NC Marine Fisheries Commission

Fishery Management Plans

November 2024 Quarterly Business Meeting

Documents

Spotted Seatrout Decision Document

Draft Spotted Seatrout FMP Amendment 1

Eastern Oyster Decision Document

Draft Eastern Oyster FMP Amendment 5

Hard Clam Decision Document

Draft Hard Clam FMP Amendment 3

DECISION DOCUMENT

Spotted Seatrout Fishery Management Plan

Amendment 1

This document was developed to help the Marine Fisheries Commission track previous activity and prepare for upcoming actions for Spotted Seatrout FMP Amendment 1.

November 2024

Summary

At their October 2024 meetings, the Marine Fisheries Commission (MFC) Northern, Southern, and Finfish Advisory Committees will review and provide input on the draft of Amendment 1 to the Spotted Seatrout Fishery Management Plan (FMP). They will receive public comment on the draft of Amendment 1 and vote on recommended management options for the MFC. At their November business meeting, Division staff will present a summary of public comment and any MFC Advisory Committee management recommendations to the MFC.

Background

The 2022 stock assessment indicated the Spotted Seatrout stock in North Carolina and Virginia waters is not overfished but overfishing is occurring. The North Carolina Fishery Reform Act of 1997 requires a Fishery Management Plan to specify a timeframe not to exceed two years from the date of adoption of the plan to end overfishing.

Amendment 1 to the Spotted Seatrout Fishery Management Plan is being developed to address overfishing in the Spotted Seatrout fishery. Although the 2022 stock assessment covers spotted seatrout in both North Carolina and Virginia waters, the management unit covered by Amendment 1 is limited to all Spotted Seatrout within the Coastal and Joint Fishing Waters of North Carolina. The Spotted Seatrout fishery is primarily a recreational fishery, with recreational harvest accounting for 86% of total harvest since 2012. Commercial harvest has accounted for 14% of total Spotted Seatrout harvest over the same period. However, harvest in both sectors increased sharply in 2019 and has remained high through 2022. As such, management measures to achieve sustainable harvest focus on both sectors.

Amendment Timing

(gray indicates a step is complete)

You Are Here

March 2023	Division holds public scoping period
May 2023	MFC approves goal and objectives of FMP
May 2023 – March 2024	Division drafts FMP
April 2024	Division held workshop to review and further develop draft FMP with the Spotted Seatrout FMP Advisory Committee
May – July 2024	Division updates draft plan
August 2024	MFC Reviews draft and votes on sending draft FMP for public and AC review
October 2024	MFC Regional and Standing Advisory Committees meet to review draft FMP and receive public comment
November 2024	**MFC selects preferred management options**
December 2024 – January 2025	DEQ Secretary and Legislative review of draft FMP
February 2025	MFC votes on final adoption of FMP
TBD	DMF and MFC implement management strategies

Goals and Objectives

The goal of this plan is to manage the Spotted Seatrout (*Cynoscion nebulosus*) fishery to maintain a self-sustaining population that provides sustainable harvest based on science-based decision-making processes. The following objectives will be used to achieve this goal:

1. Implement management strategies within North Carolina that end overfishing and maintains the Spotted Seatrout spawning stock abundance and recruitment potential.
2. Promote restoration, enhancement, and protection of 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 Spotted Seatrout stock.
3. Monitor and manage the fishery in a manner that utilizes biological, socioeconomic, fishery, habitat, and environmental data.
4. Promote outreach and interjurisdictional cooperation regarding the status and management of the Spotted Seatrout stock in North Carolina and Virginia waters, including practices that minimize bycatch and discard mortality.

Division of Marine Fisheries Recommendations

A summary of the DMF's preliminary recommendations can be found below.

The DMF recommends the following options that are projected to end overfishing with a greater than 70% probability of keeping spawning stock biomass (SSB) above the target:

Recreational Recommendations

- 3-fish recreational bag limit (*Appendix 2: Sustainable Harvest Issue Paper)*
- 14”–20” recreational slot limit with allowance for one fish >26” (*Appendix 2: Harvest Issue Paper*)
- Jan–Feb statewide recreational harvest closure (*Appendix 2: Sustainable Harvest Issue Paper*)
- Eliminate the captain/crew allowance on for-hire trips with no broader vessel limit (*Amendment 3: Supplemental Management Issue Paper*)

Commercial Recommendations

- Oct–Dec, 11:59 p.m. Friday to 12:01 a.m. Tuesday statewide commercial harvest closure (*Appendix 2: Sustainable Harvest Issue Paper)*
- Jan–Feb statewide commercial harvest closure *(Appendix 2: Sustainable Harvest Issue Paper)*
- Stop Net Management *(Appendix 2: Sustainable Harvest Issue Paper)*
    - Stop nets are restricted to the Atlantic Ocean on Bogue Banks and maintain a 4,595 lb. Spotted Seatrout season quota.

- The season will open no sooner than October 15 and close when the Spotted Seatrout quota is reached or no later than December 31.
- Stop net crews must contact N.C. DMF Marine Patrol Communication each time a stop net is set and two hours prior to each time a stop net is fished.
- The same day a stop net is fished and the catch is landed at the fish house, a representative of the stop net crew must contact DMF Fisheries Management Section to report the daily total of Spotted Seatrout harvest in pounds as it appears on the trip ticket. Same day reporting is required even if zero Spotted Seatrout are harvested.
- Failure to follow reporting requirements will result in an immediate closure of the stop net fishery.
- The Bogue Banks stop net fishery will be managed by proclamation consistent with but not limited to prior proclamations

General Recommendations

Adaptive Management

The adaptive management framework allows for adjusting management measures outside of an updated stock assessment to ensure compliance with and effectiveness of management strategies adopted in Amendment 1 and is a tool to respond to concerns with stock conditions and fishery trends. Upon evaluation by the division, if the management strategy implemented to achieve sustainable harvest (either through Amendment 1 or a subsequent revision) is not achieving the intended purpose, management measures may be revised or removed and replaced using adaptive management; provided it conforms to part 2.

- Management measures that may be adjusted using adaptive management include:
    a. Season closures
    b. Day of week closures
    c. Trip and vessel limits
    d. Size limits
    e. Bag and vessel limits
    f. Gear restrictions in support of the measures listed in a-e

Cold Stun Management

- Extend fishery closure until June 30th following a cold stun
- Adaptive Management Framework

Rationale for Division of Marine Fisheries Recommendations

It is important to remember that spotted seatrout are *not overfished*; however, *overfishing is occurring* in the fishery. N.C. General Statute 113-182.1 states that fishery management plans shall specify a time period not to exceed two years from the date of adoption of the plan to end overfishing. This distinction shapes the management approach: since the stock does not require rebuilding, *the goal is to reduce fishing effort and harvest*.

The 2020 Spotted Seatrout Stock Assessment showed a significant increase in harvest and total removals in biological year 2019 compared to previous years. While biological year 2019 was originally an outlier, *recent harvest trends show it is not*. Biological years 2019, 2020, 2021, and 2022 represent the four highest years of harvest and total removals in the entire timeseries (1991–2023) with total removals in 2020 replacing 2019 total removals as the timeseries high. Biological year 2023 experienced a small decline in harvest and total removals; however, recreational harvest through Wave 4 of biological year 2024 is on track to reach a new time series high for both harvest and total removals. Fishing effort, measured by the number of trips, has also increased recreationally and commercially.

The spotted seatrout fishery has faced unprecedented levels of harvest and total removals since 2019. While the population level effects of increased harvest in these years cannot be determined outside of an updated stock assessment, it is DMF's position that management of the spotted seatrout stock proceed with a precautious management approach. N.C. General Statute 113-182.1 states that fishery management plans shall specify a time period not to exceed two years from the date of adoption of the plan to end overfishing. Taking precautionary actions now helps ensure the long-term sustainability of the stock under higher fishing effort. Proactive management reduces the likelihood of more drastic measures or management strategies being necessary in years to come and is projected to maintain the stock at current levels of high spawning stock biomass.

Recreational Recommendations

Slot Limit

A slot limit as a standalone measure does nothing to address increased fishing effort. As more anglers enter the fishery, management that does not account for increased effort is unlikely to succeed long-term.

Implementing a spotted seatrout slot limit as a standalone measure is also unlikely to achieve the harvest reduction needed to end overfishing. On paper, it is technically possible to end overfishing through implementation of a slot limit given the slot is narrow enough. A 16"–20" slot with an allowance for one fish >24" was suggested at the Spotted Seatrout Advisory Committee Workshop and was the recreational management option recommended by the Finfish Advisory Committee. While a slot limit may initially reduce harvest levels, the effectiveness will likely diminish over time. In the short term, fewer fish will be harvested because individuals that are too small or too large will not be harvested. However, size limit increases rarely result in long term harvest reductions but instead act to delay harvest of those newly sublegal fish until they grow back into the fishery. . The realized reduction will then be lower than intended.

Implementing a maximum size limit as part of a slot limit likely provides a longer-term reduction in harvest. However, introducing a trophy allowance could counter this benefit because more larger fish will be available within trophy limits. Additionally, implementing a recreational slot limit without a size limit change in the commercial fishery may result in more larger being harvested commercially undermining the goal of reducing overall harvest through a slot limit alone.

