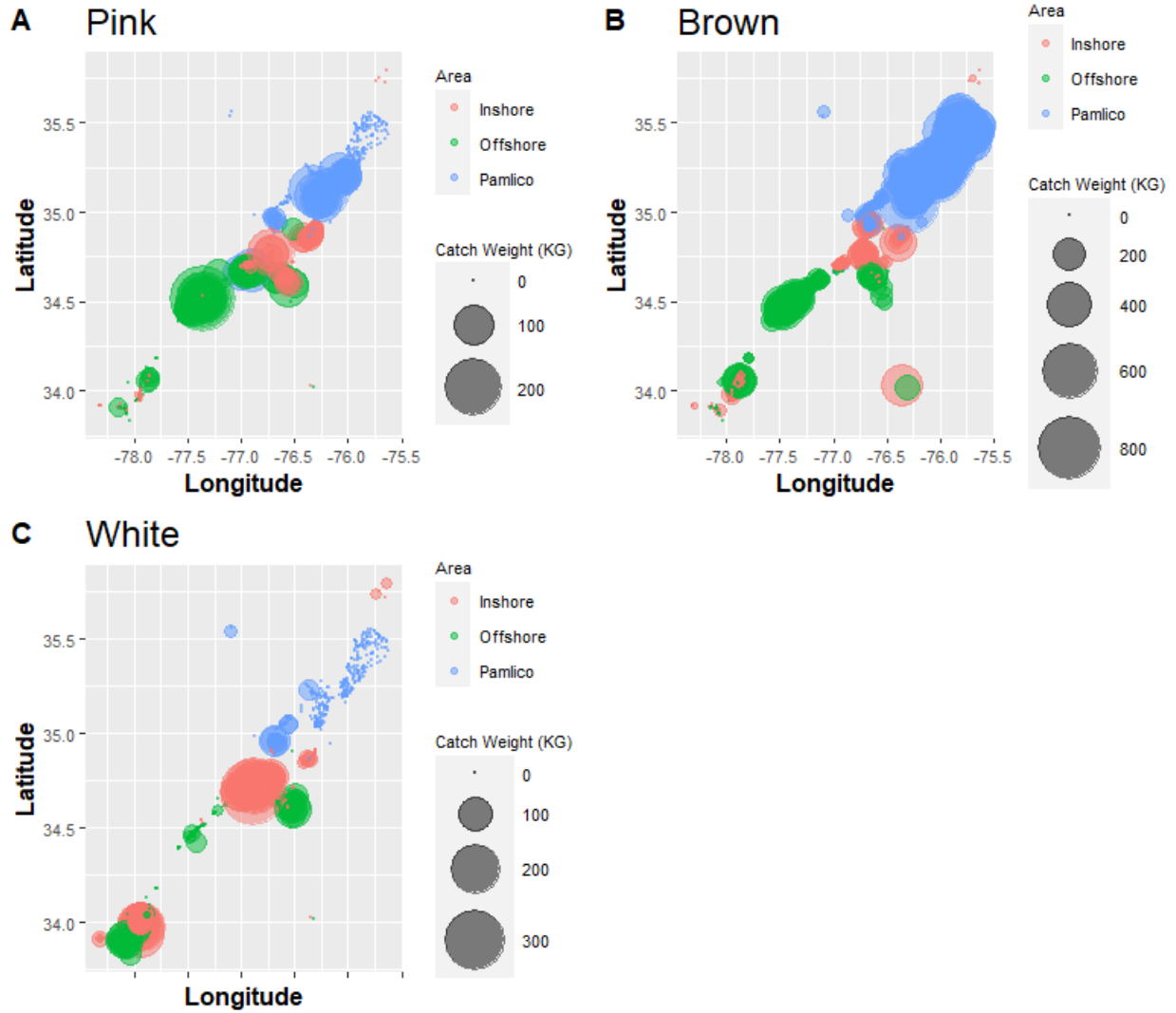


Figure 2.4.A.3. Spatial distribution and density of catch for pink shrimp (a), brown shrimp (b), and white shrimp (c).

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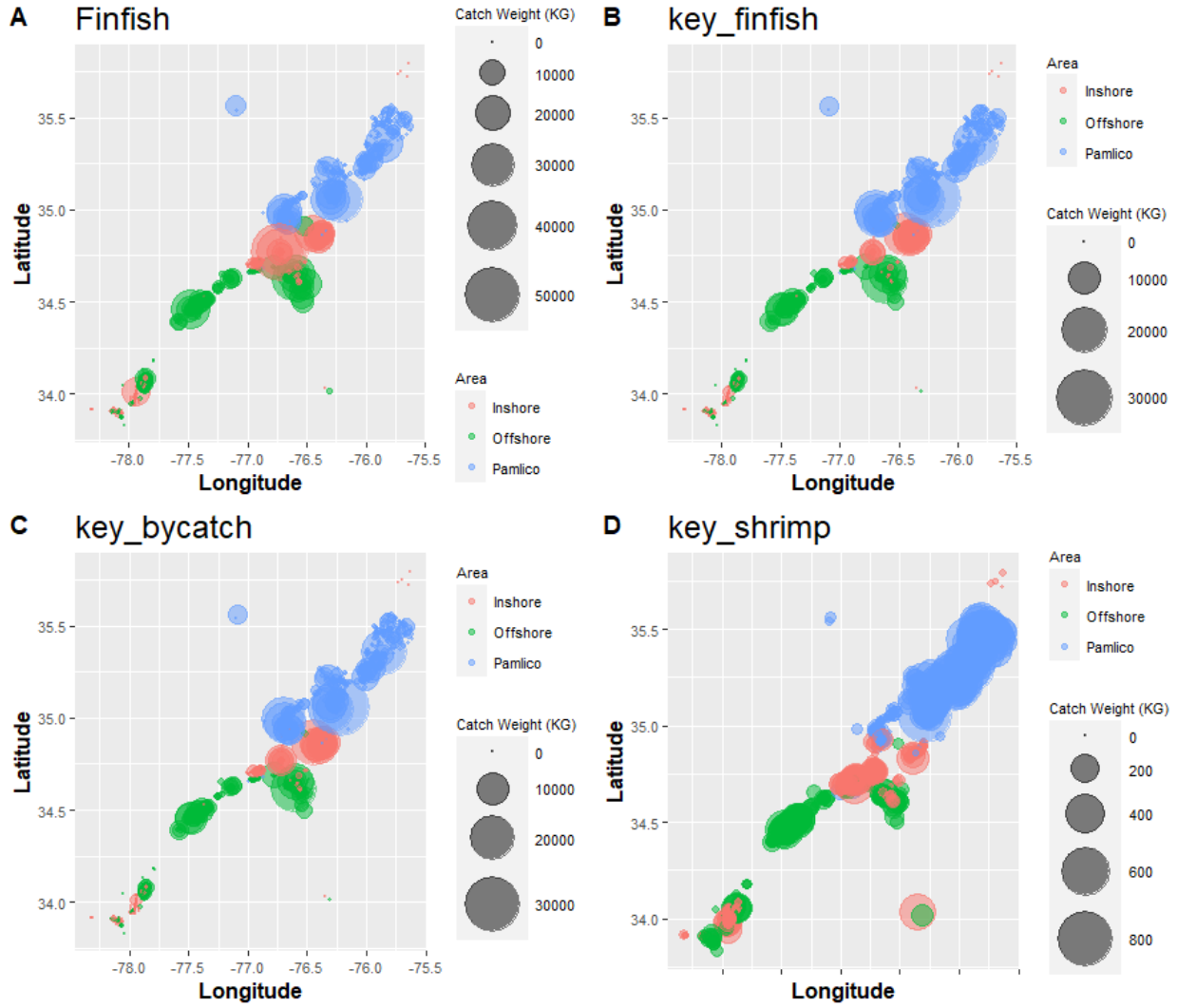


Figure 2.4.A.4. Spatial distribution and density of catch for finfish (a), key finfish (b), key bycatch (c), and key shrimp (d).

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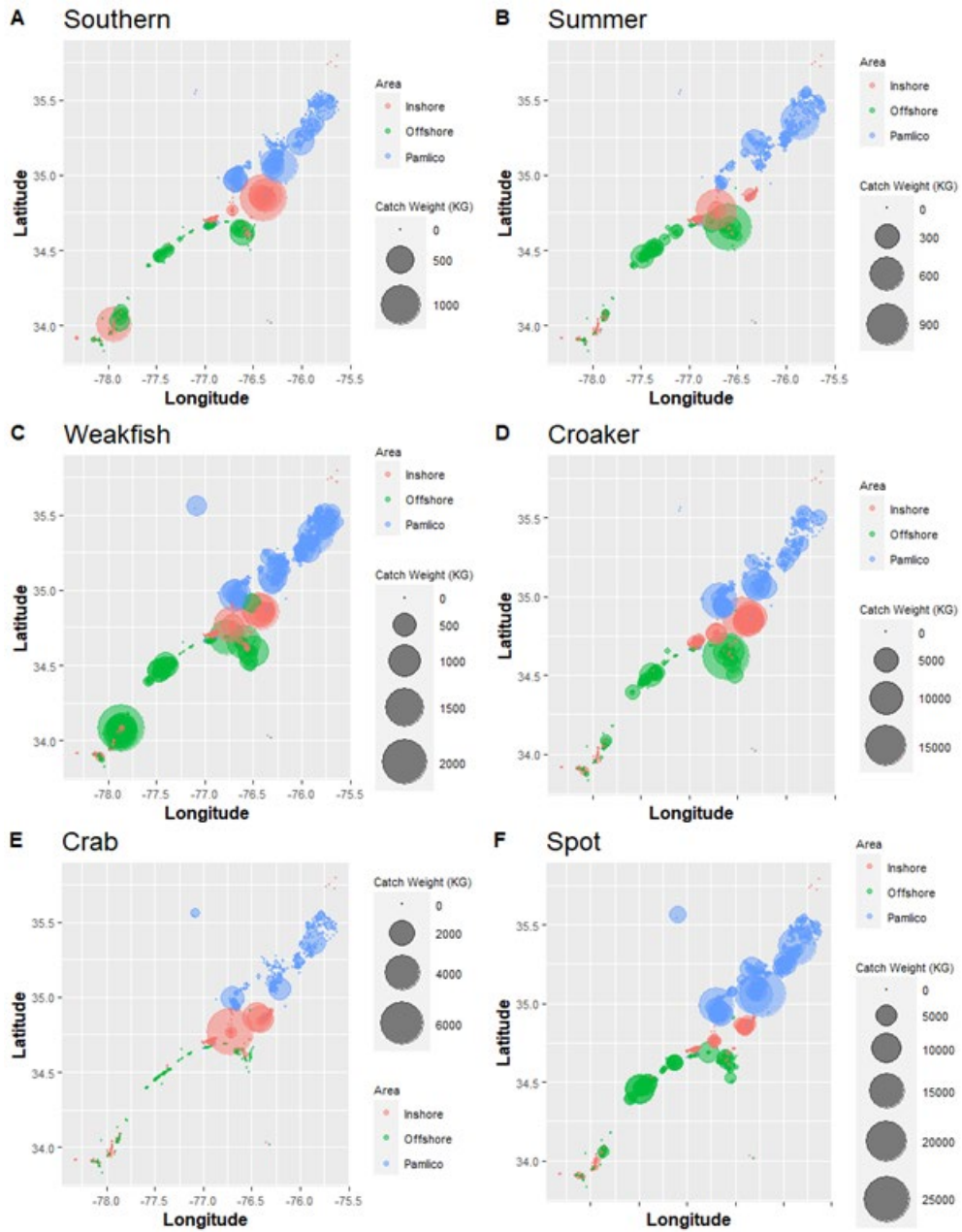


Figure 2.4.A.5. Spatial distribution and density of catch for southern flounder (a), summer flounder (b), weakfish (c), croaker (d), blue crab (e), and spot (f).

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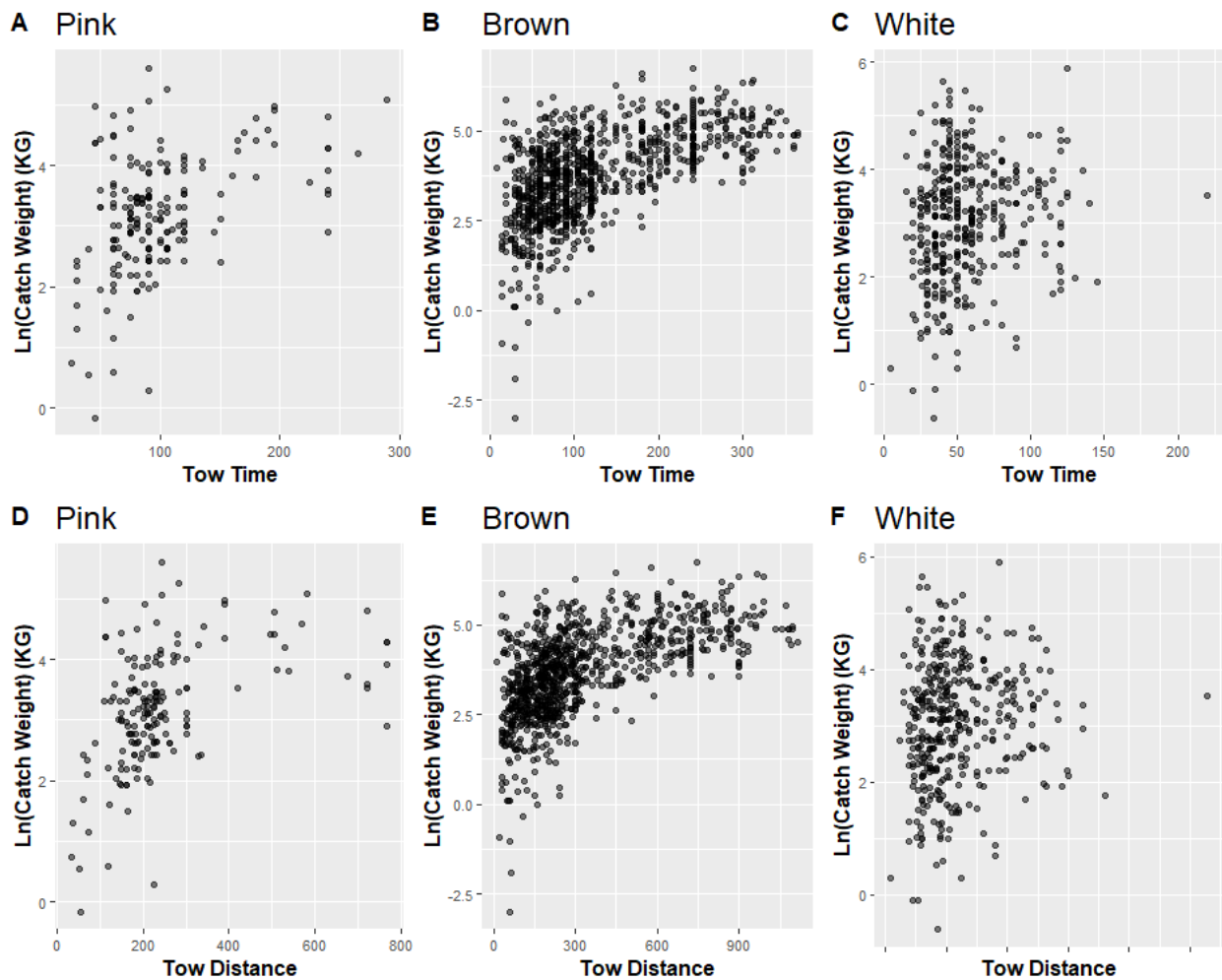


Figure 2.4.A.6. The natural log of catch weight (KG) was plotted against tow duration (tow time) for pink shrimp (a), brown shrimp (b), and white shrimp (c). The natural log of catch weight (KG) was plotted against distance towed for pink shrimp (d), brown shrimp (e), and white shrimp (f).