A slot limit as a standalone measure fails to address the issue of increased fishing effort. Without additional strategies to decrease fishing effort and harvest, any reduction from a narrow slot limit will likely be undermined by increased fishing pressure. Considering the public's desire for a slot limit, spotted seatrout biology, and input received from the Spotted Seatrout Advisory Committee Workshop, DMF developed the recommended 14"-20" slot with an allowance for 1 fish >26" in combination with other management strategies (3-fish bag limit, January-February season closure). The slot limit was combined with other management strategies due to concerns discussed above and in the sections that follow. Combining these measures enhances the prospect of harvest reductions being realized and ending overfishing.

Bag Limit

To more effectively address overfishing, a 3-fish bag limit is recommended alongside a slot limit and season closure. This measure directly reduces the number of fish each angler can harvest per day, which directly decreases harvest.

Season Closure

In addition to a slot limit and a bag limit, DMF recommends a January-February season closure to further reduce fishing effort and harvest. Throughout development of Amendment 1, recreational anglers have indicated a strong preference for not managing the spotted seatrout fishery using a season closure. In many cases, a caveat was included that if a season closure is implemented, it should be as short as possible. Every member of the Spotted Seatrout Advisory Committee who spoke about season closures expressed a preference for not having a closure but wanted as short a closure as possible if such management was deemed necessary, with one member suggesting a season closure of less than 90 days would be most palatable if necessary.

The most effective period to close a fishery is at the end of the fishing year or when most removals occur. The spotted seatrout fishery is historically most active during the fall and early winter months with most landings occurring from October-December. However, the fishing or biological year is from March through February of the following year, meaning a closure in the fall and early winter would not occur at the end of the fishing year allowing for recoupment of harvest after the season reopens. Additionally, the public and the Spotted Seatrout Advisory Committee expressed the importance of maintaining access to the fishery during this period. Considering input received, the timing of the biological year, and balancing the desire for a short season closure while maintaining the effectiveness of that season closure, DMF recommends a January-February closure.

To account for the unprecedented levels of spotted seatrout harvest and total removals since the stock assessment, the high potential for harvest recoupment with other management strategies, and unchecked effort increases in recent years, DMF considers a season closure to be the most effective and efficient management option to reduce effort and harvest as more anglers enter the fishery. A winter season closure provides additional benefits including:

- Protection of spawning capable spotted seatrout while they are aggregated and susceptible to increased harvest and cold stuns.
- A larger harvest reduction in a shorter amount of time as opposed to a longer season closure during the spring and summer months to achieve the same harvest reduction.

During the season closure, increased catch-and-release activity may result in increased dead discards. However, the discard mortality rate will likely be lower during the winter closure compared to other seasons due to higher dissolved oxygen levels and cooler water temperatures. Additionally, the number of dead discards will be lower than the number of fish that would have otherwise been harvested had a season closure not been implemented. The Division will continue Ethical Angling outreach which includes education on best handling and fishing practices that can increase the survival of released fish.

Commercial Recommendations

Slot Limit

Neither a size limit increase nor a slot limit would be an effective form of management in the commercial spotted seatrout fishery. Additionally, a size or slot limit in the commercial fishery does not address increasing effort. DMF does not recommend a size or slot limit in the commercial spotted seatrout fishery.

Trip Limit

Achieving the necessary reductions through lowering the commercial spotted seatrout trip limit alone is not realistic. Additionally, a more restrictive trip limit in the commercial fishery does not address increasing effort. DMF does not recommend changing the current 75-fish trip limit in the commercial spotted seatrout fishery. In 2014, the Finfish Advisory Committee voted to include in the next FMP update a discussion of allowing two commercial license holders fishing one set of gear on a single boat to harvest two commercial limits of spotted seatrout. This discussion is included in Amendment 1; however, such a change to the spotted seatrout trip limit is likely to increase commercial harvest. As management measures in Amendment 1 are designed to reduce harvest, DMF does not recommend allowing multiple commercial trip limits per vessel.

Season Closure

Throughout development of Amendment 1, input from the public and Advisory Committees has consistently shown interest in aligning spotted seatrout and striped mullet management. The shared seasonality and use of similar gear types in both fisheries make this alignment desirable to stakeholders as it could simplify regulations, reduce user conflict, and reduce discards. Spotted seatrout are the most common incidental catch in the striped mullet fishery and vice versa. However, spotted seatrout life history would limit the effectiveness of aligning the two closures completely. In the late fall and early winter, as striped mullet begin to move into the ocean to spawn, spotted seatrout begin aggregating in the upper estuary. In other words, striped mullet migration patterns in the late fall and early winter allow for escapement while spotted seatrout migration patterns during this same time make them more susceptible to harvest. A shift in commercial effort to weekdays would likely lead to a high degree of recoupment in the spotted seatrout fishery with the potential to greatly decrease the expected reductions from matching the weekend closures in Amendment 2 to the Striped Mullet FMP. A January–February closure reduces fishing pressure while spotted seatrout are aggregated and more vulnerable to harvest.

Additionally, a January-February commercial closure aligns with the recommended closure in the recreational fishery and balances the most effective management with minimal disruption to fishery. Should the commercial spotted seatrout fishery not close in January-February, reductions from a recreational closure will likely not meet the necessary reductions to end overfishing.

Adaptive Management

Adaptive Management would be a valuable tool for the management of the spotted seatrout fishery, offering a more responsive and proactive approach compared to the traditional Fishery Management Plan (FMP) review process. One common concern is that the current process of conducting a full FMP review takes too long, which can delay necessary adjustments to management strategies. Adaptive Management provides a solution by allowing the Division to adjust management measures between full FMP reviews through the Director's proclamation authority. This flexibility is driven by science-based metrics, including both fishery-independent and fishery-dependent data.

If science-driven metrics indicate that current management measures are not achieving sustainable harvest goals, Adaptive Management would allow the Director to make timely changes to management strategies such as season and day of week closures, trip and bag limits, size and slot limits, and gear regulations, all within the scope defined by Amendment 1. The ability to adjust management between full FMP reviews enables the Division to address issues before they become critical, preventing the need for more drastic and disruptive measures during the next review cycle. By incorporating Adaptive Management, the Division can proactively respond to shifting fishery conditions, maintaining sustainable harvest goals and ensuring the long-term viability of the spotted seatrout population. This approach not only increases the resilience of fishery management but also reinforces science-based, flexible management practices that benefit both the fishery and its stakeholders. The Division recommends adopting the Adaptive Management Framework.

Management Options

(Options recommended by DMF are outlined in blue)

Sustainable Harvest

These management options attempt to strike a balance between access to the fishery for both sectors, the necessary harvest reduction to end overfishing, accounting for potential harvest recoupment, and maintaining the current abundance of Spotted Seatrout available. Additionally, management in the recently adopted Amendment 2 to the Striped Mullet Fishery Management Plan was considered as there is a high degree of overlap in the seasonality and gear types used in the commercial Striped Mullet and Spotted Seatrout fisheries. These options are predicted to reduce harvest of Spotted Seatrout in ways that are quantifiable using existing data.

A 19.9% reduction in total harvest relative to 2019–2022 total harvest is required to reach the fishing mortality threshold and meet the statutory requirement to end overfishing while a harvest reduction of 53.9% is required to reach the fishing mortality target. Because of spikes in effort across both sectors in recent years and the potential for harvest recoupment from some management measures, the Division recommends a precautionary approach to increase the likelihood of achieving sustainable harvest.

Option 1: Size Limits

(Refer to pp. 47-51 in the Draft Spotted Seatrout FMP Amendment 1 for additional details)

Changing the current Spotted Seatrout minimum size of 14" is unlikely to reach the needed harvest reduction to meet statutory requirements. Additionally, the reduction from increasing the minimum size is most likely to be achieved in the short term while the long term harvest reduction is lower with some portion of harvest being recouped. A delay in harvest could provide non-quantifiable benefits by allowing more fish to spawn prior to harvest. However, Spotted Seatrout growth rates would likely minimize these non-quantifiable benefits as sub-legal fish grow quickly back into the fishery. Harvest reduction from a slot limit is more likely to be realized in the long term as Spotted Seatrout would grow out of the fishery relatively quickly. Implementing a slot limit for the commercial sector would likely increase dead discards. Pairing a slot limit with corresponding changes to allowable mesh sizes could prove ineffective at reducing dead discards due to the lack of size selectivity across various mesh sizes (Page 30 of Draft Amendment 1). A very narrow slot limit, even if implemented for just the recreational sector, could theoretically reduce total harvest more than the 19.9% reduction needed to reach $F_{Threshold}$ (Page 51 of draft Amendment 1, Table 2.3). However, size limit changes alone will not address the potential for increased dead discards, the high recoupment potential if commercial harvest shifted toward larger fish, and the recent trend of increased effort in both sectors. For a full discussion of size limits, see pp. 46–52 in draft Amendment 1.

a. *Status Quo – no change to commercial size limit. Consider recreational size limit changes as a part of the overall management strategy to achieve sustainable harvest but not as a single solution option.*
b. *Recreational 16"–20" slot limit with allowance for one fish over 24" and commercial 16" minimum size limit*

Option 2: Seasonal Closures

(Refer to pp. 51-52 in the Draft Spotted Seatrout FMP Amendment 1 for additional details)

Seasonal closures can be an effective way of limiting harvest, especially when closures are at the end of the biological year to prevent recoupment of harvest. It is possible to end overfishing through a closure that spans the spawning season (p. 54 of draft Amendment 1, Table 2.4), however; it is likely some amount of recoupment would occur after the season closure. A spawning season closure would also have to be longer than a winter closure (i.e., a closure at the end of the biological year) to reduce harvest to a level that will meet management objectives. Closures not at the end of the biological year should be extended or paired with other management options to increase the likelihood of reaching management objectives. Day of the week closures are a type of season closure and could be used for the commercial sector to reduce harvest. Similar to other seasonal closure options not at the end of the biological year, there is the potential for harvest recoupment if commercial effort shifts to days when the fishery is open. Day of the week closures could be considered in tandem with other management measures to ensure management objectives are met. See pp. 52-56 of draft Amendment 1 for a full discussion of seasonal closures.

a. *Status Quo – manage fishery without seasonal harvest closure*
b. *Dec 16 – Feb 28/29 harvest closure (both sectors)*
c. *11:59 p.m. Friday–12:01 a.m. Tuesday commercial harvest closure October 1–December 31 and Jan 1–February commercial harvest closure. Consider recreational seasonal closures as a part of the overall management strategy to achieve sustainable harvest but not as a single solution option.*
d. *Nov 1 – Feb 28/29 harvest closure (both sectors)*

Option 3: Bag and Trip Limits

(Refer to pp. 55-58 in the Draft Spotted Seatrout FMP Amendment 1 for additional details)

It is possible to reduce total Spotted Seatrout harvest to reach the $F_{Threshold}$ by decreasing the recreational bag and commercial trip limits, but it is not possible to reduce total harvest to reach the F_{Target} through changes to the bag or trip limits alone (draft Amendment 1 pp. 56 and 58, Tables 2.6 and 2.7). Any recreational bag or commercial trip limit would be a daily limit. Recreational bag and commercial trip limit changes could be accompanied by gear changes or limits to allowable gear (See Amendment 1 Appendix 1 and Appendix 3) to minimize the probable increase in dead discards caused by bag or trip limit changes. For a full discussion of bag and trip limit options, see pp. 56-59 of draft Amendment 1.

a. *Status Quo – manage fishery without changes to current trip limit and consider recreational bag limit changes as a part of the overall management strategy to achieve sustainable harvest but not as a single solution option.*
b. *Reduce recreational bag limit to 2 fish and commercial trip limit to 45 fish*

Option 4: Stop Nets

(Refer to pp. 58-59 in the Draft Spotted Seatrout FMP Amendment 1 for additional details)

The stop net fishery is a modification of a traditional beach seine that primarily targets Striped Mullet and is unique to Bogue Banks. The 2012 Spotted Seatrout FMP implemented a 75 fish trip limit, but the MFC tasked the DMF Director with addressing the stop net fishery outside the 2012 FMP. Since 2012, the Bogue Banks stop net fishery has opened and closed by proclamation and operates with a 4,595 lb. Spotted Seatrout quota with various reporting requirements outlined in a Memorandum of Agreement (MOA) signed by a party of the fishery and the DMF Fisheries

Management Section Chief. Due to the strict existing management of this fishery, the potential for additional harvest reduction from the recently adopted Amendment 2 to the Striped Mullet FMP, and the low contribution to Spotted Seatrout landings under current management, additional harvest restrictions may not be necessary for the stop net fishery. However, formalizing current management of the stop net fishery should be considered in this amendment. See Spotted Seatrout FMP Amendment 1 pp. 58–59 for a full discussion of stop net management.

a. *Status quo – 4,595 lb. season quota with terms and conditions of stop net fishery and responsibilities of the stop net crew outlined in Memorandum of Agreement.*

b. *Stop nets are restricted to the Atlantic Ocean on Bogue Banks and maintain a 4,595 lb. Spotted Seatrout season quota. The season will open no sooner than October 15 and close no later than the sooner of December 31 or when the Spotted Seatrout quota is reached. Any weekend closures to commercial harvest implemented in Option 2 will also apply to the Bogue Banks stop net fishery. Stop net crews must contact N.C. DMF Marine Patrol Communication each time a stop net is set and at least two hours prior to each time a stop net is fished. The same day a stop net is fished and the catch is landed at the fish house, a representative of the stop net crew must contact DMF Fisheries Management Section to report the daily total of Spotted Seatrout harvest in pounds as it appears on the trip ticket. Same day reporting is required even if zero Spotted Seatrout are harvested. Failure to follow reporting requirements will result in an immediate closure of the stop net fishery. The stop net fishery will be managed by proclamation consistent with but not limited to previous proclamations.*

Option 5/6: Combination Management Measures

(Refer to pp. 59-62 in the Draft Spotted Seatrout FMP Amendment 1 for additional details)

Combining multiple strategies to achieve management goals is common in fisheries management. Multiple management measures rather than a single, standalone management measure allow for more specific, targeted management to account for a variety of factors including species life history and biology, differences in the fishery (e.g., industry, regional, etc.), or competing interests in the fishery, and better minimize recoupment. As there are few standalone management measures to end overfishing in the Spotted Seatrout fishery, combination measures will help ensure management is realistic and management objectives are more likely to be achieved. See pp. 59–62 of the Spotted Seatrout FMP Amendment 1 for a full discussion of combination management measures.

Combination Management Measures

Table 2.8. Combination management measures to end overfishing and achieve sustainable harvest. The Total % Reduction column shows the total percent reduction if no changes to commercial management are implemented. Unless otherwise noted, season closures or bag limit reductions include the entirety of the month. *Total reduction does not reduce F to the 19.9% threshold (options 1.a, and 1.b). Harvest reduction in pounds is based on 2019–2022 average recreational harvest.

Option #	Season Closure	Bag Limit (number of fish)	Size Limit	Recreational Reduction (lb)	Recreational Reduction (%)	Total % Reduction
5.a	Jan-Feb	Oct-Dec 3 fish	-	738,113	22.1	18.9*
5.b		Nov-Feb 3fish	16” minimum	741,453	22.2	19.0*
5.c	-	Oct-Feb 3 fish	14-20”, 1 over 26”	824,950	24.7	21.1
5.d	Jan 16-Feb	-	14-20”, 1 over 26”	935,166	28.0	23.9
5.e	Dec 16-Feb	3 fish	-	1,015,323	30.4	26.0
5.f	Jan-Feb	-	14-20”, 1 over 26”	1,078,781	32.3	27.6
5.g	Jan-Feb	Oct-Dec 3 fish	14-20”, 1 over 26”	1,205,696	36.1	30.9
5.h	Apr-Jun	3 fish	14-20”, 1 over 26”	1,292533	38.7	33.1
5.i	Jan-Feb	3 fish	14-20”, 1 over 26”	1,319,252	39.5	33.8
5.j	Dec 16-Feb	3 fish	14-20”, 1 over 26”	1,436,148	43.0	36.7
5.k	Apr-Jul	3 fish	14-20”, 1 over 26”	1,439,488	43.1	36.8
5.l	Dec-Feb	2 fish	14-20”, 1 over 26”	1,923,770	57.6	49.2

Table 2.9 Combination management measures to end overfishing and achieve sustainable harvest. The Total % Reduction column shows the total percent reduction if no recreational management changes are implemented. No management options applied solely to the commercial sector reduce *total* harvest to a level where F meets the 19.9% threshold. Unless otherwise noted, seasonal closures include the entirety of the month. Harvest reduction in pounds is based on 2019–2022 average commercial harvest.

Option #	Season Closure	Trip Limit (number of fish)	Size Limit	Commercial Reduction (lb)	Commercial Reduction (%)	Total % Reduction
6.a	Jan 16-Feb	60	-	131,210	23.1	3.4
6.b	Jan-Feb	65	-	145,979	25.7	3.7
6.c	Jan-Feb	-	16” min	149,955	26.4	3.8
6.d	Feb	45	-	164,155	28.9	4.2
6.e	Jan 16-Feb	45	-	193,124	34.0	4.9
6.f	Jan-Feb	50	-	197,100	34.7	5.0
6.g	Dec 16-Feb	60	-	202,780	35.7	5.2
6.h	Dec-Feb	40	-	314,110	55.3	8.0

Option 7: Adaptive Management

The current Spotted Seatrout adaptive management framework needs to be updated. Adaptive management is a structured decision-making process when uncertainty exists, with the objective of reducing uncertainty through time with monitoring. Adaptive management provides flexibility to incorporate new information and accommodate alternative and/or additional actions.

1. The adaptive management framework allows for adjusting management measures outside of an updated stock assessment to ensure compliance with and effectiveness of management strategies adopted in Amendment 1 and is a tool to respond to concerns with stock conditions and fishery trends. Upon evaluation by the division, if the management strategy implemented to achieve sustainable harvest (either through Amendment 1 or a subsequent revision) is not achieving the intended purpose, management measures may be revised or removed and replaced using adaptive management; provided it conforms to part 2.
2. Management measures that may be adjusted using adaptive management include:
    a. Season closures
    b. Day of week closures
    c. Trip and vessel limits
    d. Size limits
    e. Bag and vessel limits
    f. Gear restrictions in support of the measures listed in a-e

Supplemental Management

As a result of the popularity of Spotted Seatrout as a targeted species; Marine Fisheries Commission (MFC) commissioners, MFC Advisory Committee members, and the public have mentioned a wide variety of potential recreational and commercial management strategies that could benefit the Spotted Seatrout stock but the scope of which are not immediately quantifiable. The increase in recreational trips targeting Spotted Seatrout and increased total Spotted Seatrout harvest in recent years combined with the presence of a dedicated catch and release segment of the recreational fishery suggest that even management measures lacking immediately quantifiable benefits are worth exploring. Additionally, there are management measures that could provide supplementary benefits when paired with sustainable harvest measures discussed in Appendix 2.