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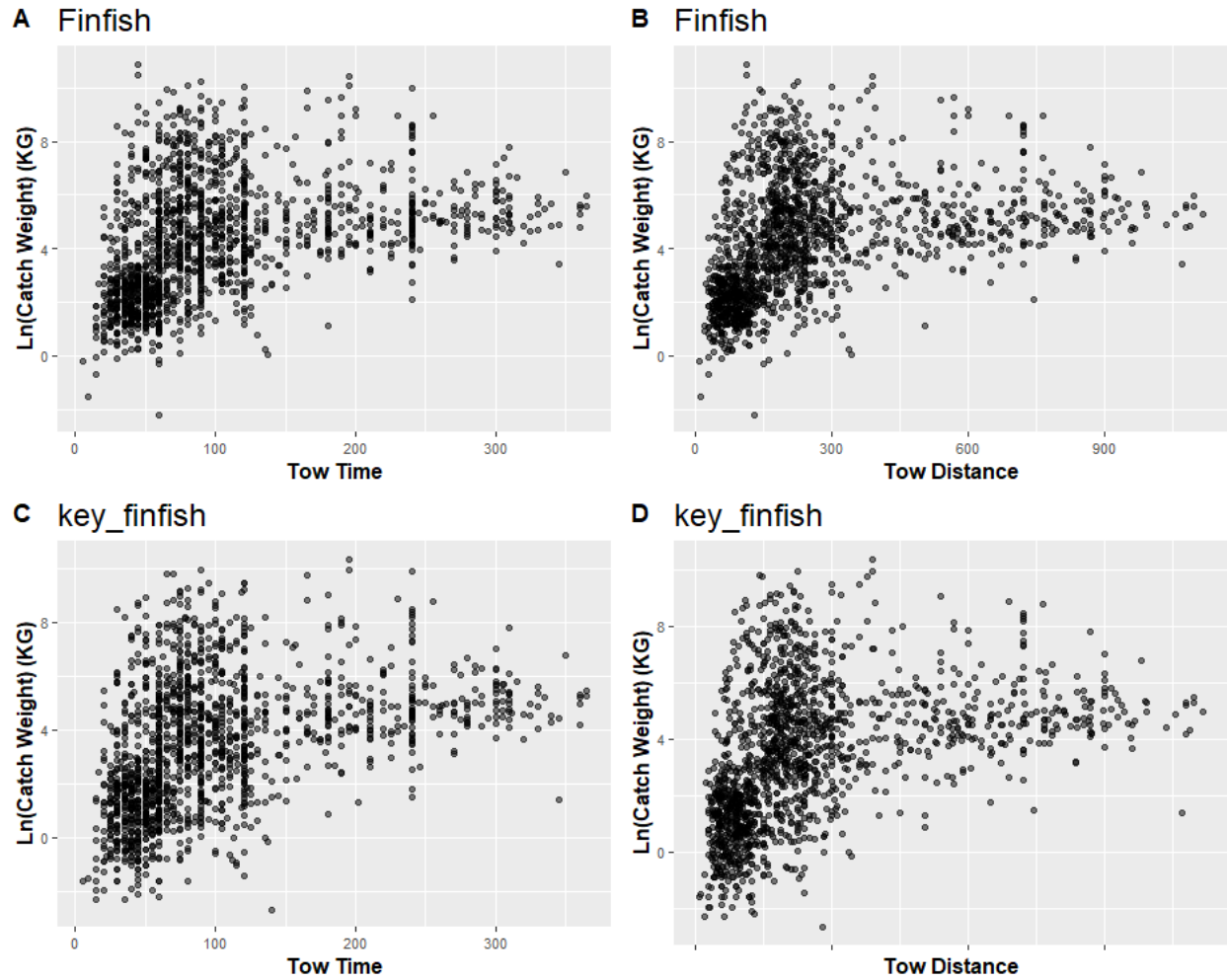


Figure 2.4.A.7. The natural log of catch weight (KG) was plotted against tow duration (tow time) for finfish (a) and key finfish (c). The natural log of catch weight (KG) was plotted against distance towed for finfish (b) and key finfish (d).

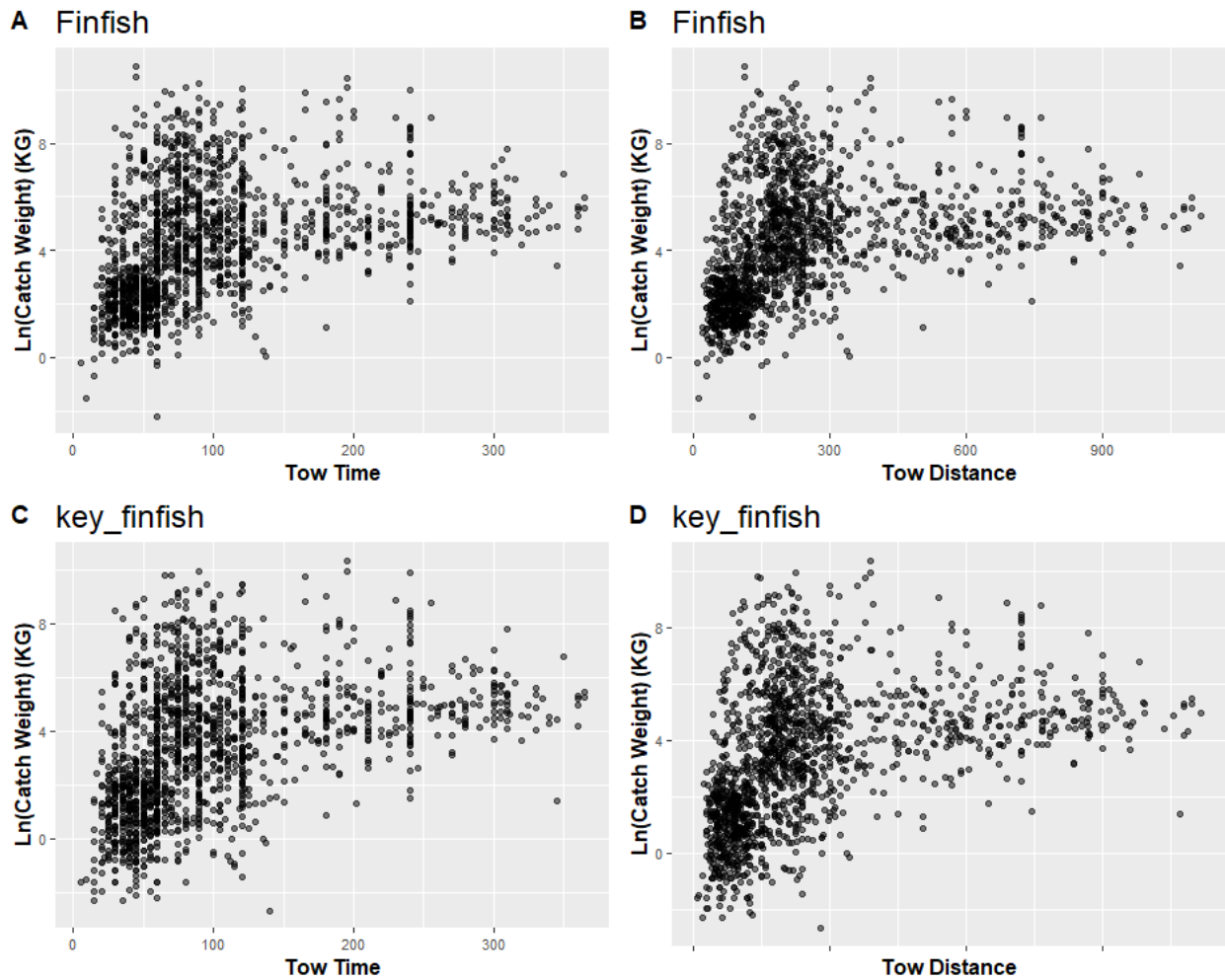


Figure 2.4.A.8. The natural log of catch weight (KG) was plotted against tow duration (tow time) for finfish (a) and key finfish (c). The natural log of catch weight (KG) was plotted against distance towed for finfish (b) and key finfish (d).

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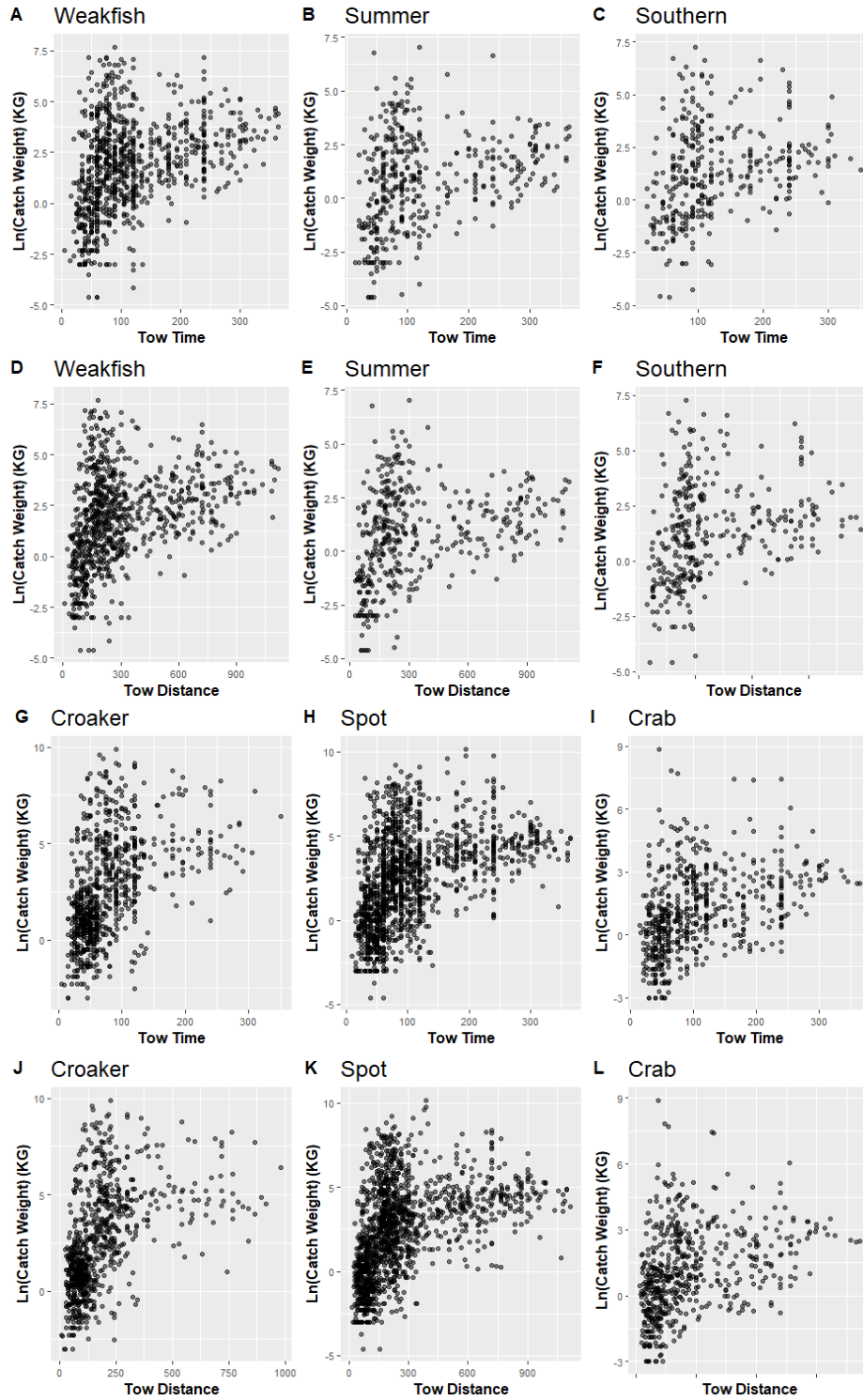


Figure 2.4.A.9. The natural log of catch weight (KG) was plotted against tow duration (tow time) for weakfish (a), summer flounder (b), southern flounder (c), croaker (g), spot (h), and blue crab (i). The natural log of catch weight (KG) was plotted against distance towed for weakfish (d), summer flounder(e), southern flounder (f), croaker (j), spot (k), and blue crab (l).

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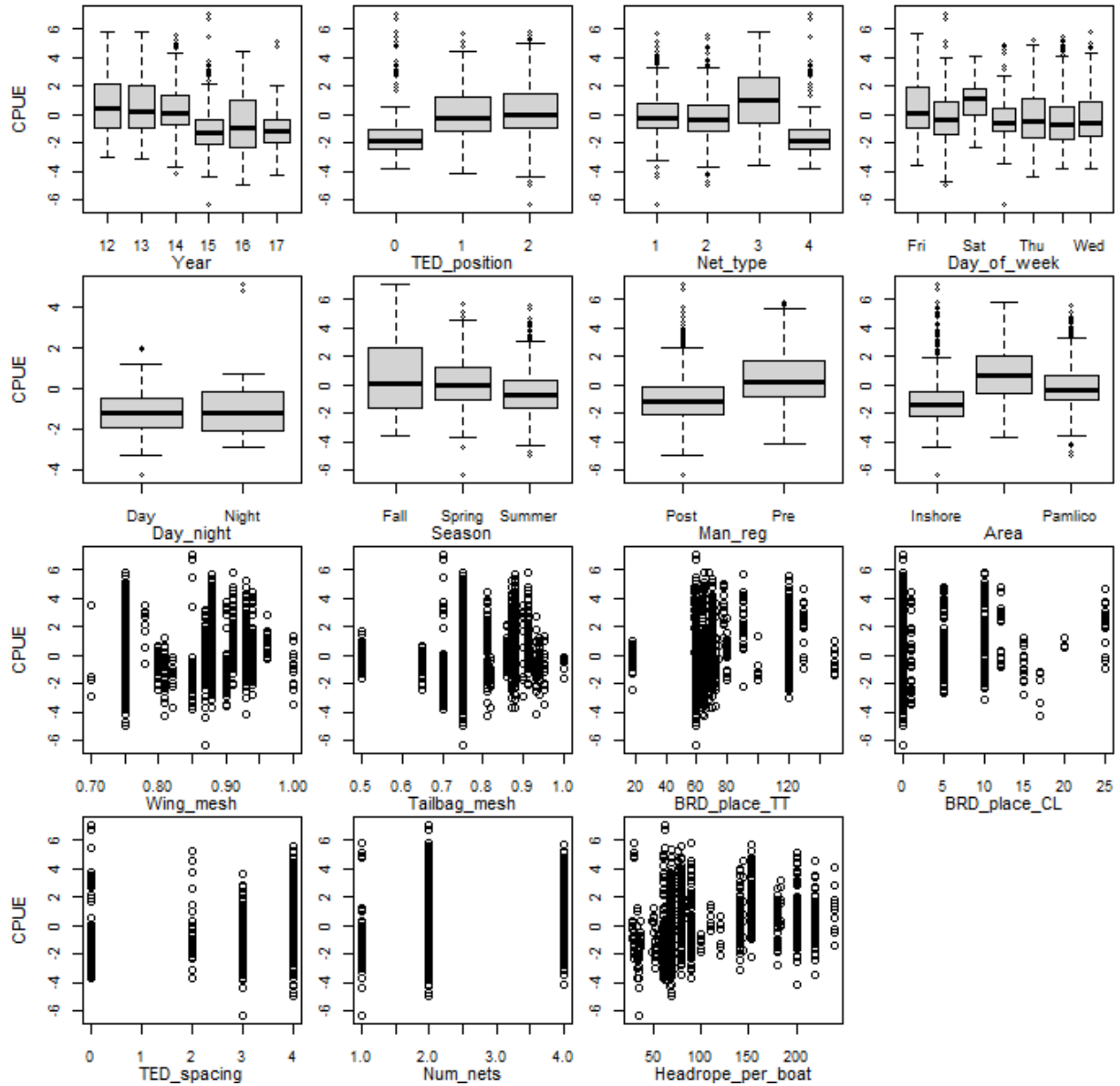


Figure 2.4.A.10. Plots of log(CPUE) against each potential predictor variable for finfish.

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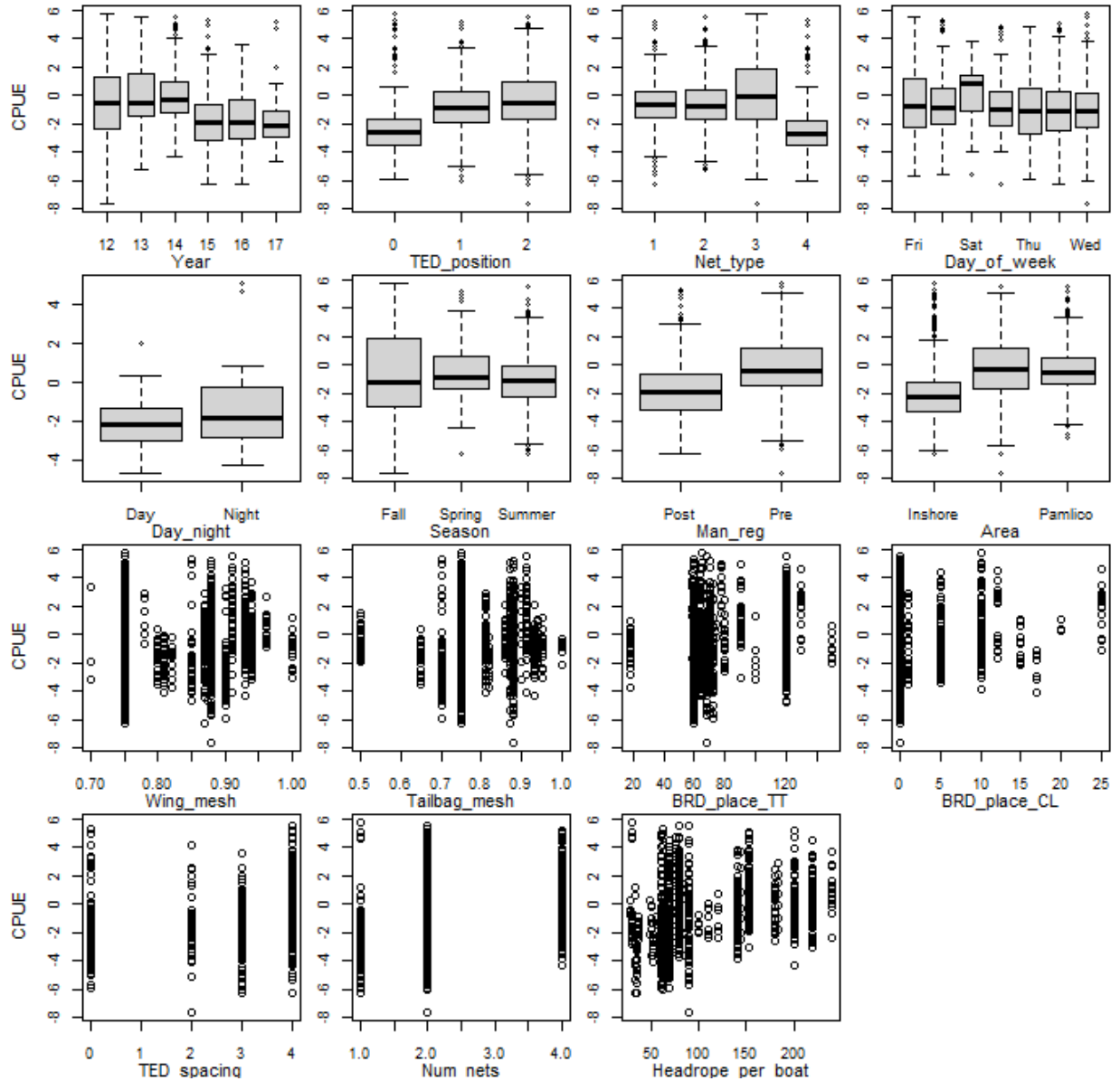


Figure 2.4.A.11. Plots of log(CPUE) against each potential predictor variable for key bycatch (blue crab, southern flounder, summer flounder, spot, croaker, and weakfish).