Option 1: Recreational Vessel Limits

(Refer to pp. 71-72 in the Draft Spotted Seatrout FMP Amendment 1 for additional details)

Limiting the harvest of fish through a vessel limit less than the sum of individual bag limits when multiple anglers are on a vessel or by eliminating the allowance for captain and crew to keep a recreational limit when on for-hire trips are common practices in many state and federal fisheries. For a full discussion of vessel limits, see pp. 68–69 of draft Amendment 1.

a. Status Quo – Manage fishery without changes to the recreational vessel limit or for-hire captain/crew allowance
b. Eliminate captain/crew allowance for Spotted Seatrout on for-hire trips with no broader recreational vessel limit
c. Implement 8 fish Spotted Seatrout recreational vessel limit with captain/crew allowance on for-hire trips counted as part of vessel limit.

Option 2: Commercial Vessel Limits

At their April 2014 meeting, the MFC Finfish Advisory Committee (AC), while acting as the Striped Mullet AC, passed a motion to recommend allowing two commercial fishing license holders fishing from the same vessel using one set of gear to harvest two commercial limits of spotted seatrout. At their May 2014 business meeting, the MFC voted to include discussion of the Finfish AC recommendation in the next scheduled Spotted Seatrout FMP rather than reopening the plan for an amendment. It is very likely that adopting the 2014 Finfish recommendation would increase harvest in the Spotted Seatrout fishery. For a full discussion of commercial vessel limits, see pp. 76–77 of draft Amendment 1.

a) Status Quo – Maintain current management of one 75 fish trip limit per vessel per day.
b) Allow two commercial license holders fishing on one boat with one set of gear to harvest two commercial limits of Spotted Seatrout.

Cold Stun Management

Spotted Seatrout are susceptible to periodic cold stun events which occur when water gets so cold that it slows down a fish's body functions, making them sluggish or unable to move. In North Carolina, Spotted Seatrout are more likely than other commercially and recreationally important fish species to experience population-level effects from these events. Cold stun events can occur because of snow and ice melt following a winter storm or by sudden and-or prolonged periods of cold temperatures. At their February 2012 business meeting, the Marine Fisheries Commission (MFC) directed the division to remain status quo regarding spotted seatrout cold stun management, with the assumption that in the event of a "catastrophic" cold stun the director would use proclamation authority to enact a temporary closure. The objective of a spotted seatrout fishery closure after a cold stun event is to allow surviving fish an opportunity to spawn during their spring spawning season, potentially increasing recruitment the following year. Cold stun management options include size limits (draft Amendment 1 pp. 79–80), recreational bag and commercial trip limits (draft Amendment 1 pp. 80–81), seasonal closures (draft Amendment 1 pp. 81-82), area closures (draft Amendment 1 pp. 82–83), and an adaptive management framework (draft Amendment 1 pp. 83–84).

Option 1: Season Closures

(Refer to pp. 83-84 in the Draft Spotted Seatrout FMP Amendment 1 for additional details)

a. Status quo – fishery closed until June 15 following a cold stun
b. Extend fishery closure until June 30 following a cold stun
c. Extend fishery closure until October 15 following a cold stun

Option 2: Size Limits

(Refer to pp. 79-80 in the Draft Spotted Seatrout FMP Amendment 1 for additional details)

a. Status quo – no size limit change following a cold stun
b. Temporary adjustment of size and-or slot limits following a cold stun

Option 3: Bag and Trip Limits

(Refer to pp. 84-85 in the Draft Spotted Seatrout FMP Amendment 1 for additional details)

a. Status quo – no recreational bag or commercial trip limit changes following a cold stun
b. Temporary adjustment of recreational bag or commercial trip limits following a cold stun

Option 4: Adaptive Management Framework

(Refer to pp. 86-87 in the Draft Spotted Seatrout FMP Amendment 1 for additional details)

1. If a severe cold stun event occurs the Director will close the spotted seatrout fishery statewide through the date adopted in this Amendment
2. Temporary measures that may be implemented through adaptive management to aid in stock recovery after the standard closure period following a cold stun event include:
    a. recreational bag limit
    b. commercial trip limit
    c. size limit changes
    d. seasonal closure
    e. gill net yardage restrictions
    f. Use of adaptive management to further aid in stock recovery once the fishery reopens following a cold stun event is contingent on approval by the Marine Fisheries Commission.

Next Steps

The Division will consider input received during the public comment period and AC review prior to finalizing recommendations. Comments received during the comment period and AC recommendations, as well as the Division's final management recommendations, will be presented to the MFC during their November business meeting. At that meeting, the MFC will select their preferred management options.

DRAFT, 2024

North Carolina Spotted Seatrout Fishery Management Plan Amendment 1

North Carolina Division of Marine Fisheries

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

ACKNOWLEDGMENTS

Amendment 1 to the North Carolina (NC) Spotted Seatrout Fishery Management Plan (FMP) was developed by the NC Department of Environmental Quality (NCDEQ), Division of Marine Fisheries (NCDMF) under the auspices of the NC Marine Fisheries Commission (NCMFC) with the advice of the Spotted Seatrout Advisory Committee (AC). Deserving special recognition are the members of the Spotted Seatrout AC and the NCDMF Plan Development Team (PDT) who contributed their time and knowledge to this effort.

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The following Division staff were also invaluable in assisting with the development of this document: Corrin Flora, Debbie Manley, Casey Knight, Lee Paramore, Steve Poland, and Tina Moore.

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EXECUTIVE SUMMARY

*** This section is completed prior to final approval***

INTRODUCTION

This is Amendment 1 to the Spotted Seatrout Fishery Management Plan (FMP). FMPs are the ultimate product that brings all information and management considerations into one document. The N.C. Division of Marine Fisheries (NCDMF) prepares FMPs for adoption by the N.C. Marine Fisheries Commission (NCMFC) for all commercially and recreationally significant species or fisheries that comprise state marine or estuarine resources. The goal of these FMPs is to ensure long-term viability of these fisheries. By law, each FMP must be reviewed at least once every five years (G.S. 113-182.1). The NCDMF reviews each FMP annually and a comprehensive review is undertaken approximately every five years. The last comprehensive review of the Spotted Seatrout FMP was approved by the NCMFC in 2012. All management authority for the North Carolina Spotted Seatrout fishery is vested in the State of North Carolina. The NCMFC adopts rules and policies and implements management measures for the Spotted Seatrout fishery in Coastal and Joint Fishing Waters in accordance with G.S. 113-182.1. Until Amendment 1 is approved for management, Spotted Seatrout is managed under the Spotted Seatrout FMP (NCDMF, 2012, 2014).

Fishery Management Plan History

Original FMP Adoption:	February 2012
Amendments:	None
Revisions:	None
Supplements:	Supplement A to the 2012 FMP – February 2014
Information Updates:	None
Schedule Changes:	None
Comprehensive Review:	Five years after the adoption of Amendment 1

The original Spotted Seatrout FMP (NCDMF 2012) and Supplement A to the 2012 FMP (NCDMF 2014) are available on the NCDMF website.

Management Unit

The management unit includes all Spotted Seatrout within the Coastal and Joint Fishing Waters of North Carolina.

Goal and Objectives

The goal of this plan is to manage the Spotted Seatrout (*Cynoscion nebulosus*) fishery to maintain a self-sustaining population that provides sustainable harvest based on science-based decision-making processes. The following objectives will be used to achieve this goal.

1. Implement management strategies within North Carolina that end overfishing and maintain the Spotted Seatrout spawning stock abundance and recruitment potential.
2. Promote restoration, enhancement, and protection of 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 Spotted Seatrout stock.
3. Monitor and manage the fishery in a manner that utilizes biological, socioeconomic, fishery, habitat, and environmental data.
4. Promote outreach and interjurisdictional cooperation regarding the status and management of the Spotted Seatrout stock in North Carolina and Virginia waters, including practices that minimize bycatch and discard mortality., including practices that minimize bycatch and discard mortality.

DESCRIPTION OF THE STOCK

Biological Profile

Spotted seatrout, also known as speckled trout, are an estuarine fish species that inhabit rivers, estuaries, and shallow coastal systems. Spotted seatrout are found in coastal waters ranging from Massachusetts to southern Florida continuing throughout the Gulf of Mexico but are most abundant in the mid-Atlantic and southeastern regions of the United States. Genetic markers in North Carolina fish suggest mixing between two genetically distinct populations: one population from Georgia to the Cape Fear River, North Carolina and a another that expands north from Bogue Sound, North Carolina (Ellis et al., 2018; O'Donnell et al., 2014).

Spotted seatrout have distinct seasonal migrations. In the winter, fish migrate to shallow estuarine habitats (Ellis, 2014). As waters warm, fish will return to oyster beds, shallow bays, and grass flats (Daniel, 1988). Although Spotted Seatrout seasonally migrate, based on tag return studies, most individuals exhibit strong site fidelity traveling less than 50 km (Music, 1981; Ellis, 2014; Moulton et al., 2017; Loeffler et al., 2019).