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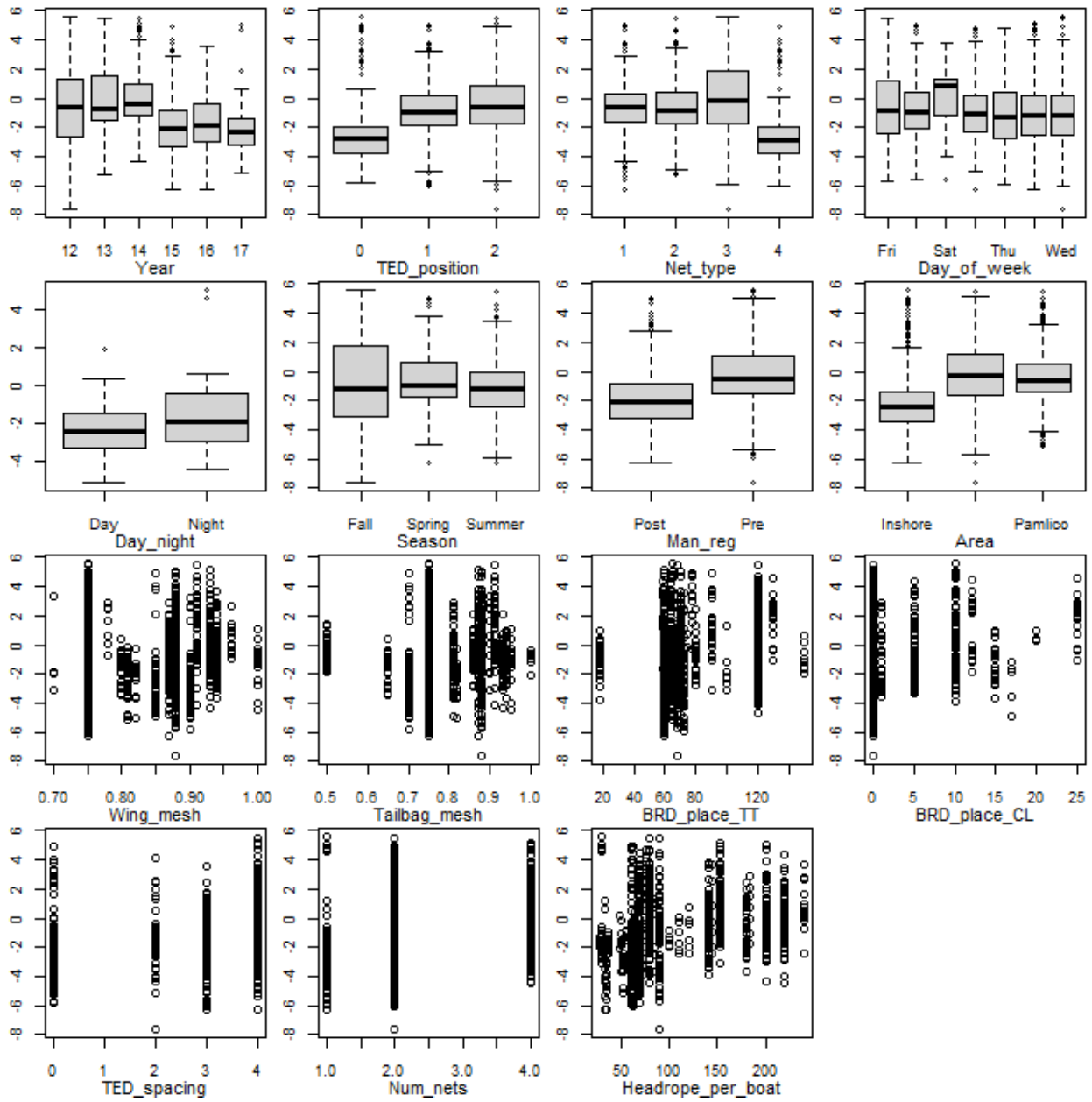


Figure 2.4.A.11. Plots of log(CPUE) against each potential predictor variable for key finfish (southern flounder, summer flounder, spot, croaker, and weakfish).

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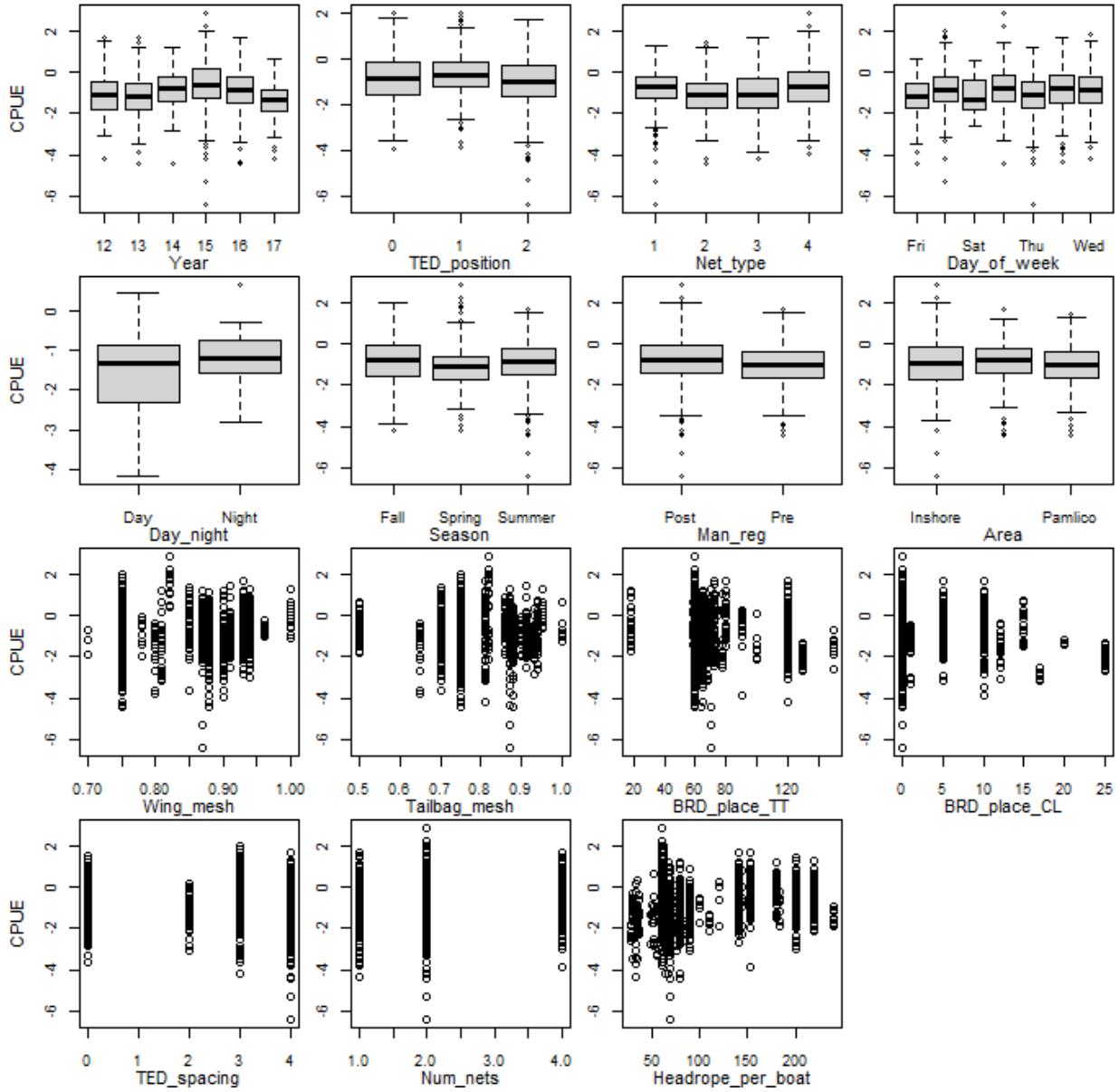


Figure 2.4.A.13. Plots of log(CPUE) against each potential predictor variable for key shrimp (brown, white, and pink).

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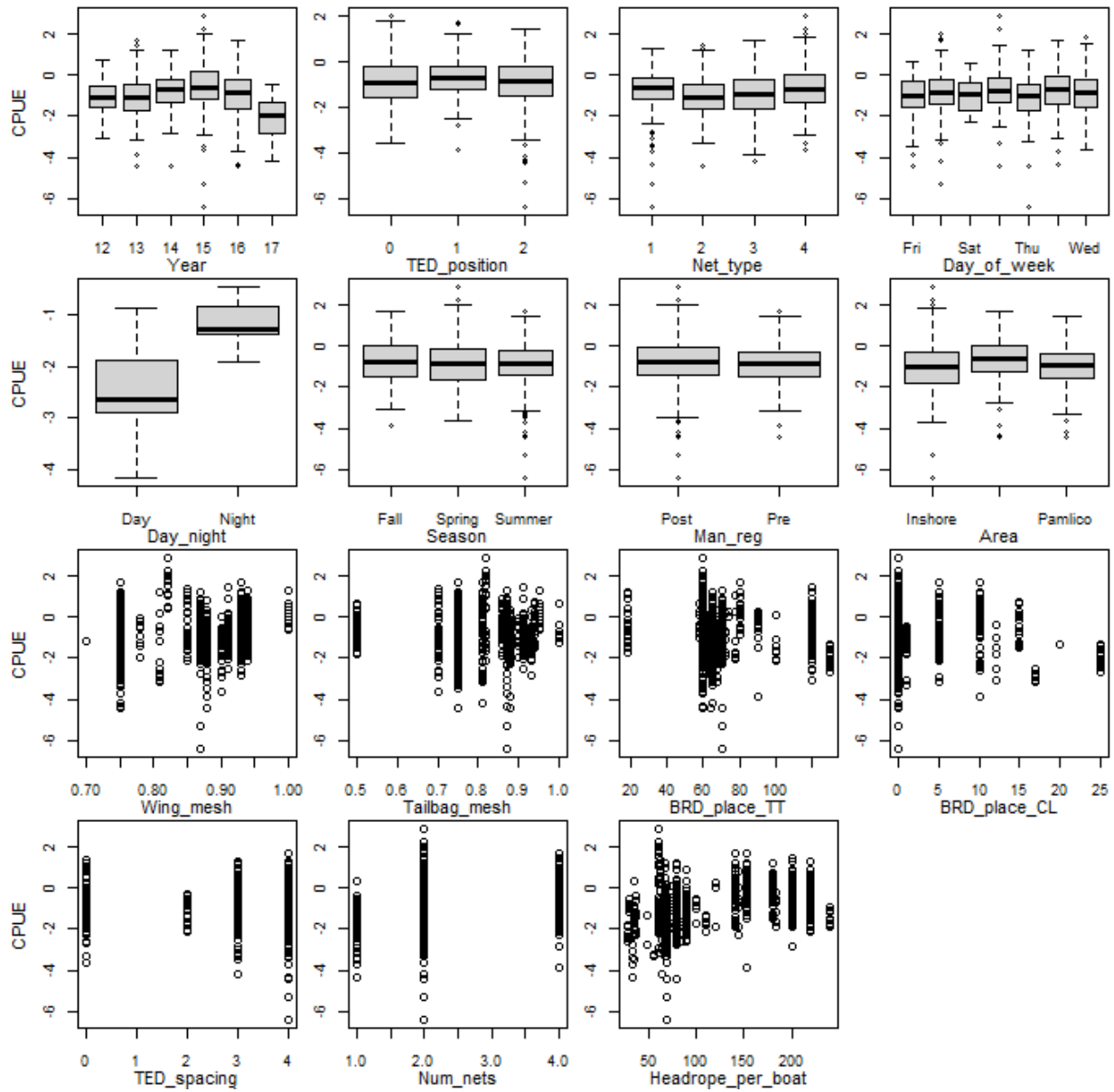


Figure 2.4.A.14. Plots of log(CPUE) against each potential predictor variable for brown shrimp.

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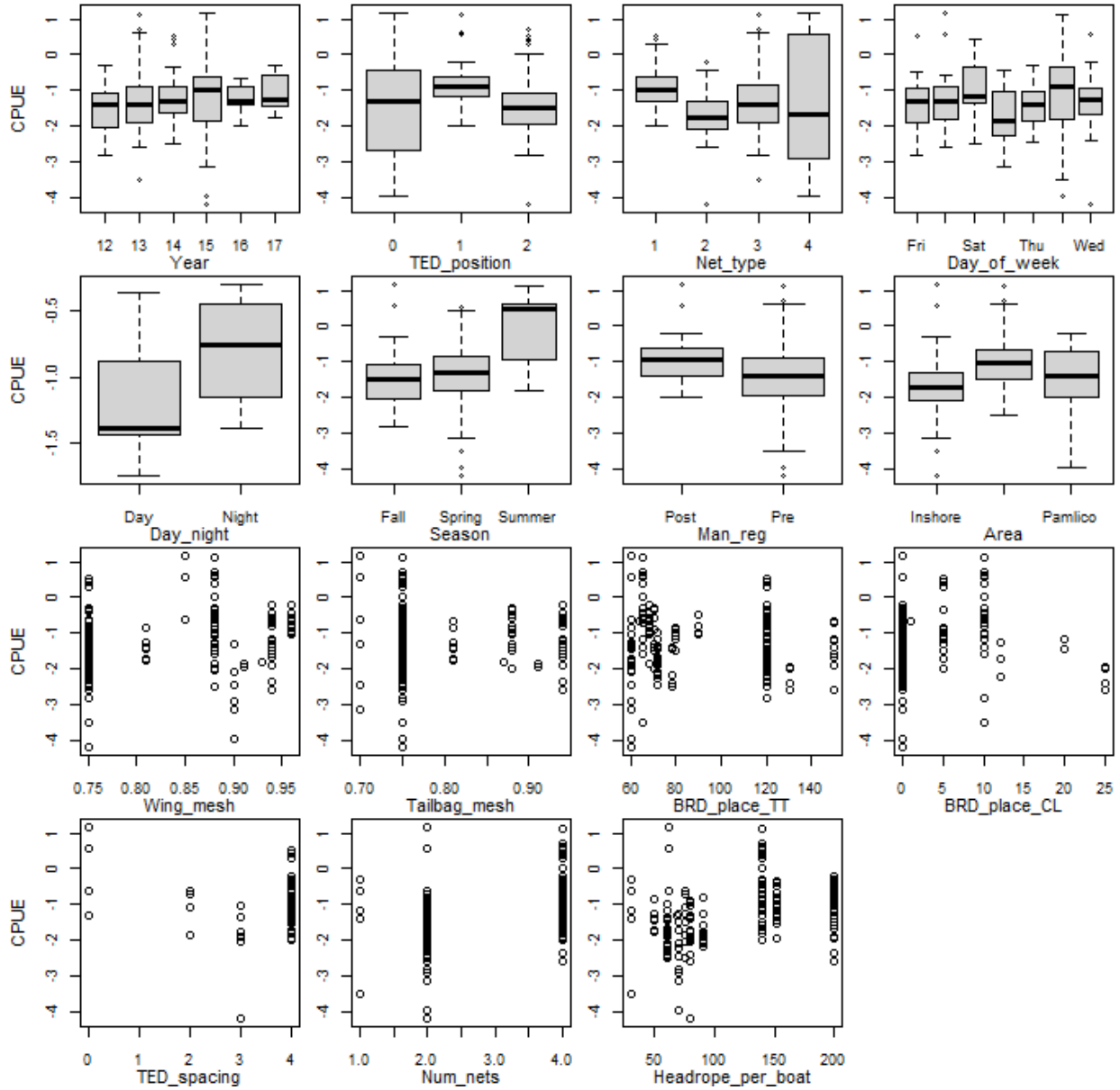


Figure 2.4.A.15. Plots of log(CPUE) against each potential predictor variable for pink shrimp.

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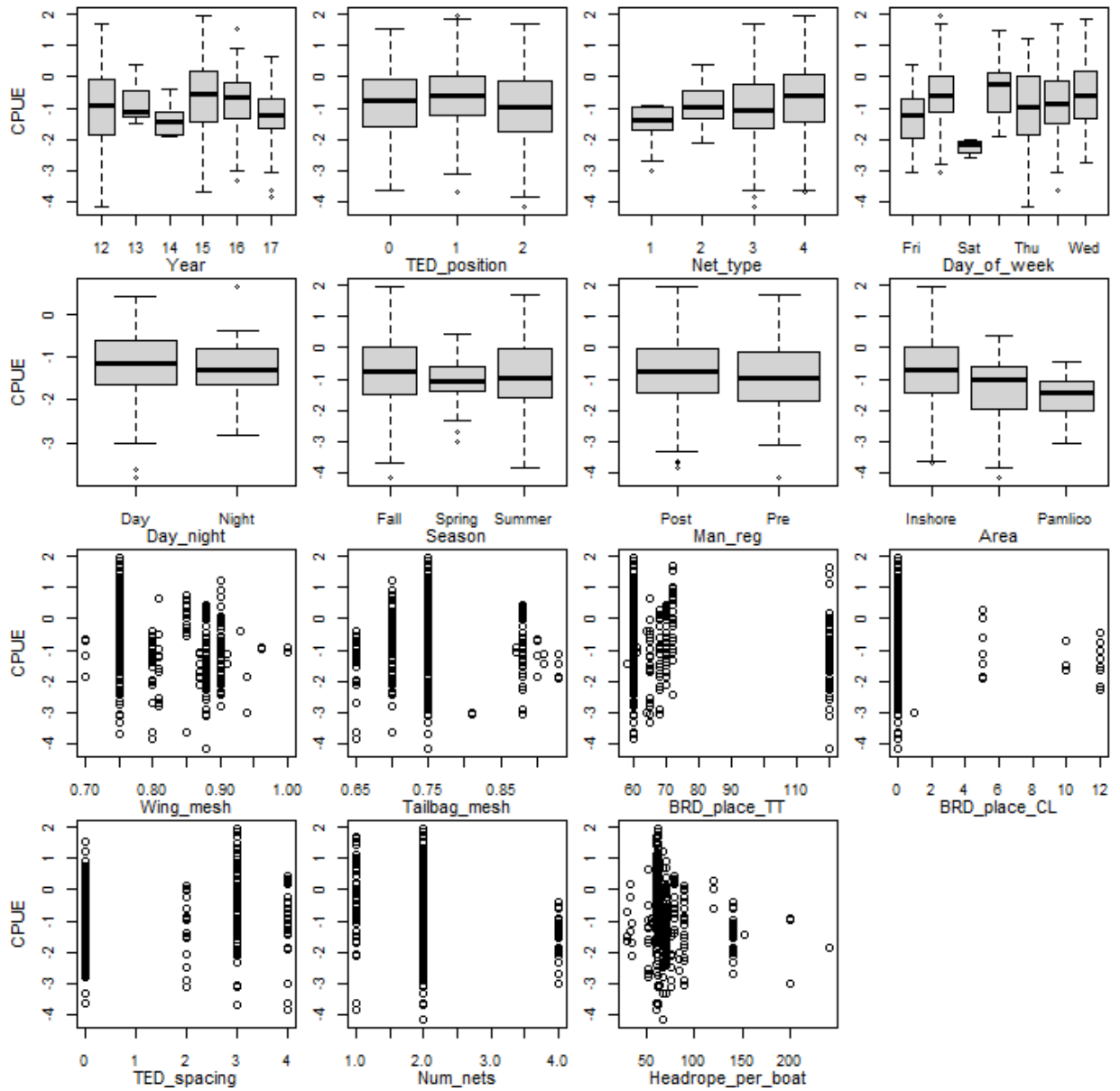


Figure 2.4.A.16. Plots of log(CPUE) against each potential predictor variable for white shrimp.

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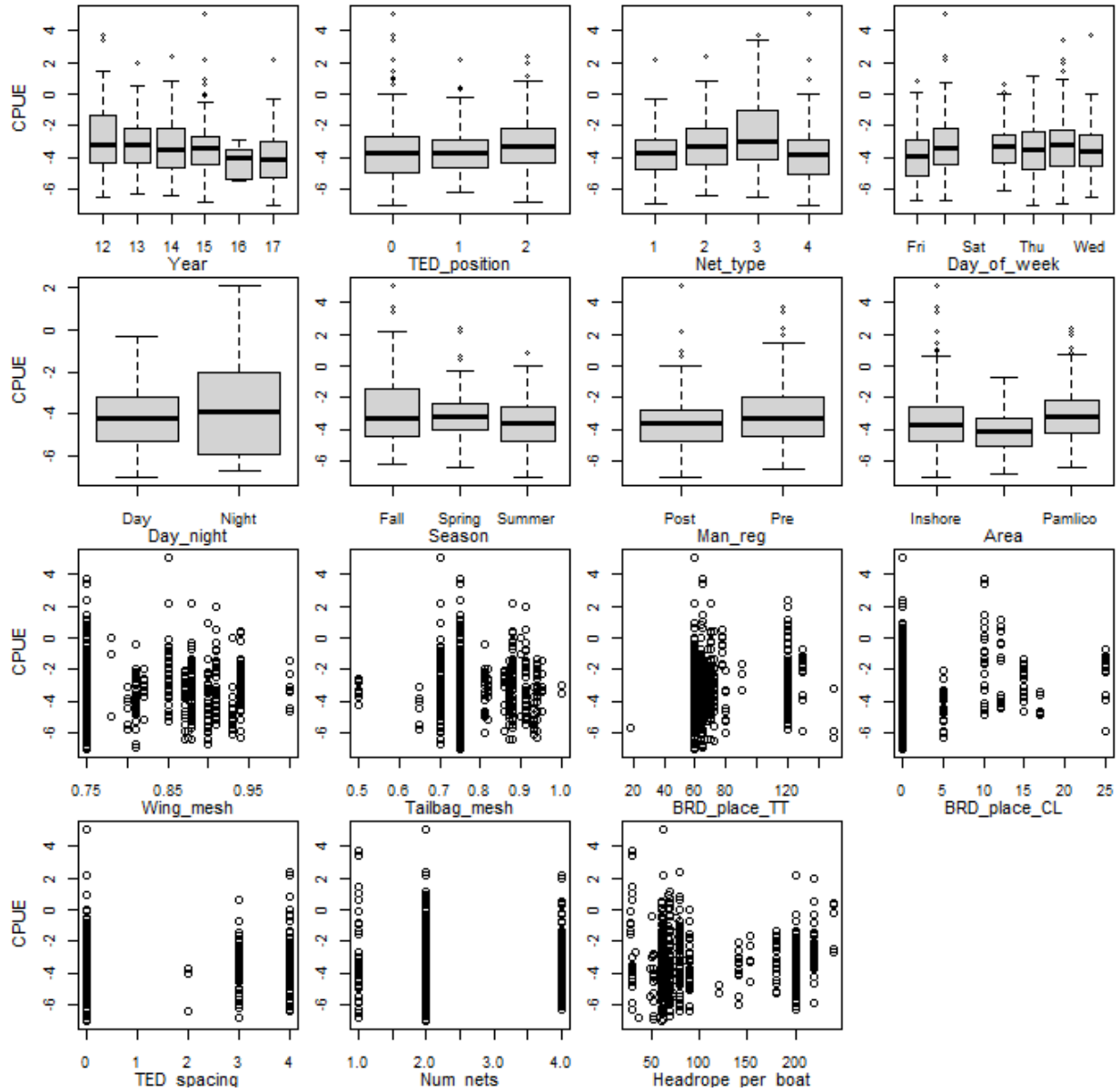


Figure 2.4.A.17. Plots of log(CPUE) against each potential predictor variable for blue crab.

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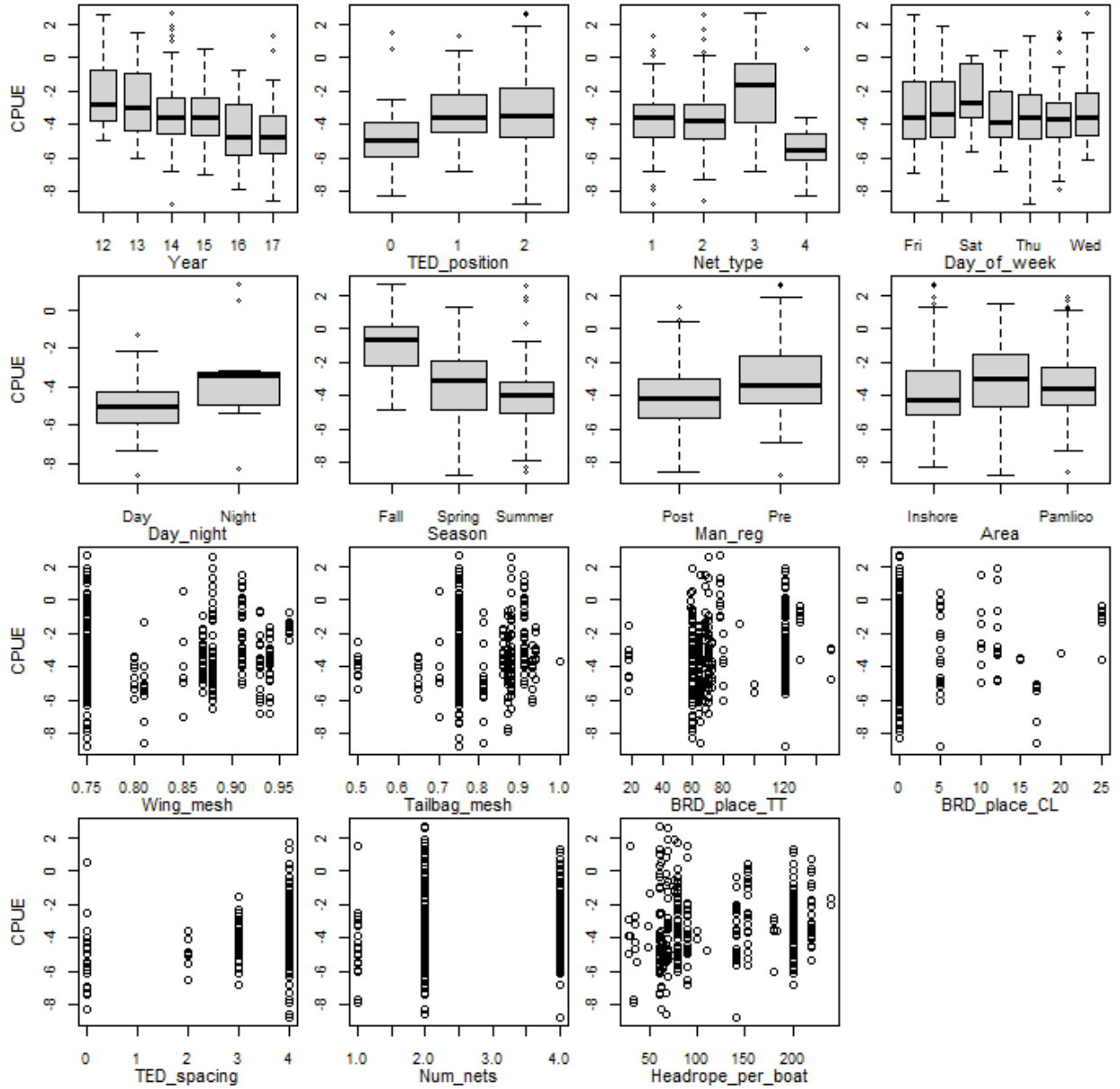


Figure 2.4.A.18. Plots of log(CPUE) against each potential predictor variable for southern flounder.

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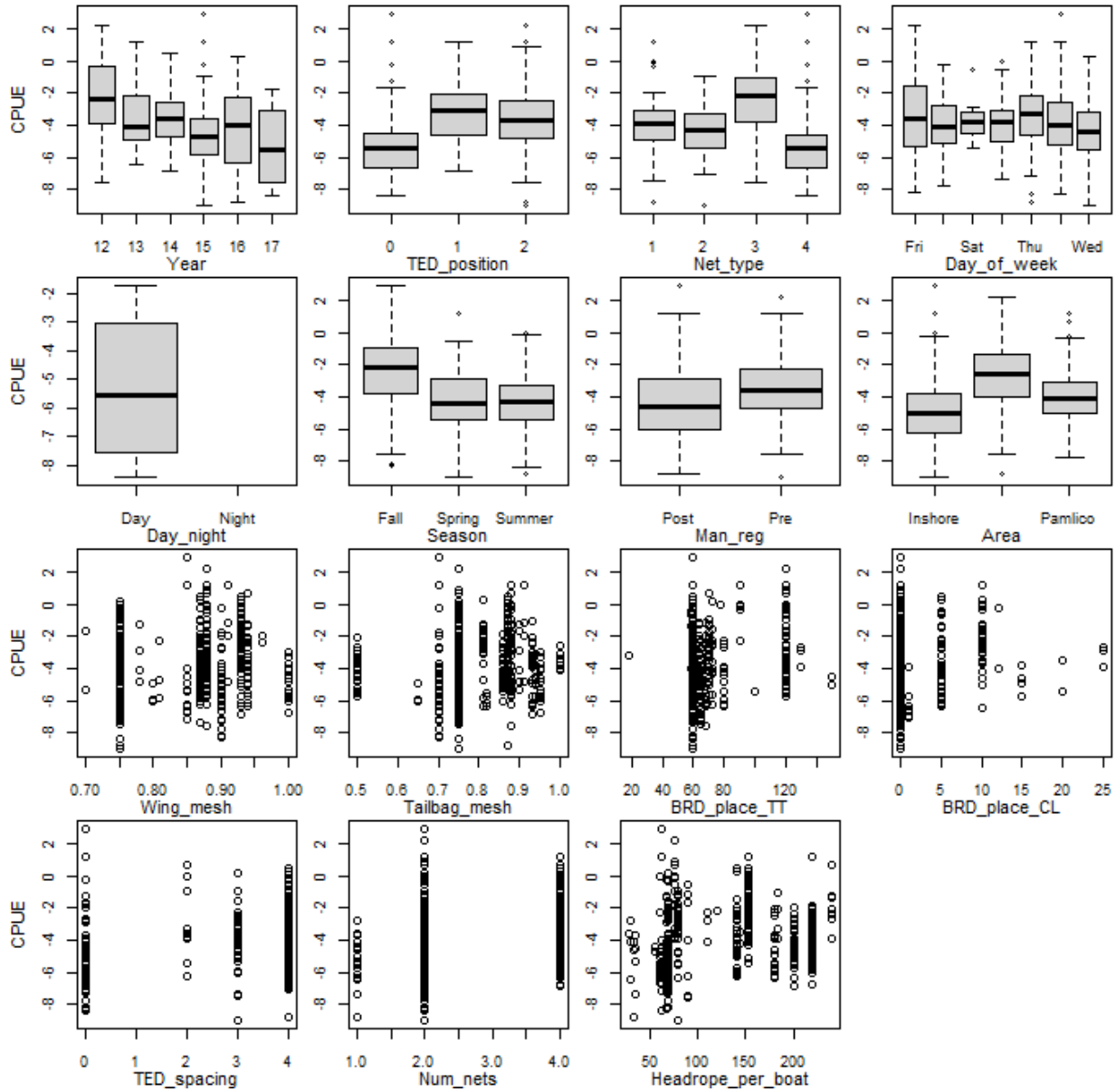


Figure 2.4.A.19. Plots of log(CPUE) against each potential predictor variable for summer flounder.

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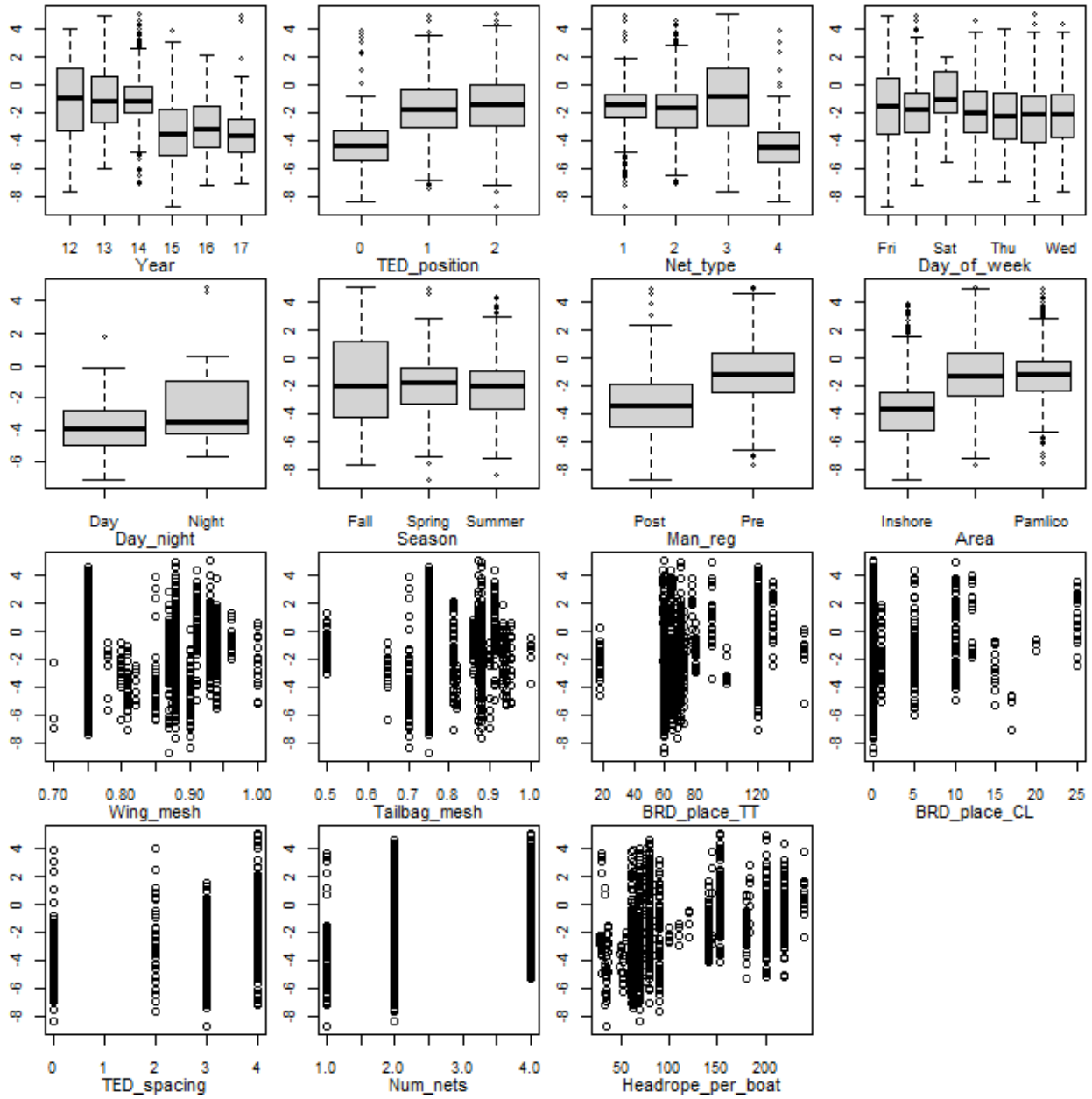


Figure 2.4.A.20. Plots of log(CPUE) against each potential predictor variable for spot.