Spawning occurs from April to October with peak spawning occurring in May and June (Burns, 1996). Spawning generally occurs near inlets or within estuaries. Because Spotted Seatrout are batch spawners, females are capable of spawning multiple times throughout the season. Fish mature between the ages of one and three. Younger, newly matured fish may spawn every four days while fish older than three years may spawn every two days (Roumillat & Brouwer, 2004). Estimates of the number of eggs a female can produce in a year vary based on age and size but ranges between 3-20 million eggs per year (Nieland et al., 2002; Roumillat & Brouwer, 2004; Murphy et al., 2010). Most male Spotted Seatrout in North Carolina are mature at 7.9 inches total length (TL) and most females are mature at 9.9 inches TL. All males are mature at 12 inches and all females are mature at 15 inches.

North Carolina's state record is currently a 12.5 pound, 33.5-inch fish caught from the lower Neuse River in 2022. The annual average size of Spotted Seatrout from 1991-2021 ranged from 14.4 to 18.3 inches in North Carolina's commercial fisheries and 14.2 to 17.6 inches in the recreational fishery. Spotted seatrout can live as long as ten years old. The oldest, otolith-based age of both male and female fish reported in North Carolina is 9 years old.

Spotted seatrout are especially susceptible to cold stun events, times in which water temperatures drop below what fish can survive. The effect of cold stuns on Spotted Seatrout abundance depends on the severity and duration of the event. The impact can be minimal if only sub-adults are affected, if the event is localized to a few areas, or if the event is short lived. Cold stun events can have a substantial impact if all size classes are affected, if larger areas are affected, or if the event lasts for an extended period. Interannual Spotted Seatrout abundance can be driven by cold stun events that cause large losses to the stock, which can prompt management to suspend both recreational and commercial harvests (Hurst, 2007; NCDMF, 2012).

These fish are known to be highly opportunistic predators, feeding on a variety of prey items depending on their size and availability. Their diet mainly consists of small fish, shrimp, crabs, and other invertebrates. Spotted seatrout are ambush predators, relying on camouflage and patience to wait for prey to come within striking distance. They are most active during dusk and dawn.

Assessment Methodology

A seasonal size-structured assessment model was applied to data characterizing commercial and recreational landings and discards, fisheries-independent survey indices, and biological data collected from 1991 through 2019. A nonstationary process was assumed for natural mortality and growth in the model. The seasonal time step and nonstationary natural mortality assumption allows for capturing the cold-stun effects that have been observed for Spotted Seatrout. Both the observed data and model predictions suggest a shift in population dynamics around 2004 when the fisheries-independent survey index data became available. Lower fishing mortality and higher spawning stock biomass and recruitment with greater variation were predicted for the period after 2004. This trend was also observed in the recreational landing and discards data which exhibited higher values after 2004.

Stock Status

Reference point thresholds for the Spotted Seatrout stock were based on 20% spawner potential ratio (SPR). Due to large uncertainty in the terminal year (2019) estimates, a weighted average of the estimates over the most recent three years (2017–2019) was used to represent the terminal year estimate for determination of stock status. The estimates of 2017–2019 from the base model were weighted by the inverse of their CV values before calculating the average. The threshold and target values for the terminal year were also averaged over 2017–2019. The estimated *F* threshold *F*20% was 0.60 per year, and the estimated terminal year (2019) *F* was 0.75 per year. Thus, the estimated *F*/*F*20% for 2019 is greater than one (1.3), suggesting the stock is currently experiencing overfishing (Figure 11). The estimated SSB threshold (SSB20%) for 2019 was 1,143 metric tons, and the estimated 2019 SSB was 2,259 metric tons. Therefore, the estimated

SSB/SSB20% for 2019 is greater than one (2.0), suggesting the stock is not currently overfished (Figure 22).

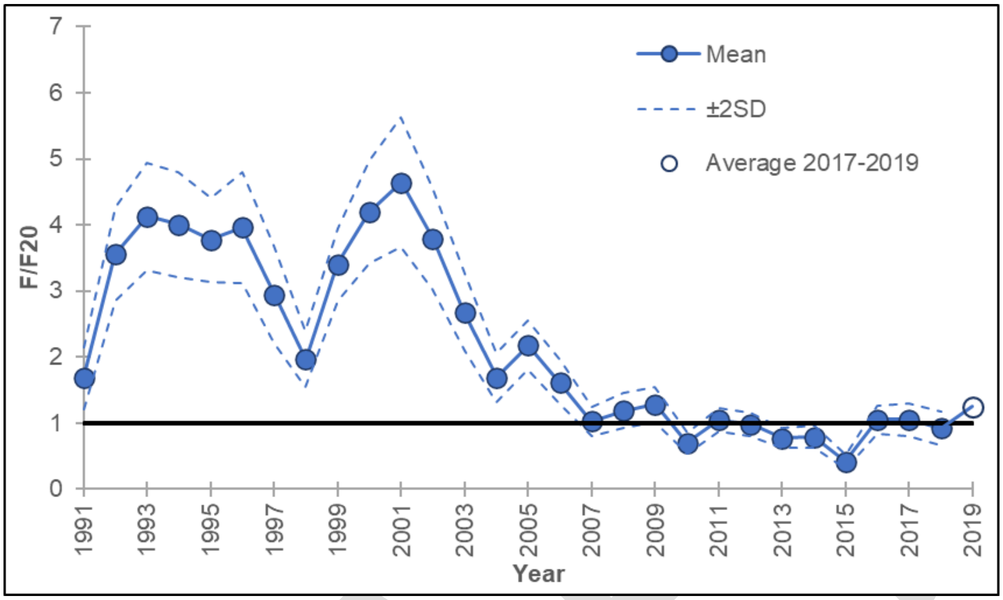


Figure 1. Annual predicted fishing mortality relative to the fishing mortality threshold (F/F20) from the base model of the stock assessment, biological years (Mar–Feb) 1991–2019. The horizontal black line shows a ratio of one. The terminal-year estimate is an average of the most recent three years weighted by the inverse CV values.

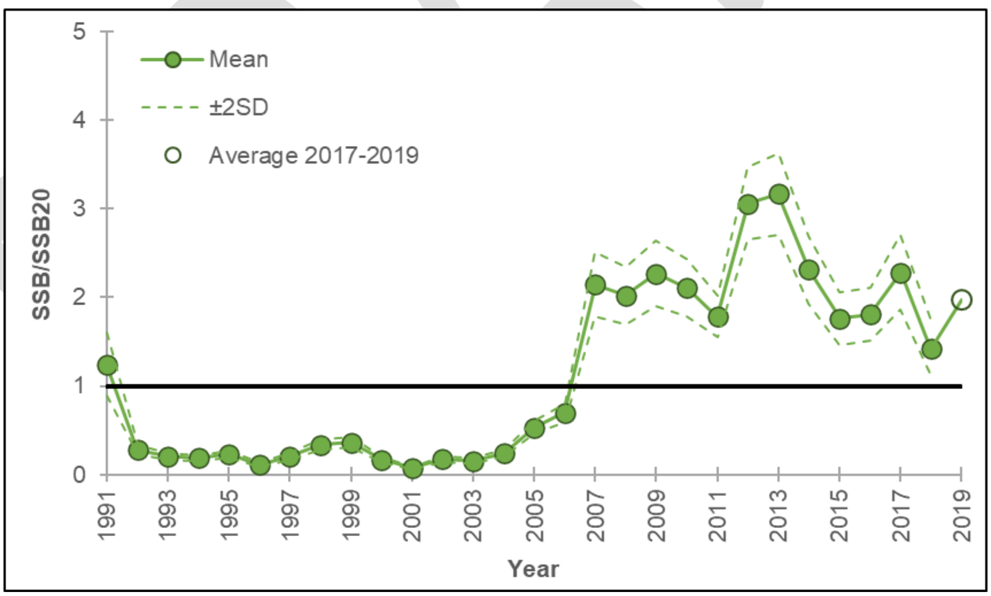


Figure *1*. Annual predicted spawning stock biomass (metric tons) relative to the spawning stock biomass threshold (SSB/SSB20) from the base model of the stock assessment, biological years (Mar–Feb) 1991–2019. The horizontal black line shows a ratio of one. The terminal-year estimate is an average of the most recent three years weighted by the inverse CV values.

DESCRIPTION OF THE FISHERY

Additional in-depth analyses and discussion of North Carolina's commercial and recreational Spotted Seatrout fisheries can be found in the original Spotted Seatrout FMP and Supplement A (NCDMF 2012 and 2014); all FMP documents are available on the DMF Fishery Management Plans website and commercial and recreational landings can be found in the License and Statistics Annual Report (NCDMF 2023) produced by the DMF which can be found on the DMF Fisheries Statistics page.

Recreational and commercial landings are typically variable from year to year and are influenced by winter weather conditions (i.e., low harvest follows severe winters) and fish availability. Confirmed cold stun events, with varying severity, occurred in 1995, 2000, 2001, 2003, 2004, 2009, 2010, 2014, 2015, 2018, and 2022 (Table 1). Since cold stuns typically occur in December and January (the end of the biological year), their impacts to recreational and commercial landings are experienced the following year.

Table 1. Confirmed Spotted Seatrout cold stun events and fishery closure dates, 1995-2022.

Calendar Year	Month	Biological Year	Closure	Fishery Closure Dates*
1995	December	1995	No	-
2000	January	1999	No	-
2001	January	2000	No	-
2003	January	2002	No	-
2004	December	2004	No	-
2010	January	2009	No	-
2010	December	2010	Yes	Jan. 14 - June 15, 2011
2014	January	2013	Yes	Feb. 5 - June 14, 2014
2015	February	2014	No	-
2018	January	2017	Yes	Jan. 5 - June 14, 2018
2022	December	2022	No	-

Commercial Fishery

DMF instituted a mandatory, dealer-based, trip-level, reporting system known as the North Carolina Trip Ticket Program (NCTTP) for all commercial species in 1994. All seafood landed in North Carolina and sold by licensed commercial fishermen must be reported on a trip ticket by a licensed seafood dealer. For more information about licensing requirements for purchasing and selling seafood in North Carolina and how commercial fishing data were collected prior to 1994, please refer to the DMF License and Statistics Section Annual Report (NCDMF, 2023). In 2022, 138 seafood dealers reported Spotted Seatrout on trip tickets, landed by 701 fishery participants during 11,695 fishing trips (Figure 33).

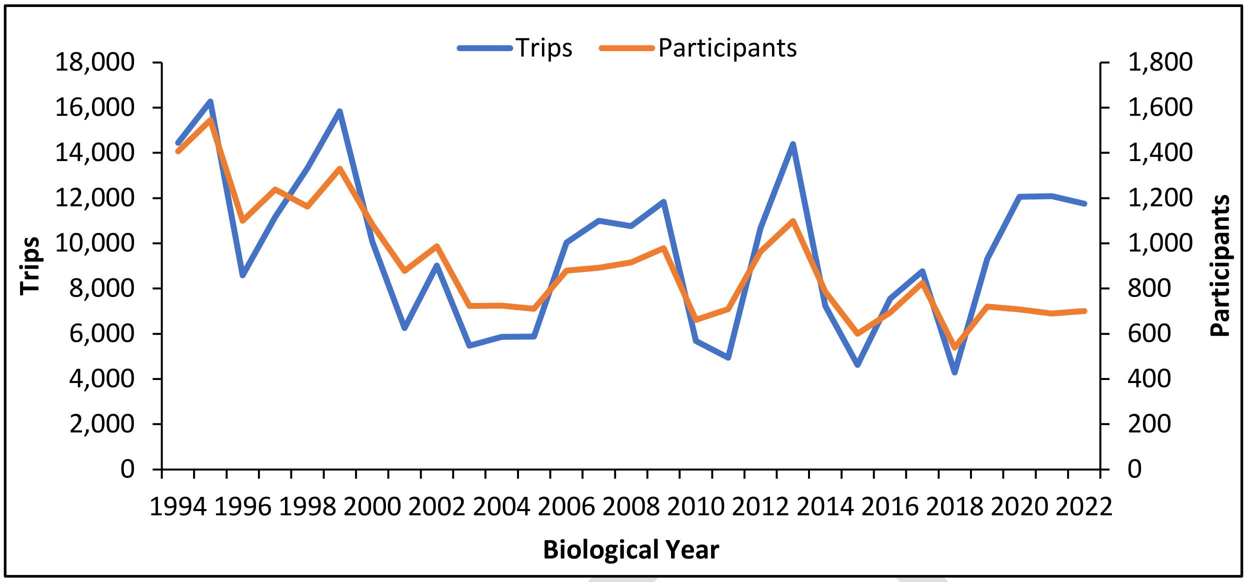


Figure 2. Annual number of trips and participants for the North Carolina Spotted Seatrout fishery from 1994 to 2022.

Annual Landings and Value

In recent years (2012 to 2022), total landings averaged 361,656 pounds per year (Figure 44). The lowest landings during this period was 115,547 pounds in 2015 and the highest was 654,327 pounds in 2021. Spotted seatrout landings have increased in recent years, exceeding 650,000 pounds in 2020 and 2021. Annual dockside value of Spotted Seatrout commercial landings averaged $891,180 from 2012 to 2022. Annual dockside value was lowest in 2015 at $290,709 and reached a high of just under $1.7 million in 2021.

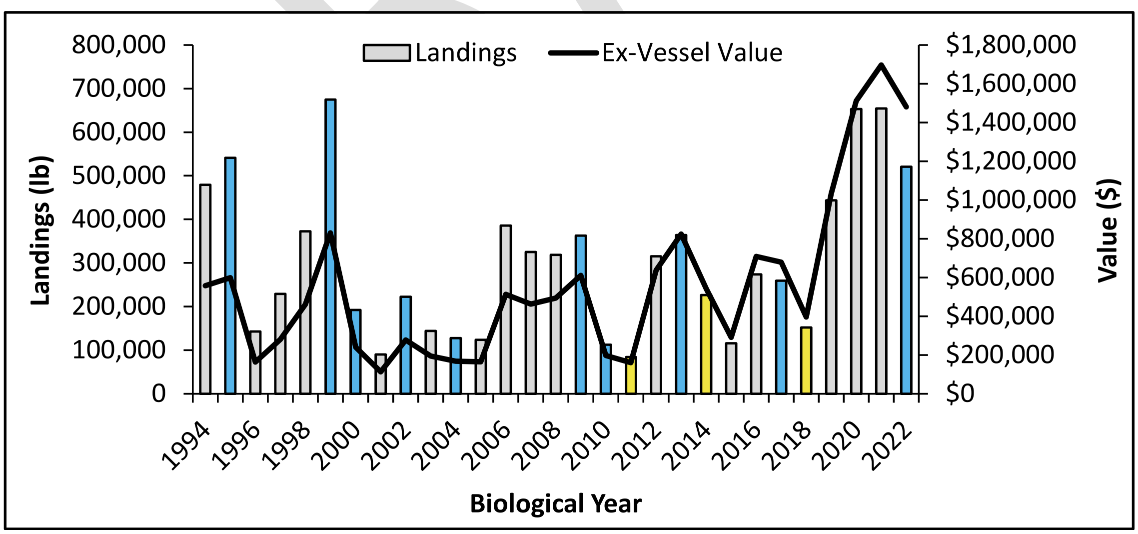


Figure 4. North Carolina annual Spotted Seatrout commercial landings and ex-vessel value, 1994-2022. Values include all market grades and are not adjusted for inflation. The biological year begins in March and ends in February the following year (ex.: biological year 1994 begins in March 1994 and ends in February 1995). Gray bars indicate years without a cold stun or cold stun closure, blue bars indicate years with a confirmed cold stun event, and yellow bars indicate years with a cold stun closure.

Landings by Month

Spotted seatrout are harvested year-round but there are distinct seasonal peaks (Figure 55). From 1994 through 2022, on average the largest harvest peak occurs from October through February, with a second smaller harvest plateau occurring from April through May. The fall/winter harvest season has accounted for 71% of the harvest and the shorter spring season has accounted for 12% of the harvest from 1994-2022. Harvest is typically highest in colder months as Spotted Seatrout aggregate in smaller waterbodies and can be caught in higher numbers. Harvest tends to taper off as waters warm and fish disperse in preparation for the summer spawning season.

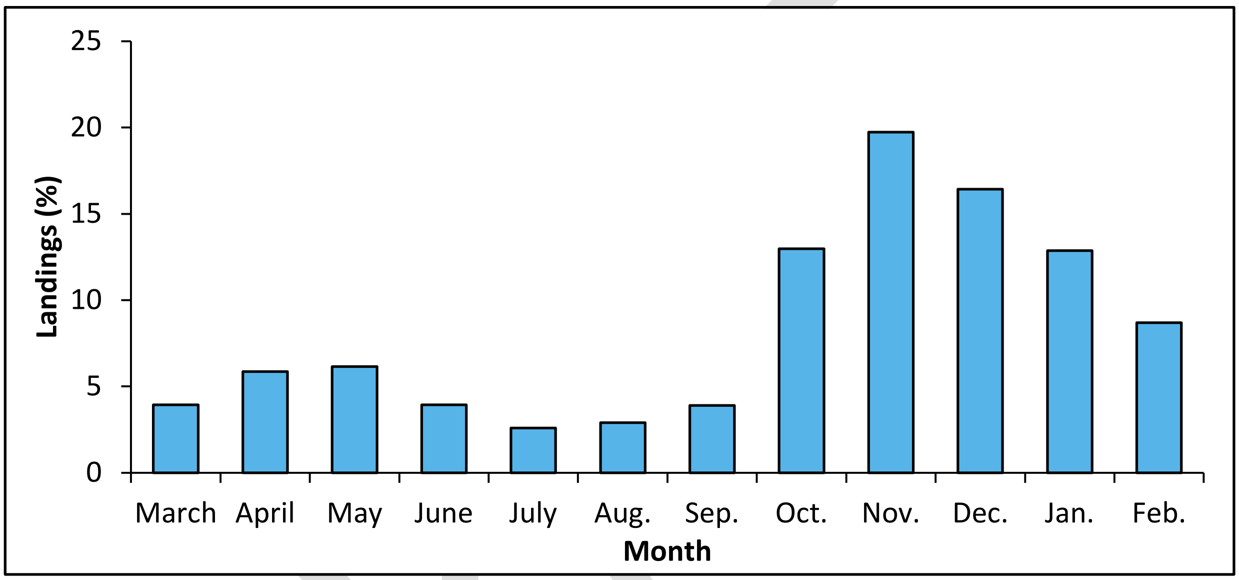


Figure *3*. North Carolina Spotted Seatrout commercial landings proportion by month, 1994-2022. Months are ordered according to the biological year which begins in March and ends in February the following year.