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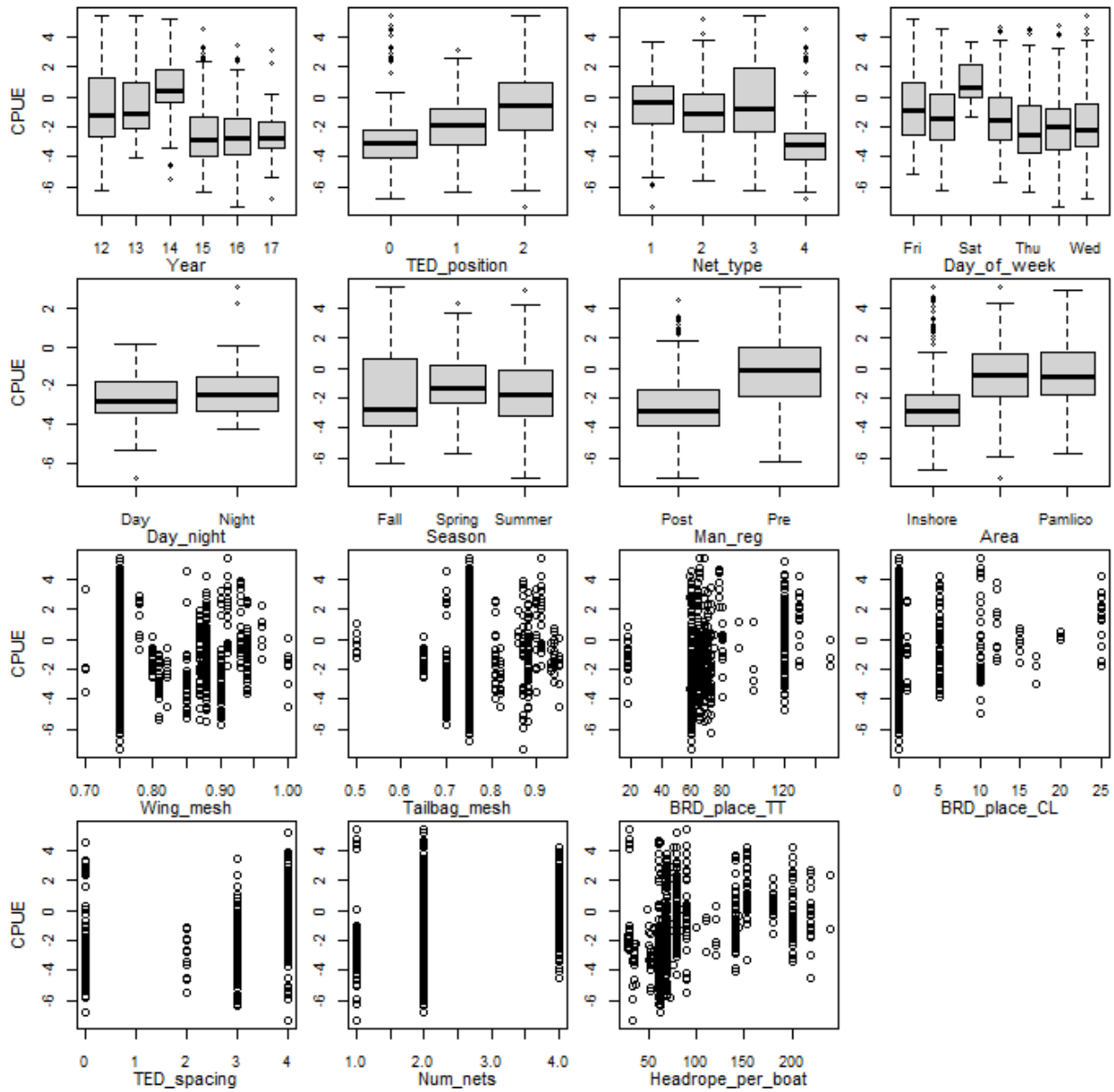


Figure 2.4.A.21. Plots of log(CPUE) against each potential predictor variable for croaker.

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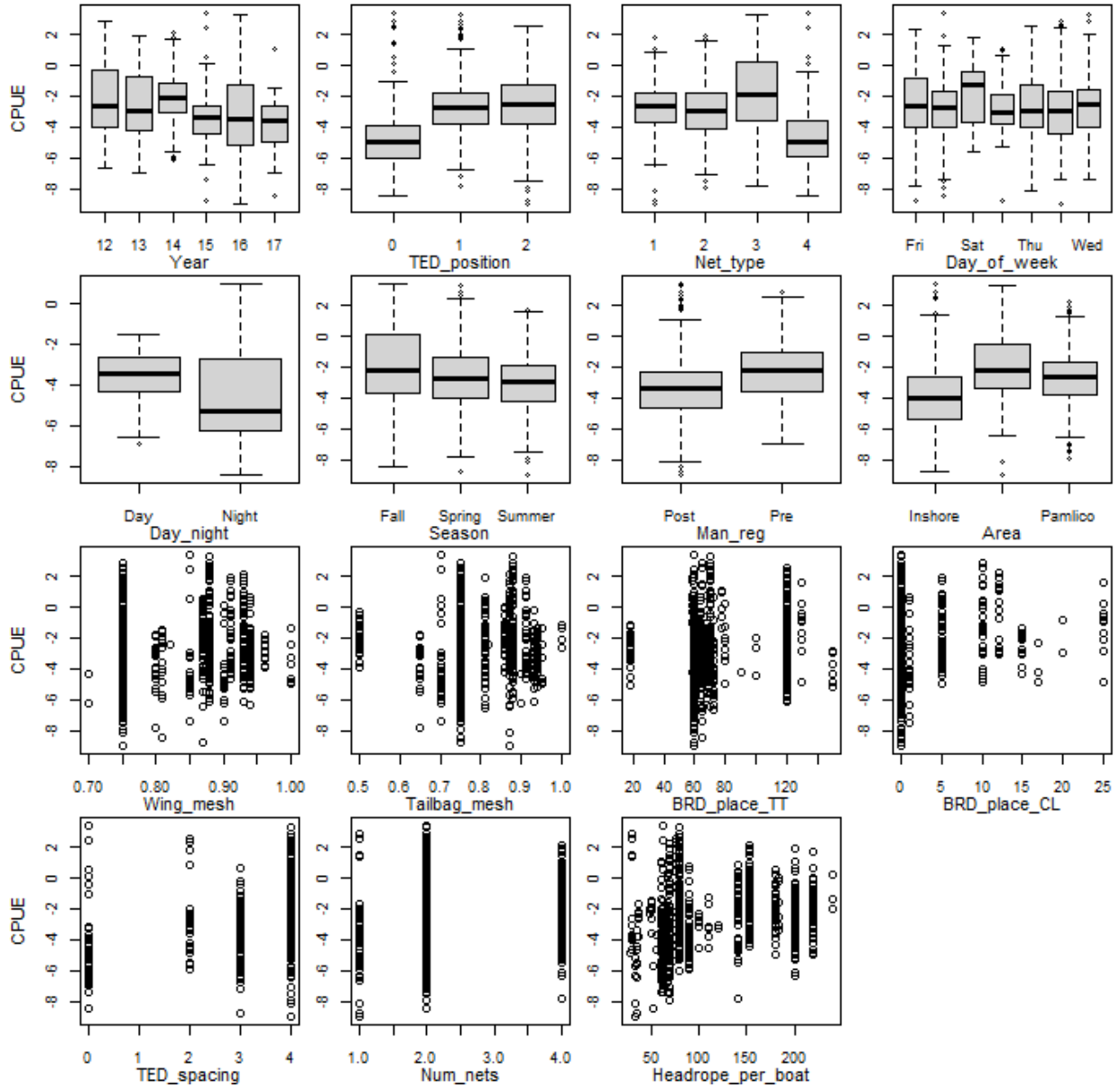
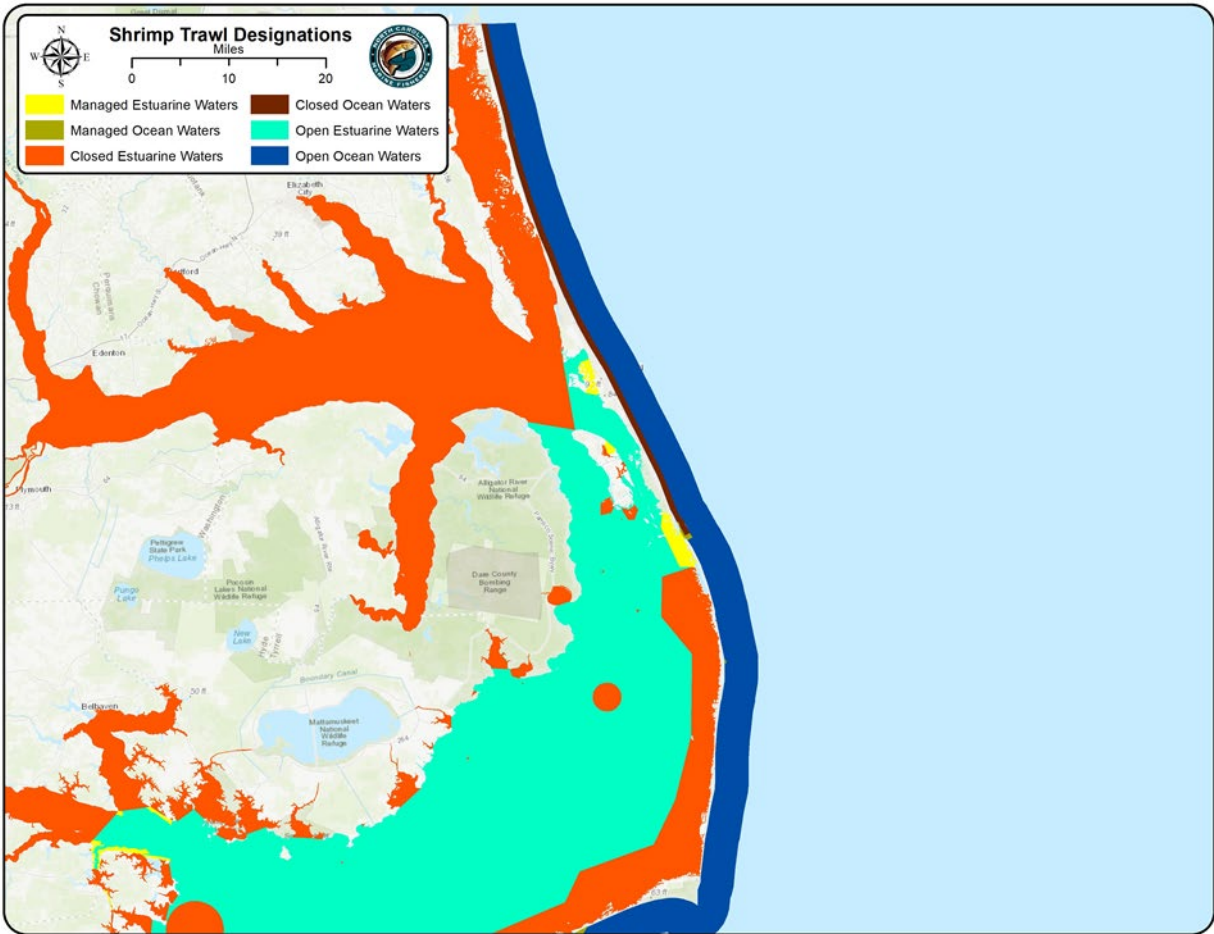


Figure 2.4.A.22. Plots of log(CPUE) against each potential predictor variable for weakfish.

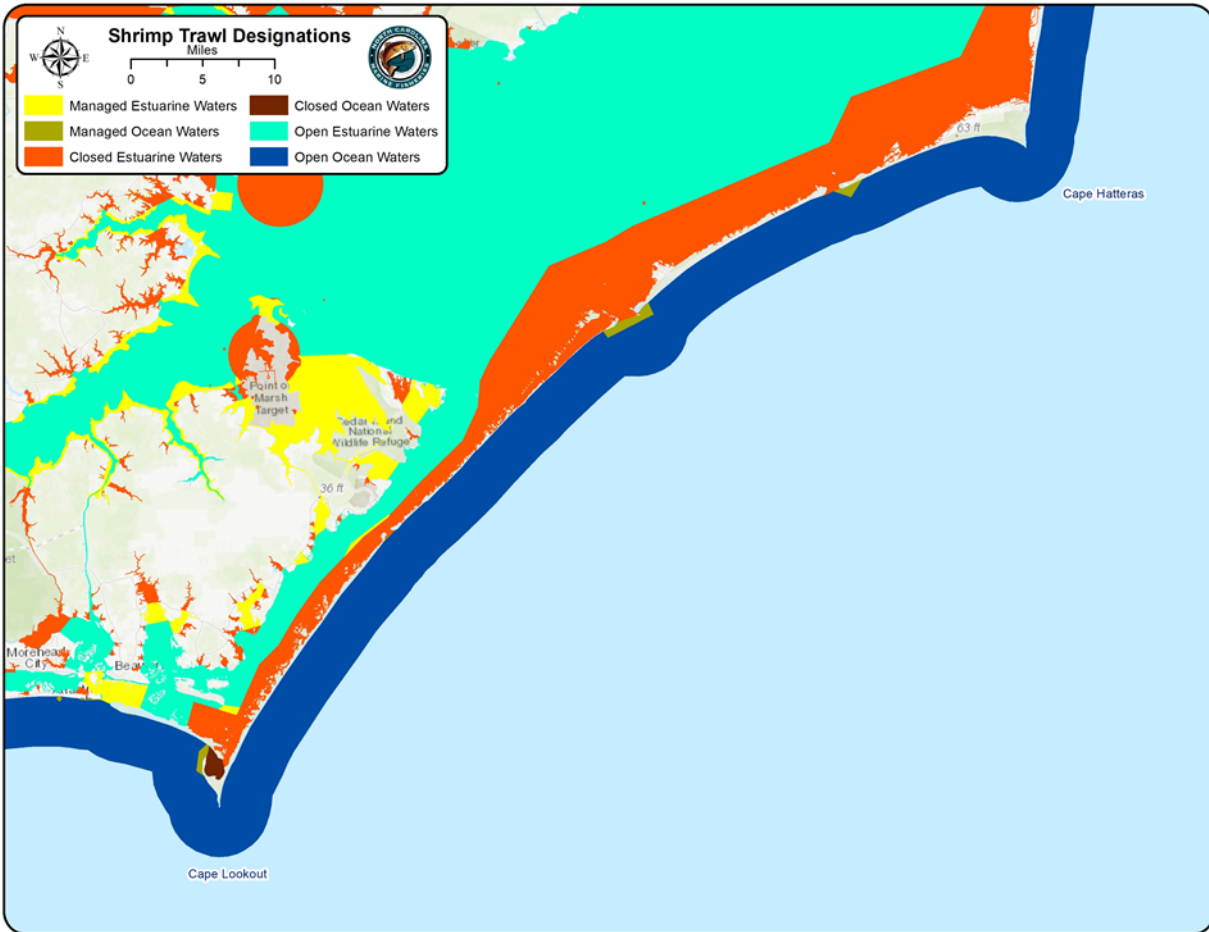
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APPENDIX 3. MAPS OF CURRENT AREA CLOSURES



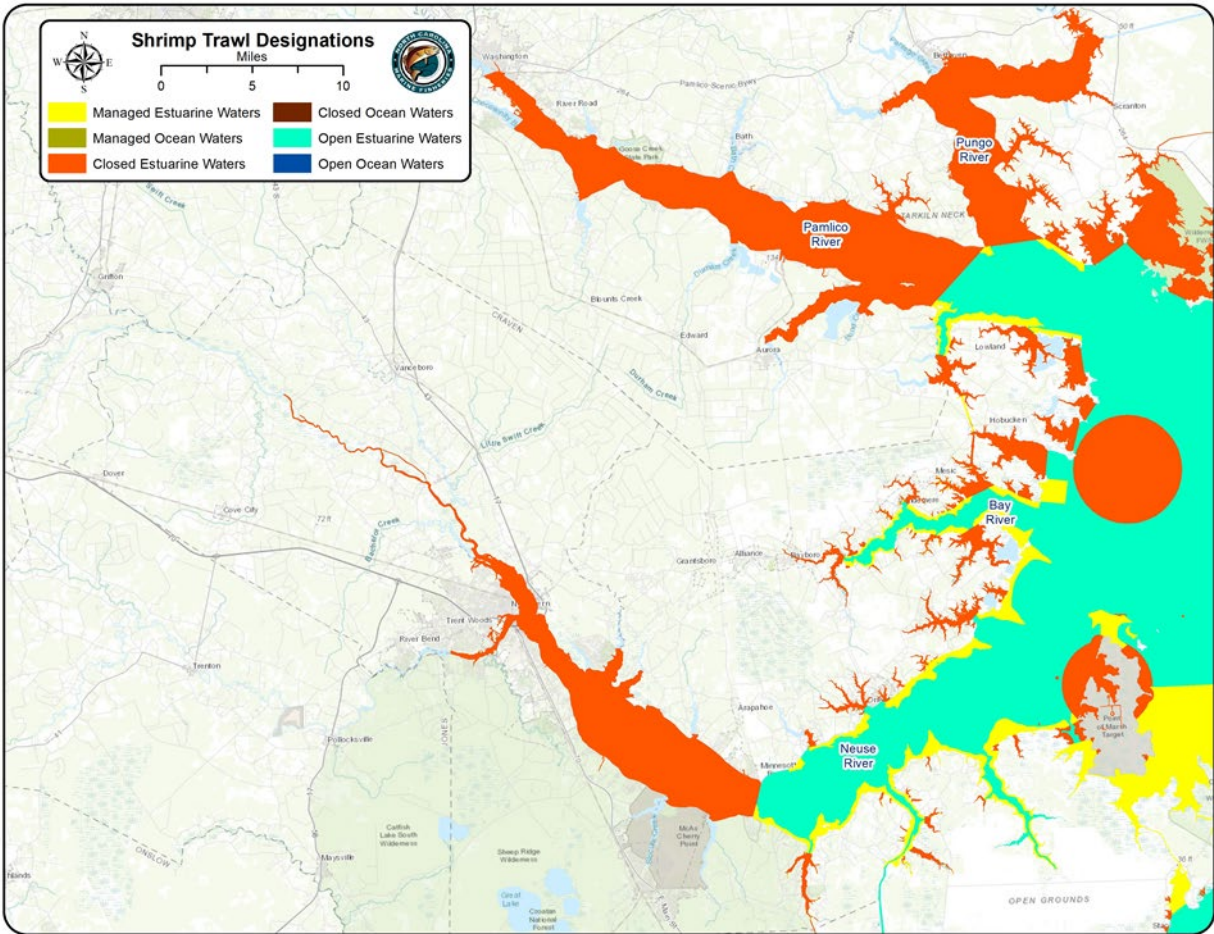
Map 3.1. Map of shrimp trawl areas in northern Pamlico Sound.