Landings by Area

Spotted seatrout are harvested statewide. The main harvest areas are typically Pamlico Sound, followed by the Neuse and Bay rivers and Central Sounds area (Core, Back, and Bogue sounds; Figure 66). Pamlico Sound accounted for 28% of the harvest from 2012 through 2022. Annual harvest from Pamlico Sound during this period ranged from 11,569 lb in 2018 to 255,176 lb in 2021. During this same period, the Neuse and Bay rivers accounted for 24%, the Central Sounds and Southern area each accounted for 13%, Albemarle Sound accounted for 11%, the Pamlico and Pungo rivers accounted for 9%, and the Ocean accounted for 2% of the harvest.

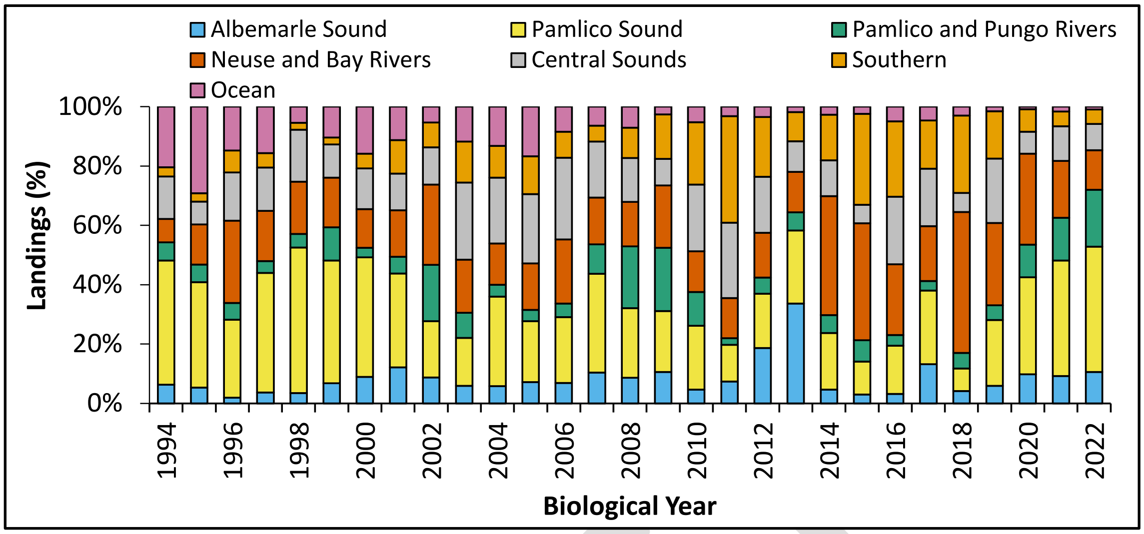


Figure 4. North Carolina annual Spotted Seatrout commercial landings proportion by area, 1994-2022. Albemarle Sound includes Albemarle, Currituck, Croatan, and Roanoke sounds and their tributaries. Pamlico Sound includes Pamlico Sound and its bays and tributaries. Central Sounds includes Core, Back, and Bogue Sounds and their tributaries. Southern includes the White Oak River and all waters south to the SC state line.

Landings by Gear Type

Spotted seatrout are harvested with a variety of gears but anchored gill nets and runaround gill nets account for most of the current harvest (Figure 77). Other gears used include haul seines, beach seines, and ocean gill nets. Since 2012, anchored gill nets have accounted for 43% of the harvest and runaround gill nets have accounted for 48% of the harvest.

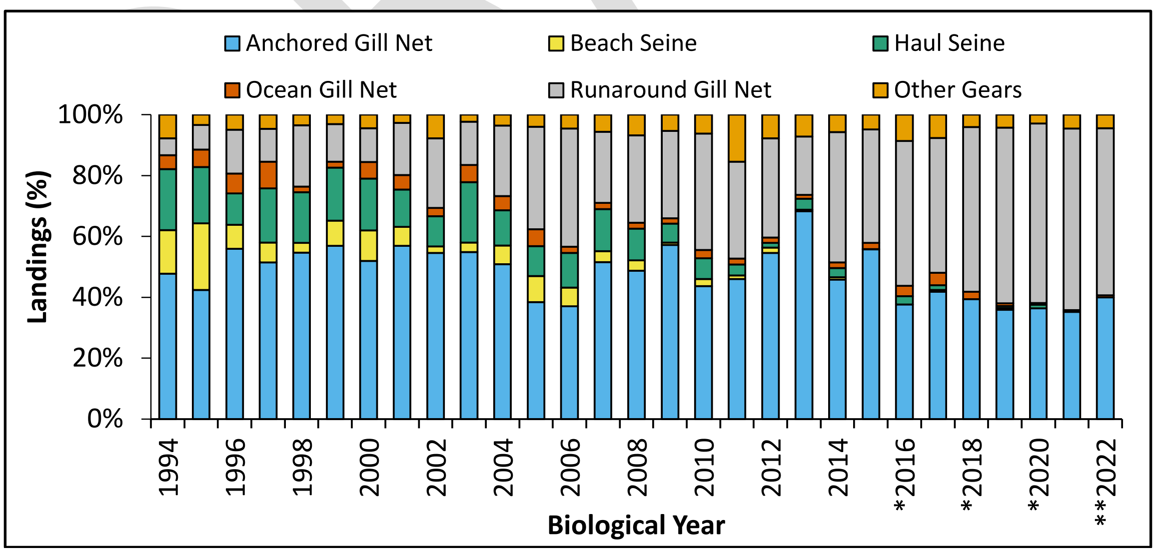


Figure 5. North Carolina annual Spotted Seatrout commercial landings proportion by gear type, 1994-2022. *Beach Seine landings combined with Other Gears due to data confidentiality. **Beach Seine and Haul Seine landings combined with Other Gears due to data confidentiality.

Commercial bycatch

Large mesh anchored gill nets target demersal fish such as flounder during the fall months and pelagic fish such as clupeids during the spring months. Small-mesh anchored gill-net trips occur consistently throughout the year dependent on the target species for that time of year. Spotted Seatrout are targeted primarily during fall and winter. The Spotted Seatrout small-mesh fishery would potentially interact with green sea turtles and Atlantic sturgeon. Most sea turtle interactions occur in the late summer and fall months. Sea turtle movement is typically influenced by water temperature. As soon as water temperatures start to decline within the estuaries, incidental takes significantly decline. Atlantic Sturgeon have the greatest abundance in spring but fall and winter make up for 47% of estimated discards in the small-mesh fishery.

Table 2. Estimates for the number of green sea turtles, Kemp's ridley sea turtles, and Atlantic sturgeon caught incidentally in the small-mesh and large-mesh anchored gill-net fisheries from 2013-2022. A hyphen (-) represents values that could not be calculated based on data provided.

		Green sea turtle discards		Kemp's ridley sea turtle discards		Atlantic Sturgeon discards	
Seasons	MU	Large Mesh	Small Mesh	Large Mesh	Small Mesh	Large Mesh	Small Mesh
Spring	A	17	4	19	-	1805	181
	B	66	125	13	-	18	478
	C	15	5	4	-	93	41
	Core	37	22	-	-	7	114
	D	4	1	1	-	1	1
	E	19	6	7	-	15	15
Summer	A	16	3	19	-	119	11
	B	313	62	66	-	8	64
	C	28	5	8	-	11	5
	Core	121	3	-	-	3	4
	D	21	2	4	-	1	1
	E	121	9	54	-	7	4
Fall	A	63	8	38	-	1773	88
	B	1,050	206	143	-	96	249
	C	55	14	7	-	72	31
	Core	316	81	-	-	26	134
	D	110	24	8	-	5	1
	E	194	58	43	-	37	39
Winter	A	8	3	-	-	722	131
	B	11	30	-	-	4	125
	C	1	3	-	-	3	27
	Core	1	1	-	-	1	5
	D	1	1	-	-	1	1
	E	2	4	-	-	1	9
Total		2,590	680	434	-	4,829	1,759

Recreational Fishery

The Spotted Seatrout fishery in N.C. is predominately a recreational fishery. Since 2012, recreational landings have accounted for approximately 86% of total landings. Recreational harvest, release, and trip data are estimated from the Marine Recreational Information Program (MRIP) which is a series of surveys designed to estimate total recreational catch. Recreational estimates across all years have been updated and are now based on MRIP's new Fishing Effort Survey-based calibrated estimates. For more information on MRIP see NOAA's MRIP informational page.

Annual landings and releases

Landings in 2019 increased sharply and have remained high through 2022 (Figure 88). In recent years (2012 to 2022) landings averaged 2,212,806 pounds, but since 2019 (2019 to 2022) landings averaged 3,339,879 pounds. Landings have been below a million pounds in only two years since 2012 (2015, 339,436 pounds and 2018, 728,411 pounds) and both years follow documented cold stuns including a fishery closure in 2018 (Table 1). Landings from 2019–2022 represent the four highest landings values in this timeframe and four of the five highest landings since 1991.