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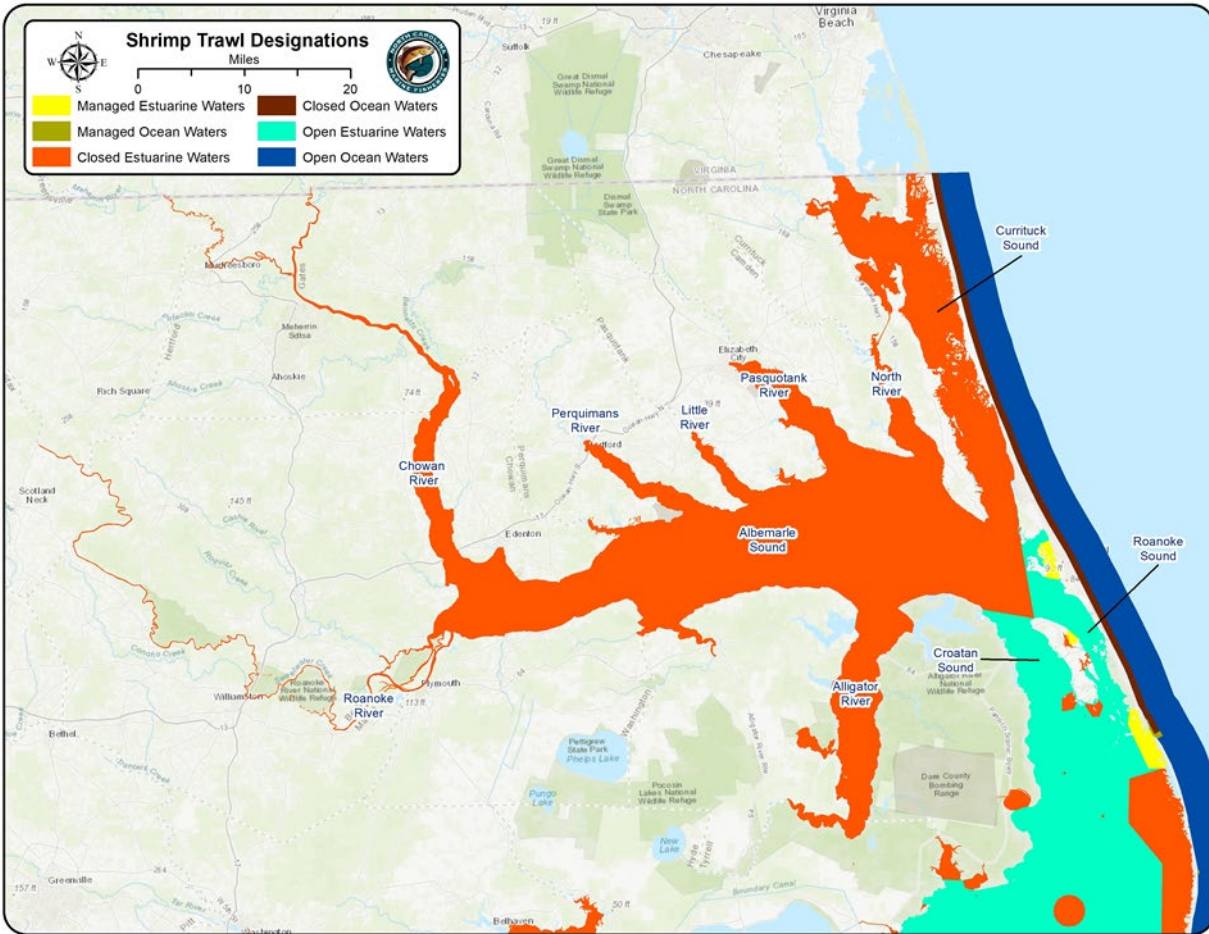
Map 3.2. Map of shrimp trawl areas in eastern Pamlico Sound Core Sound.

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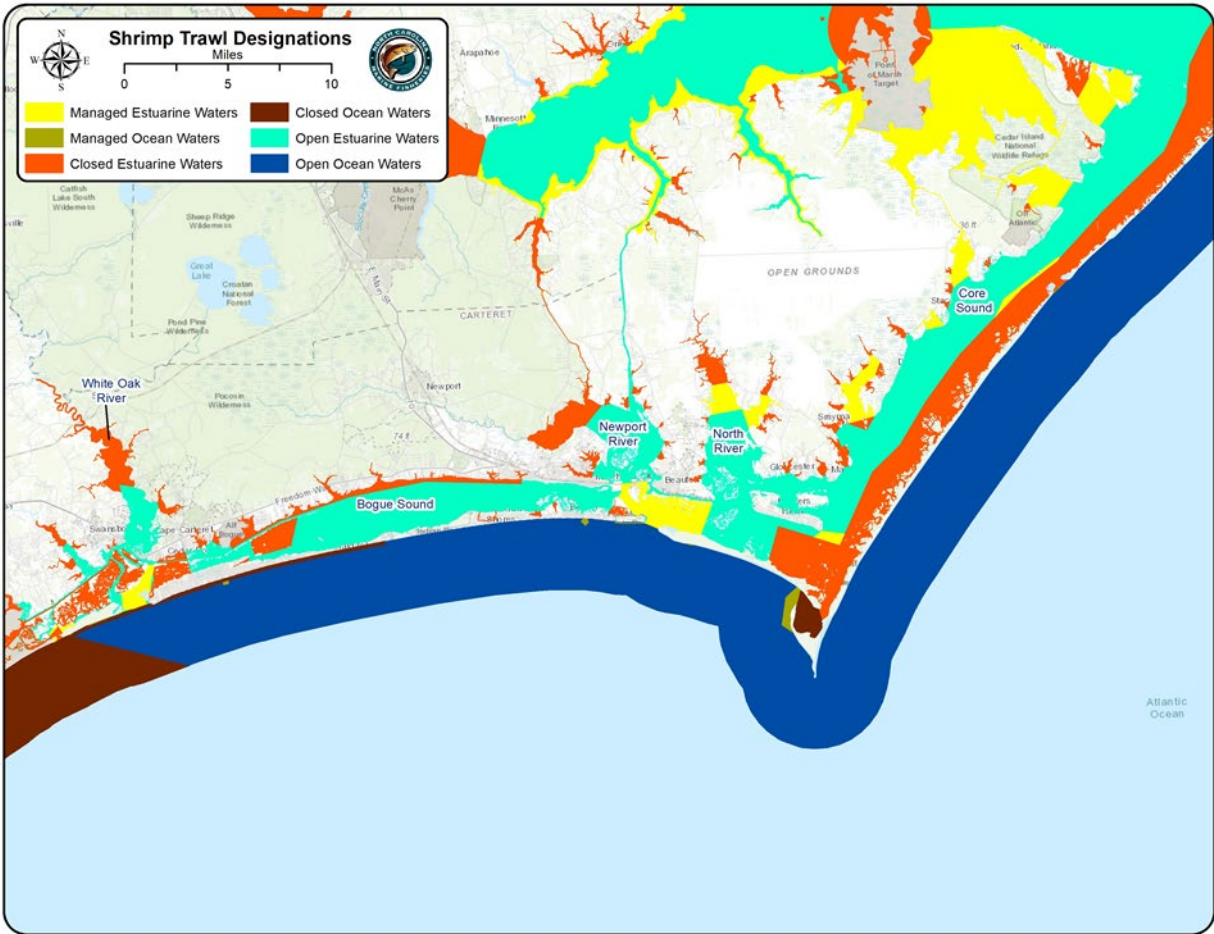
Map 3.3. Map of shrimp trawl areas in Pamlico, Pungo, Bay and Neuse rivers.

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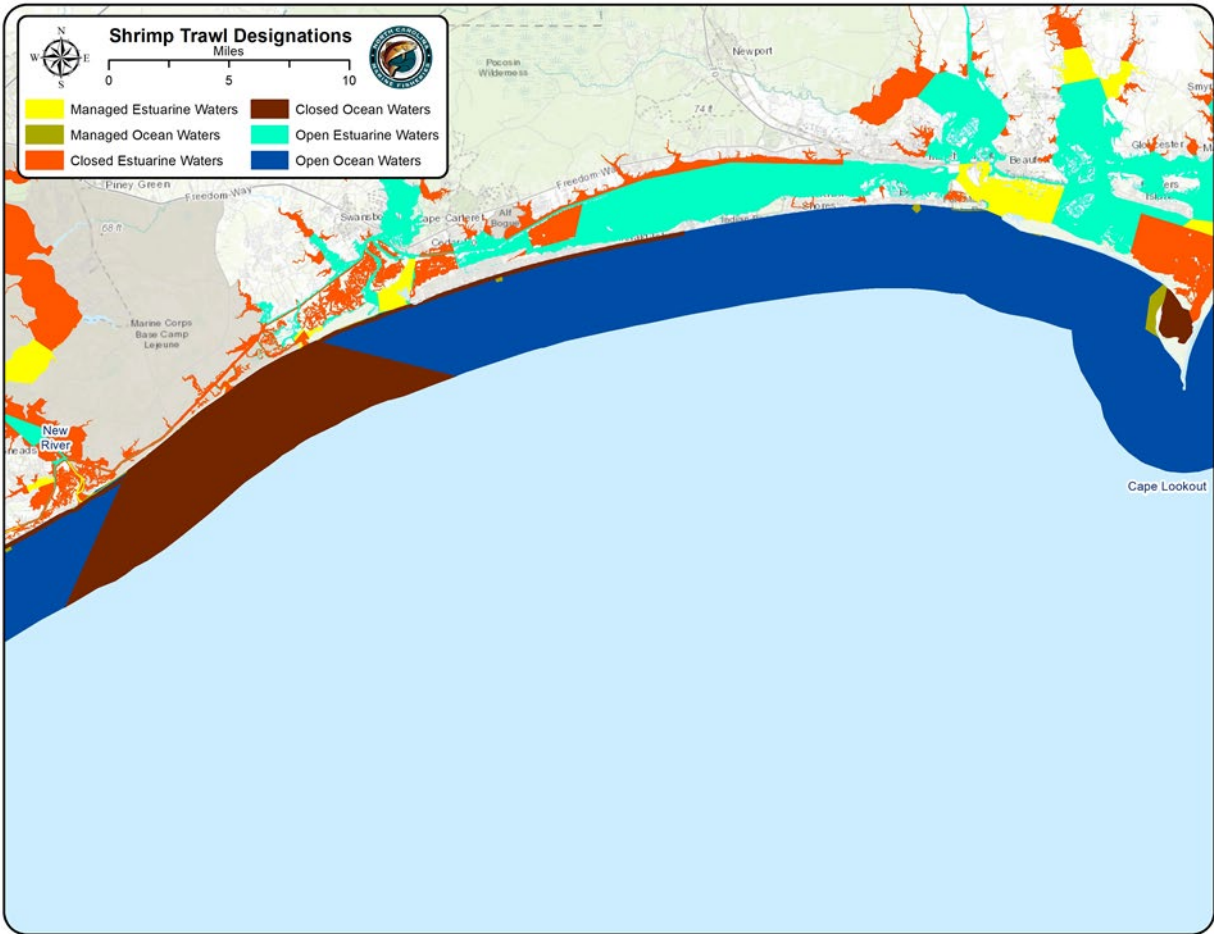
Map 3.4. Map of shrimp trawl areas north of Pamlico Sound (Croatan and Roanoke sounds).

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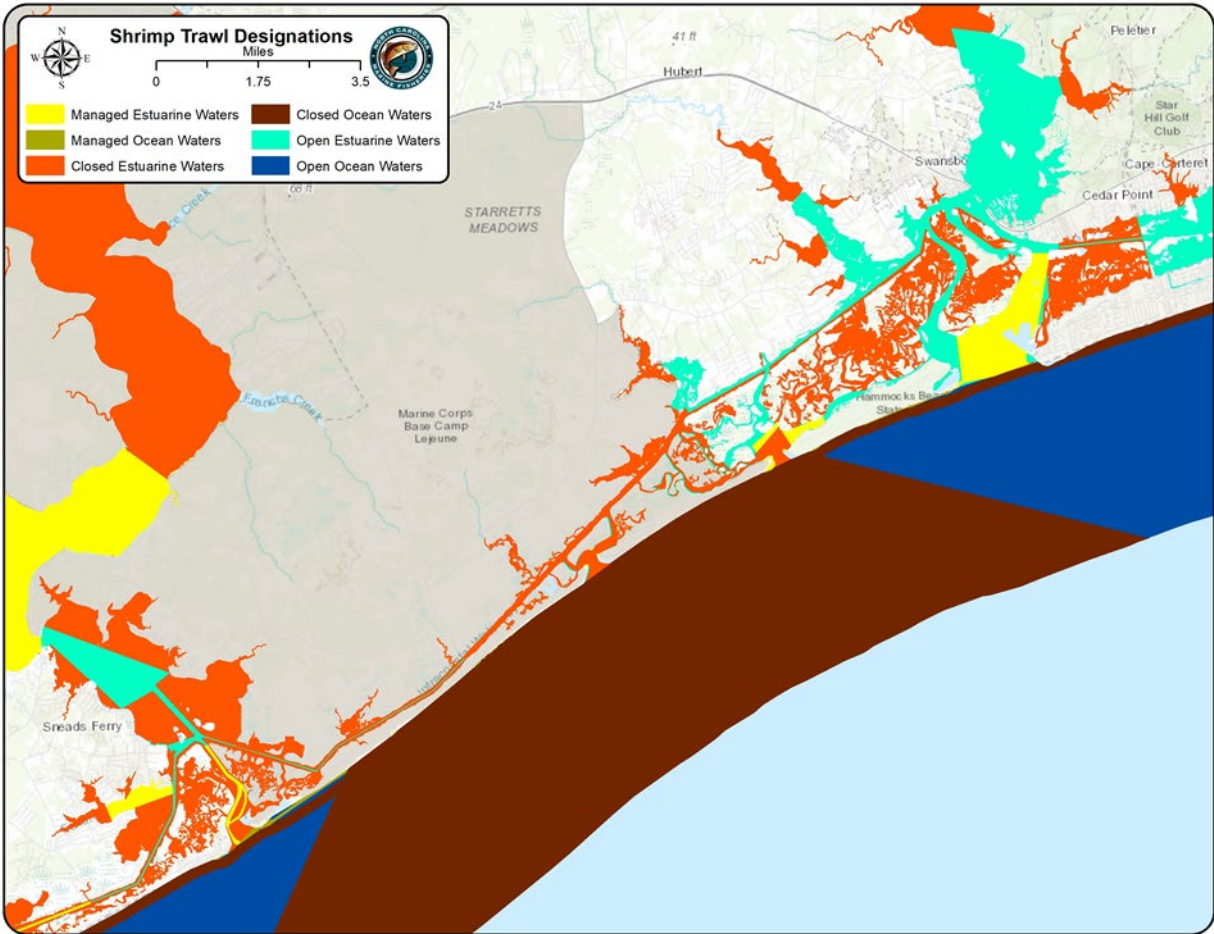
Map 3.5. Map of shrimp trawl areas from Core Sound to White Oak River.

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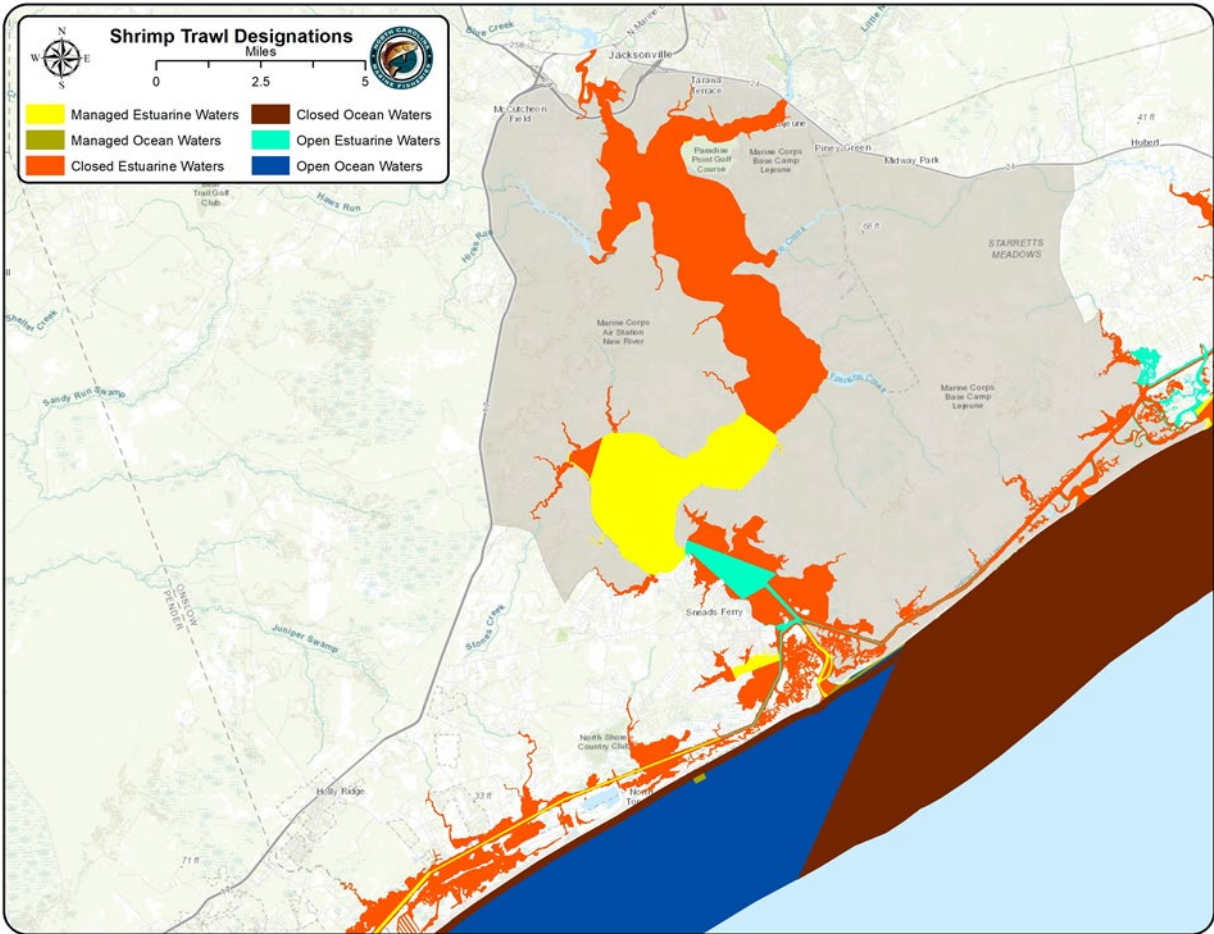
Map 3.6. Map of shrimp trawl areas from Cape Lookout to New River.

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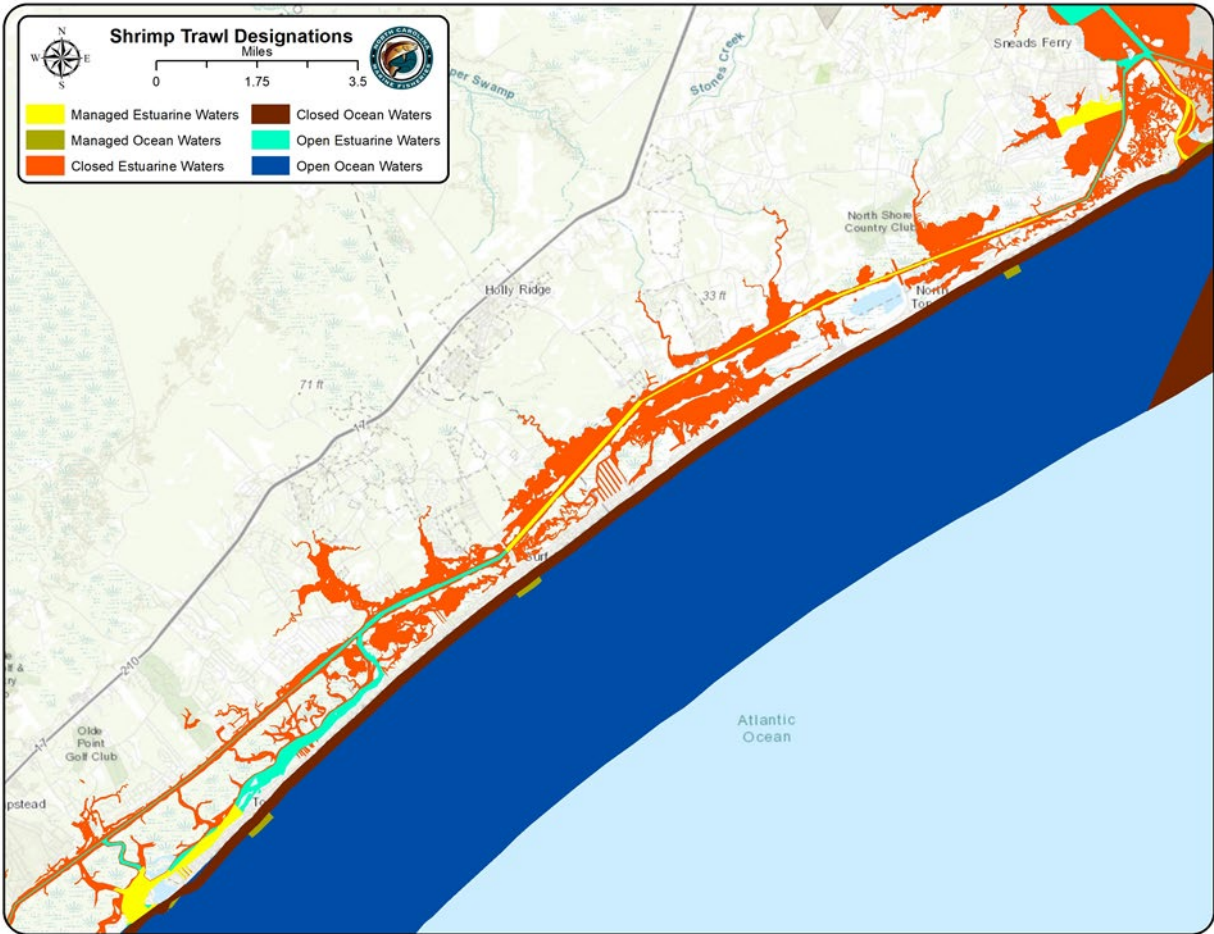
Map 3.7. Map of shrimp trawl areas from White Oak River to New River.

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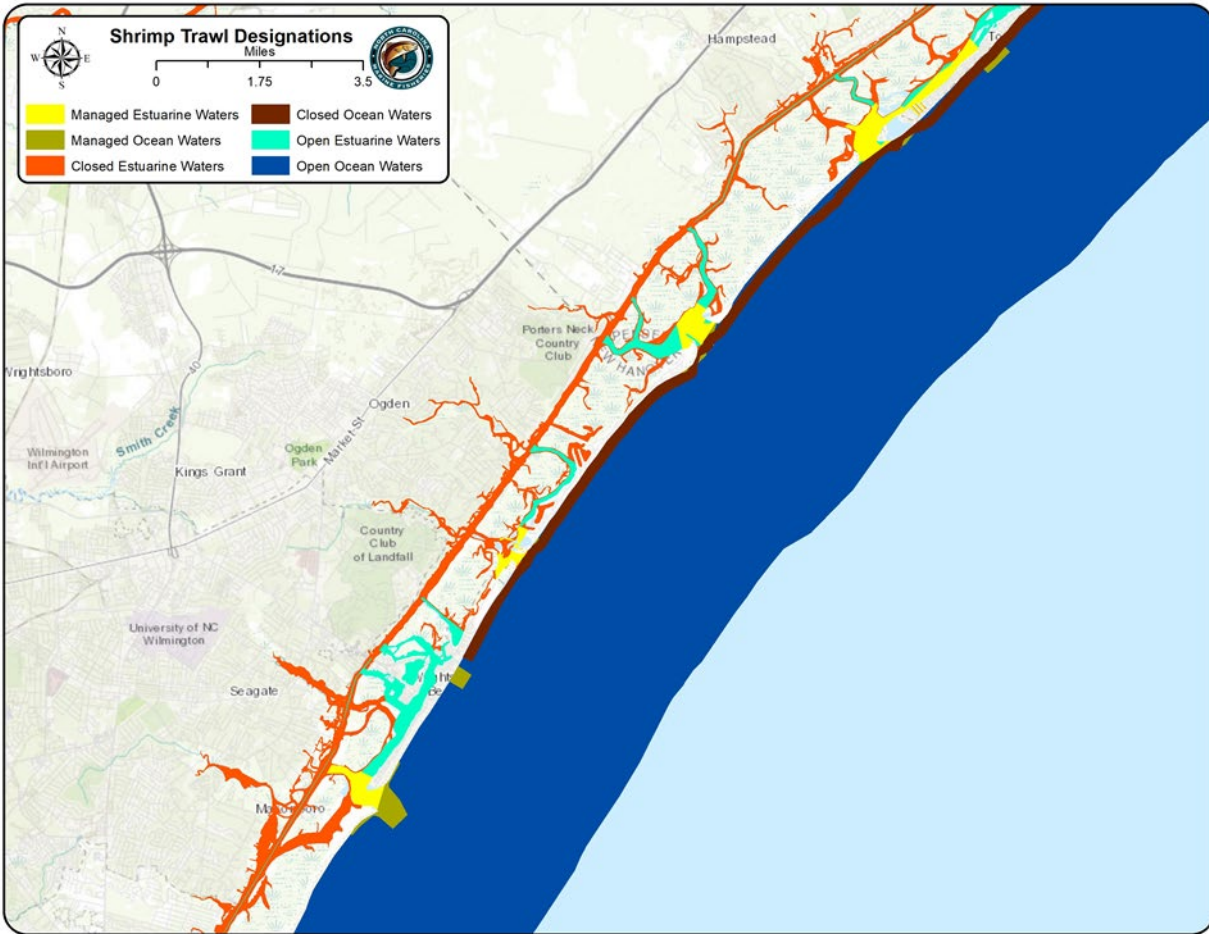
Map 3.8. Map of shrimp trawl areas in New River.

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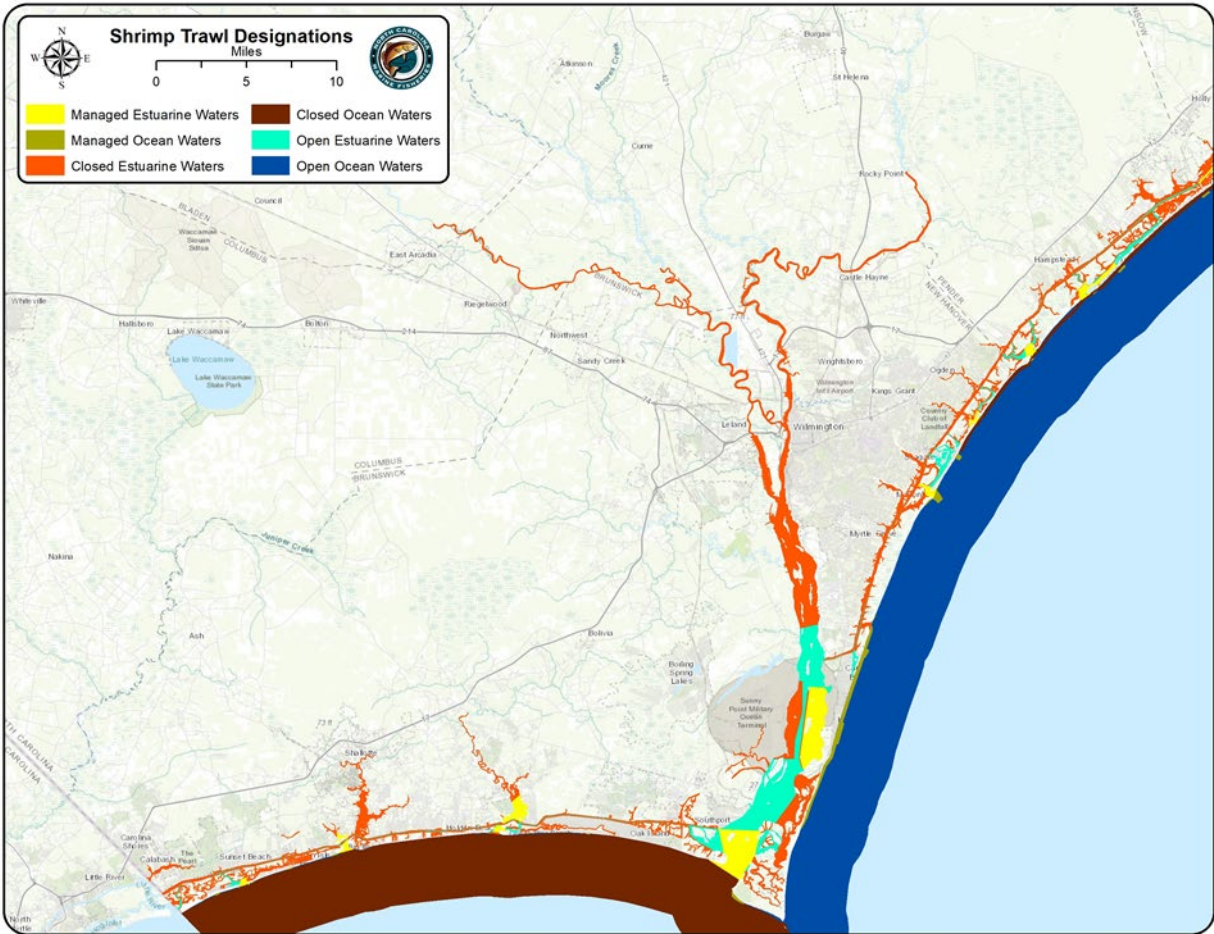
Map 3.9. Map of shrimp trawl areas from New River to Topsail Inlet.

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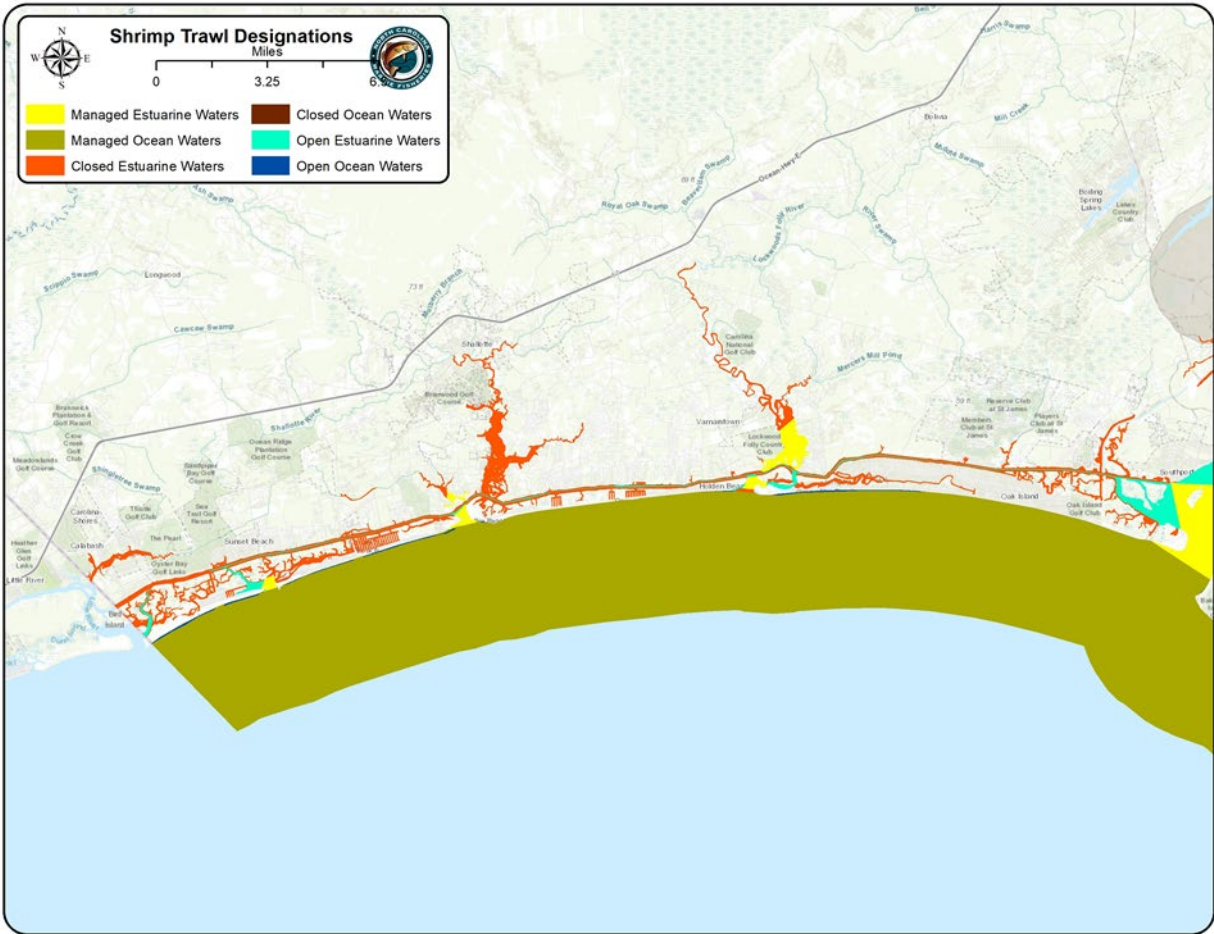
Map 3.10. Map of shrimp trawl areas from Topsail Inlet to Wrightsville Beach.

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Map 3.11. Map of shrimp trawl areas in Cape Fear River

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Map 3.12. Map of shrimp trawl areas from Cape Fear River to South Carolina state line.

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APPENDIX 4. COMMERCIAL, BAIT, AND RECREATIONAL SHRIMP TRAWL REGULATIONS FOR SOUTH ATLANTIC AND GULF STATES MAY 2021

Table 4.1. Commercial food shrimp trawl regulations for South Atlantic and Gulf of Mexico states. *Unable to verify regulations with state fisheries agency.

State	Gear Restrictions	Season	Estuarine Trawling Allowed	Miscellaneous
North Carolina	Pamlico Sound up to 220 ft of headrope; other inshore waters up to 90 ft headrope; no headrope limit in state ocean waters; two BRDs required in all otter trawl nets	Open year-round in most areas; special secondary nursery areas and other managed areas open based on biological sampling	Yes: prohibited in primary and secondary nursery areas and Albemarle Sound	
South Carolina	Up to 220 ft of footrope; BRD required in nets with 2.5" stretch mesh or less or with a headrope 16 ft or greater	Open May - Dec. in general trawl areas; open Sep. - Dec. 15 below channel net areas	Yes: mouths of St Helena, Port Royal, and Alibogue sounds and Winyah and North Santee bays	Cannot dispose of bycatch within half mile of beach; no shrimping at night
Georgia*	BRD in all nets > 16 ft headrope; TED in all nets >12 ft headrope unless hand retrieved	Open as early as May 15; close Dec 31 or may extend into Jan or Feb	No	No TED required if hand retrieved, must follow seasonal tow time restrictions
Florida*	1-2 roller frame, otter, and/or skimmer trawls depending on region; no more than 500 square feet of mesh area in net/bag; BRD and TED required	June-Oct.: no weekend shrimping; Apr-May: closed in certain counties	Yes, managed by region: North West region-yes with additional gear restrictions; Big Bend Region-yes; South West Region-Tampa Bay-yes; South East Region-Biscayne Bay-no; North East Region-yes, tributaries of rivers closed	
Alabama	Up to 50 ft headrope and no more than 2 trawls; no restrictions offshore; TED required	Closed May 1 - June 1, other specific seasonal closures	Yes: Mobile Bay, parts of Mississippi Sound, and other smaller bays	Minimum size limit 68 count head-on or lower

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State	Gear Restrictions	Season	Estuarine Trawling Allowed	Miscellaneous
Mississippi	Up to 50 ft headrope if using one trawl net; up to 25 ft of headrope per net if using two trawl nets; no more than two trawl nets may be used; trawl doors: 8 ft length, 43 in. high; TED required	Opens in May/June; closes: Jan. 1 north of IWW and April 30 south of IWW	Yes: all inside bays and rivers closed and closed in Mississippi Sound within 1/2 mile of mainland shoreline; closed within 1 mile perimeter around barrier islands eight miles from mainland shoreline	Minimum size limit 68 count head on
Louisiana	Inshore: up to 50 ft headrope if using one trawl net; up to 25 ft headrope per net if using two trawl nets; no more than two trawl nets may be used; max trawl door size: 8' long x 43" high; Offshore to 3 miles: up to 130 ft headrope max; Breton and Chandeleur Sounds - 2 trawl nets, with no more than 65 ft of headrope each; EEZ: up to 4 trawls, any size; Mesh size restrictions - 5/8" bar or 1-1/4" stretch, 3/4" bar or 1.5" stretch mesh in Vermilion-Teche Basin in fall shrimp season; BRD and TED required in federal waters, TED required in trawl nets fishing state waters	Spring inshore season: typically, May - early July; fall inshore season: Aug - Dec; offshore: open year-round; exemptions (live bait) close late fall-early winter	Yes: managed by zones	Minimum size limit of 100 count heads on for white shrimp, except Oct. 15 - third Monday in Dec.; crab trap interactions requirements; night shrimping prohibited in some areas (Vermilion-Teche and Calcasieu Basins); restricted areas in refuges and WMAs;
Texas	Major bays: spring - one otter trawl net 40-54 ft wide depending on door size, one beam trawl up to 25 ft; fall - one trawl up to 95 ft wide; winter - same as spring, BRD and TED required. Minimum mesh size: spring - 1.3 in.; fall - Aug. 15-Oct. 31 1.75 in., Nov. 1-Nov. 30 1.3 in.; winter: 1.3 in.	Major Bays: Spring - May 15 - July 15; Fall - Aug. 15 - Nov. 30; Winter (south of Colorado River only) - Feb. 1 - April 15.	Yes	Daily fishing time: spring and fall - 30 minutes before sunrise to 30 minutes after sunrise; winter - 30 minutes after sunset to 30 minutes before sunrise. Harvest limit: spring - 800 lb; fall - Aug. 15-Oct. 31 50 count heads on per pound, Nov. 1-Nov. 30 no limit; winter - no limit.
	Inside 3 nm: Southern and Northern zones - up to two trawl nets, each net 71-89 ft wide depending on door size, minimum mesh size 1.75 in., BRD and TED required.	Southern: July 16-Nov. 30; Northern: Feb. 16-May 15 and July 16-Nov. 30.		Daily fishing time: Southern and Northern zones 30 minutes before sunrise to 30 minutes after sunset.
	3-5 nm: Southern and Northern zones - minimum mesh size 1.75 in., BRD and TED required.	Southern: July 16-Nov. 30; Northern: Feb. 16-May 15 and July 16-Nov. 30.		Daily fishing time: Southern and Northern zones 30 minutes before sunrise to 30 minutes after sunset.

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State	Gear Restrictions	Season	Estuarine Trawling Allowed	Miscellaneous
Texas cont.	5-9 nm: Southern and Northern zones - minimum mesh size 1.75 in., BRD and TED required.	Southern and Northern zones: July 16-Nov. 30 and Dec. 1-May 15.		Daily fishing time: Southern and Northern zones 30 minutes before sunrise to 30 minutes after sunset.
	Seabob fishery: one otter trawl net 48-62 ft wide depending on door size, minimum mesh size 1.3 in., BRD and TED required.	Northern zone only: Dec. 1-May 15 and July 16-Nov. 30.		Daily fishing time: 30 minutes before sunrise to 30 minutes after sunset. No more than 10% in weight or number any other species of shrimp.

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Table 4.2. Commercial bait shrimp trawl regulations for South Atlantic and Gulf of Mexico states. *Unable to verify regulations with state fisheries agency.

State	Gear Restrictions	Season	Estuarine Trawling Allowed	Miscellaneous
North Carolina	One trawl net with up to 40 ft headrope	Same as commercial	Same as commercial	Allowed on weekend with permit; live well required; no more than 1-gallon dead shrimp
South Carolina	Same as commercial	Same as commercial	Same as commercial	Same as commercial
Georgia*	One trawl net with up to 20 ft headrope	Open year-round	Yes: 60 bait zones located in middle and upper estuaries	TED and BRD are not required; 50-quart harvest limit; less than 10% dead shrimp
Florida*	Roller frame trawl only except 1 otter trawl in North East Region with 5/8 in. body and 1/2 in. cod end	North East Region closed Apr - May	Yes	Live well required; no more than 5-gallon dead shrimp
Alabama	One trawl net with up to 50 ft headrope; trawl net cannot exceed 16 ft headrope in areas temporarily closed to commercial shrimping or in exclusive bait areas	Closed May 1 - June 1	Yes: same as commercial and exclusive bait areas	Exclusive bait areas open 4 a.m. to 10 p.m.; live well or aerator required; two standard shrimp baskets live or dead harvest limit; 20-minute maximum tow time
Mississippi	One trawl net no larger than 16 ft headrope and 22 ft footrope, except areas west of Bayou Caddy where trawl net may be up to 25 ft headrope and 32 ft footrope	Open year-round	Yes: major bays closed; live bait catcher boats can trawl within 1/2 mile of the mainland shoreline	Minimum size of 100 count or lower; no more than 30 lb dead shrimp; daytime only; 25-minute maximum tow time

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State	Gear Restrictions	Season	Estuarine Trawling Allowed	Miscellaneous
Louisiana	One trawl net no more than 25 ft along the cork line and 33 ft along the lead line; two skimmer nets with individual nets no more than 16 ft measured horizontally, 12 ft measured vertically, or 20 ft measured diagonally	Open year-round	Yes	\$1,000 cash bond, background check, facility inspection, 12" signage, and VMS required
Texas	One trawl net with a 40 to 54 ft headrope	Open year-round	Yes: major bays	200 lb harvest limit; Nov. - Aug. 50% must be live; Aug. - Nov. all heads must be attached

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Table 4.3. Recreational shrimp regulations for South Atlantic and Gulf of Mexico states. *Unable to verify regulations with state fisheries agency.

State	Gear Restrictions	Season	Estuarine Trawling Allowed	Miscellaneous
North Carolina	One trawl net with up to 26 ft headrope; BRDs required; TED required for mechanical retrieval	same as commercial	same as commercial	Recreational Commercial Gear License (RCGL) required; harvest limit of 48-quart heads on or 30-quart heads off per person; up to two limits per vessel if more than one RCGL holder onboard
South Carolina	same as commercial	same as commercial	same as commercial	Trawling for personal use is restricted to the same license requirements, areas, and seasons as commercial
Georgia*	One trawl net with up to 10 ft headrope	Open year-round	60 bait zones located in middle and upper estuaries	Harvest limit of 2 quarts per person or 4 quarts per vessel; no recreational trawling for food shrimp
Florida*	Dip net, cast net, push net, frame net, shrimp trap, and seine only	Closed season: April and May closed in Nassau, Duval, St. Johns, Putnam, Flagler, and Clay counties.	No	Harvest limit of 5-gallon heads on limit
Alabama	One trawl net with up to 16 ft headrope; hand retrieval only; TED not required	Closed May 1 - June 1	same as commercial and exclusive bait areas	Harvest limit of 5 gallons heads on per person in non-bait areas; harvest limit of 1 gallon heads on per person in exclusive bait areas
Mississippi	One trawl net with up to 16 ft headrope; TED not required for hand retrieval	same as commercial	same as commercial	same as commercial

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State	Gear Restrictions	Season	Estuarine Trawling Allowed	Miscellaneous
Louisiana	One trawl net with up to 16 ft or 25 ft headrope (separate licenses); minimum mesh size of 5/8" bar or 1-1/4" stretch; Vermilion-Teche Basin minimum mesh size of 3/4" bar or 1-1/2" stretch	same as commercial	same as commercial; must be 500' beyond shoreline around Grand Isle	Minimum size limit of 100 count for white shrimp, except Oct 15 - third Monday of Dec; harvest limit of 100 lb per boat (for headrope 16 ft or less) or 250 lb limit per boat (for headrope 16-25 ft headrope)
Texas	Maximum of 20 ft width between trawl doors	Major bays (excluding closed areas): May 15 - July 15 and August 15 - November 30. Gulf: same as commercial.	same as commercial	Bays: harvest limit of 15 lb heads-on per person per day; Gulf: harvest limit of 100 lb heads-on per boat per day; required to have a valid recreational fishing license; fishing hours are 30 minutes before sunrise to 30 minutes after sunset

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APPENDIX 5. SUMMARY OF ADVISORY COMMITTEE AND NCDMF RECOMMENDATIONS FOR ISSUE PAPERS IN THE AMENDMENT 2 OF THE SHRIMP FISHERY MANAGEMENT PLAN

Table 5.1. Summary of the North Carolina Division of Marine Fisheries (NCDMF), and standing and regional Advisory Committees (AC), and public online questionnaire recommendations for Amendment 2 to the Shrimp Fishery Management Plan.

Issue	NCDMF	Northern Regional AC	Southern Regional AC	Finfish AC	Shellfish / Crustacean AC	Habitat and Water Quality AC	Public Questionnaire
Protection of Critical Sea Grass and Shell Bottom Habitats	<ul style="list-style-type: none"> • Prohibit shrimp trawling east and north of a line from Pea Island marshes to the southwestern shore of Wanchese (close all of Roanoke Sound and area around Oregon Inlet) • Prohibit shrimp trawling in Core Sound and its tributaries except within the Mechanical Clam Harvest Area (MCHA) • Prohibit shrimp trawling in North River, Back Sound, and their tributaries except within the MCHA in North River • Prohibit shrimp trawling in Bogue Sound and its tributaries except the Intracoastal Waterway (IWW) 	In regard to Management of Shrimp Trawling for Protection of Critical Sea Grass and Shell Bottom Habitats remain at status quo.	No motion passed	No motion or recommendation	No motion passed	<ul style="list-style-type: none"> • Align shrimp trawling areas with Mechanical clam harvest areas in Core Sound and North River and allow trawling in Straits Channel of Core Sound. • Supports management strategies for protection of SAV and Shell bottom habitat from trawling impacts. • Amend the current document to include a formal decision analysis for the options presented in the FMP and other options discussed during the Habitat and Water Quality AC meeting. The analysis will be presented to the NCMFC for review at a future date. 	<ul style="list-style-type: none"> • Respondents agreed area closure management would protect SAV and shell bottom habitats. • Respondents self-identifying as commercial support use of distance from shore closures and status quo.

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Table 5.1 (continued).

Issue	NCDMF	Northern Regional AC	Southern Regional AC	Finfish AC	Shellfish / Crustacean AC	Habitat and Water Quality AC	Public Questionnaire
Shrimp Management in Special Secondary Nursery Areas	<ul style="list-style-type: none"> • Change the designation of all SSNAs to SNAs 	No recommendation	Change the designation of "all SSNA listed to SNA[s]"	No motion or recommendation	No motion passed	No motion or recommendation	<ul style="list-style-type: none"> • Respondents self-identifying as non-commercial supported redesignating all SSNAs to permanent SNAs. • Respondents self-identifying as commercial support status quo; however, there was mixed support to use static seasons to manage SSNAs. • Oct-Dec static seasons preferred in Croatan, Roanoke, Core, and Stump sounds. • Sep-Nov static seasons preferred in New River.

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Table 5.1 (continued).

Issue	NCDMF	Northern Regional AC	Southern Regional AC	Finfish AC	Shellfish / Crustacean AC	Habitat and Water Quality AC	Public Questionnaire
Reducing Shrimp Trawl Bycatch Through Area Closures	<ul style="list-style-type: none"> • Prohibit all trawling year round in Crab Spawning Sanctuaries • Prohibit shrimp trawling in a portion of Croatan Sound • Prohibit shrimp trawling in the entirety of Parched Corn Bay, Berrys Bay, East Bluff Bay, West Bluff Bay, and West Bay • Extend existing closures by prohibiting shrimp trawling in areas near the mouth of Stumpy Point Bay, Pains Bay, Long Shoal River, and Otter Creek • Prohibit shrimp trawling west of the 76° 28.0000' W longitude line which passes near Roos Point at the mouth of Pamlico River south to Point of Marsh at the mouth of the Neuse River • Prohibit shrimp trawling in Newport River and its tributaries except for the MCHA and waters north and west between the MCHA and the Trawl Net Prohibited Area • Prohibit shrimp trawling in the White Oak River and its tributaries • Prohibit shrimp trawling in Queens and Bear creeks • Prohibit shrimp trawling in the channels that connect to the Atlantic Ocean [Banks Channel (Topsail Sound), Green Channel, Nixon Channel, Mason Channel, Stokley Cut/Old Moores Inlet Channel, Lee's Cut/Spring, Landing Channel, Banks Channel (Wrightsville Beach), Mott Channel, Muddy Slough, Dutchman Creek, Elizabeth River, Eastern Channel (Montgomery Slue), Jinks Creek, and Bonaparte Creek] • Prohibit shrimp trawling in the Carolina Beach Yacht Basin 	<p>No motion passed</p>	<p>Supports no additional area closures without supporting information to inform those closures.</p>	<p>No recommendation</p>	<ul style="list-style-type: none"> • Does not agree with closing all internal waters. • Does not agree with any additional seasonal closures in internal waters. 	<p>No motion or recommendation</p>	<ul style="list-style-type: none"> • Respondents supported area closures. The most support was closing the river mouths and support decreased moving eastward. • Support to use seasonal area closures at river mouths and eastern Pamlico Sound.

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Table 5.1 (continued).

Issue	NCDMF	Northern Regional AC	Southern Regional AC	Finfish AC	Shellfish / Crustacean AC	Habitat and Water Quality AC	Public Questionnaire
Managing Effort and Gear to Reduce Bycatch	<ul style="list-style-type: none"> • Maintain existing headrope limits for shrimp harvest in Internal Coastal Waters. If needed, implement additional headrope restrictions to resolve user conflicts using current proclamation authority • Allow non-trawl net gears (e.g., seines, channel nets, cast nets, etc.) to harvest shrimp in areas closed to shrimp trawling (all other existing gear restrictions would remain in place) • Eliminate the four quarts (heads-on) or two and one-half quarts (heads-off) recreational creel limit for cast nets only in areas closed to the taking of shrimp 	<p>Cannot support these options because there are no quantifiable data or targets to apply to the options.</p>	<ul style="list-style-type: none"> • Cannot support these options because there are no quantifiable data or targets to apply to the options. • Recommend the NCMFC supports focused studies on the effects of effort and gear restrictions on bycatch. 	<ul style="list-style-type: none"> • Continue to work toward bycatch reduction with gear modification and devices with industry input taking the lead with the support of the division. • Strongly encourages the NCDMF to enhance data collection to obtain the data to be able to better quantify bycatch in the shrimp trawl fishery, and its impacts on the populations of concern. 	<p>Continue to work toward bycatch reduction with gear modification and devices with industry input taking the lead with the support of the division.</p>	<p>No motion or recommendation</p>	<ul style="list-style-type: none"> • Respondents self-identifying as non-commercial support the use tow times, daily fishing time, reduced fishing days, trip limits, and reduced headrope to limit effort in the shrimp trawl fishery. • Respondents self-identifying as commercial do not support the use of tow times, daily fishing time, reduced fishing days, trip limits, or reduced headrope to limit effort in the shrimp trawl fishery. • Respondents support to allow non-trawl gear in areas closed to shrimp trawling. • Respondents support to align recreational cast net limits in open and closed areas.