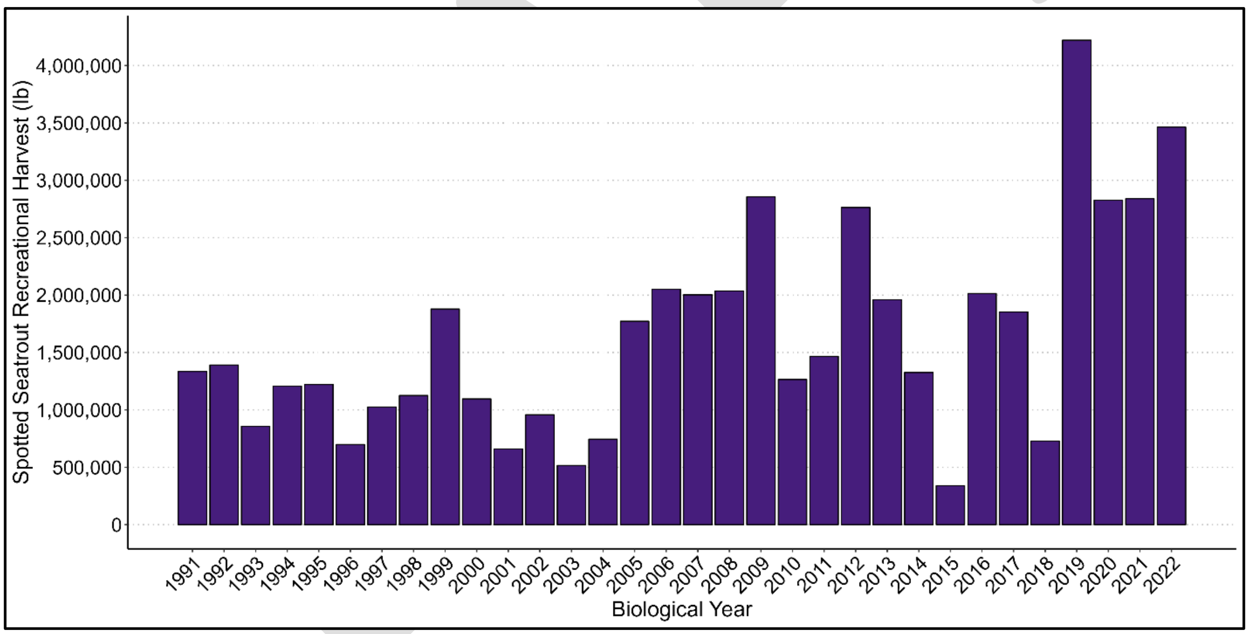


Figure 6. North Carolina Spotted Seatrout recreational landings biological years 1991–2022 (March–February).

There is a dedicated catch and release segment of the recreational fishery, though how anglers participate in this segment varies. Some anglers release all fish, some anglers release all larger fish (e.g., any fish over 20"), and some anglers continue to target Spotted Seatrout for catch and release fishing after harvesting their limit. Recreational releases vary annually and 2018 represents a large outlier for the time series likely due to Hurricane Florence impacting MRIP surveys throughout most of North Carolina in late 2018 but releases have generally increased since 2009 (Figure 99). Recreational releases may change seasonally as well because Spotted Seatrout growth rates and life history can lead to greater numbers of sublegal fish at times. Anglers released an average of 6,150,931 fish annually from 2009–2022 with the 2018 outlier removed which is nearly five times the number of fish harvested.

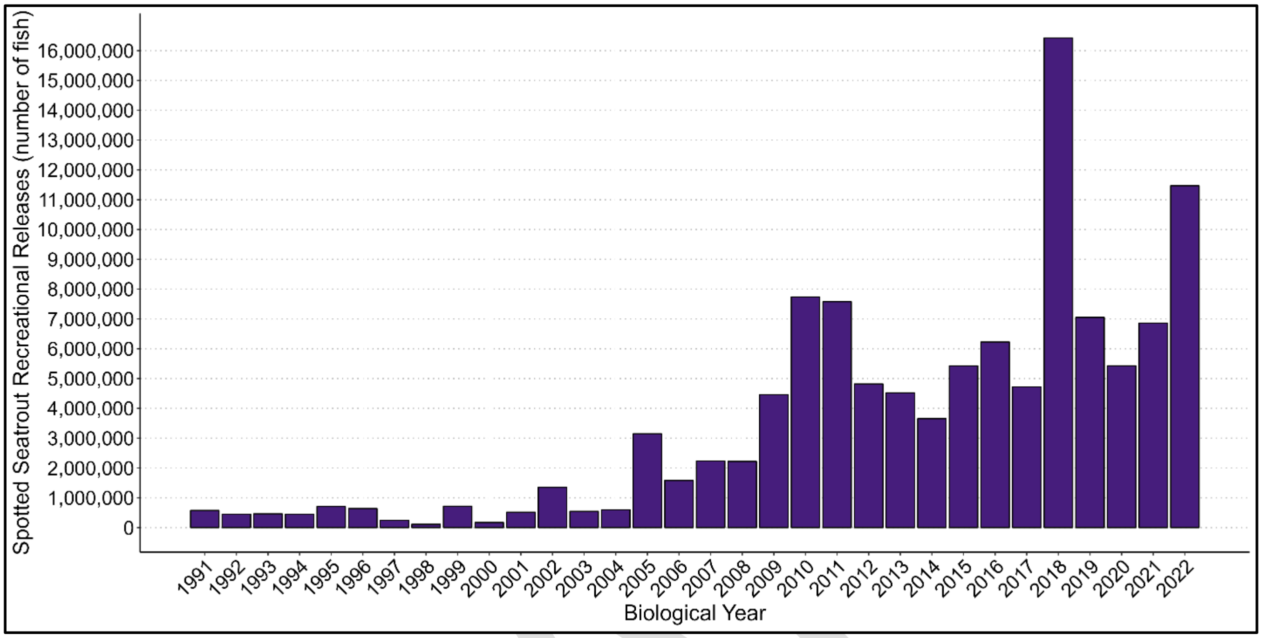


Figure 9. North Carolina Spotted Seatrout recreational releases biological years 1991–2022 (March–February). Hurricane Florence impacted MRIP sampling in most of North Carolina in late 2018. As such recreational releases from 2018 should be viewed with a high degree of caution.

Landings by month

Although recreational harvest occurs throughout the year, most harvest occurs in late fall and early winter. Harvest increases in October, peaks sharply in November, then decreases in winter but remains above average compared to the rest of the year in December, January, and February (Figure 1010). A second, slight increase in landings occurs in June and July, likely driven by tourism. From 1991 to 2022 approximately 63% of harvest occurs during the primary harvest peak (October – February) while the slight increase in June and July encompasses about 11% of harvest. In recent years (2012–2022), the general harvest patterns remain, but winter months make up a larger proportion of harvest (Figure 1111). Though minor regional variation in these seasonal patterns might exist, these patterns are broadly consistent across the state.

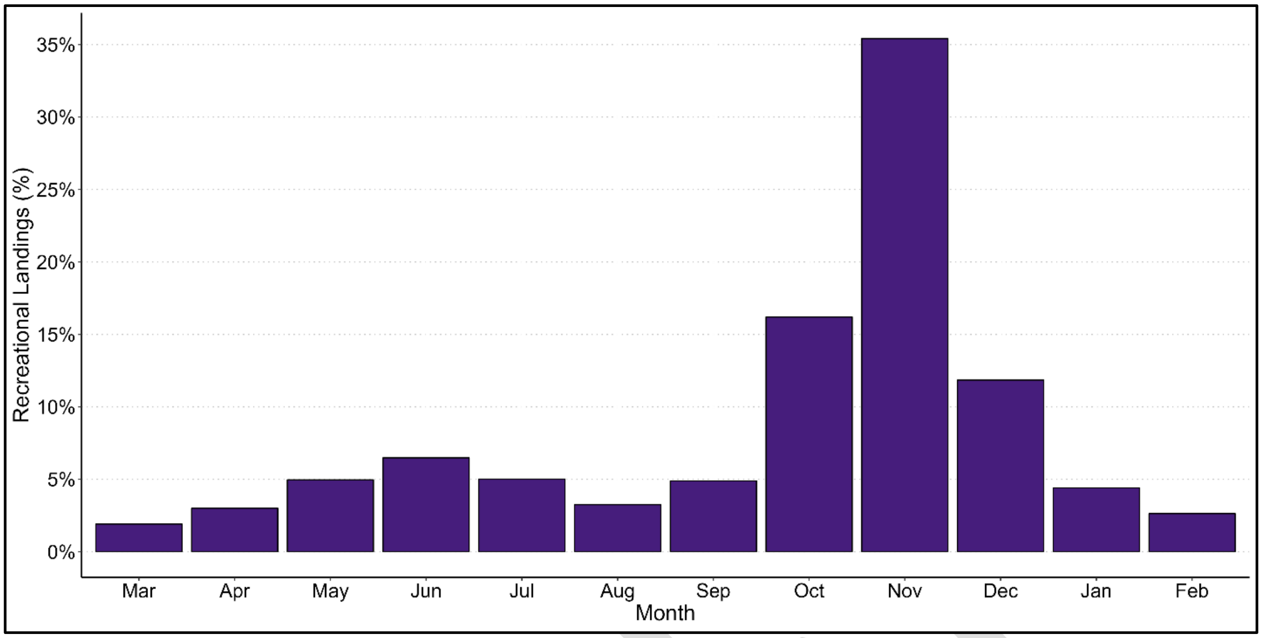


Figure 107. North Carolina average monthly Spotted Seatrout recreational landings proportion by month, 1991-2022. Months are ordered according to the biological year (March – February).

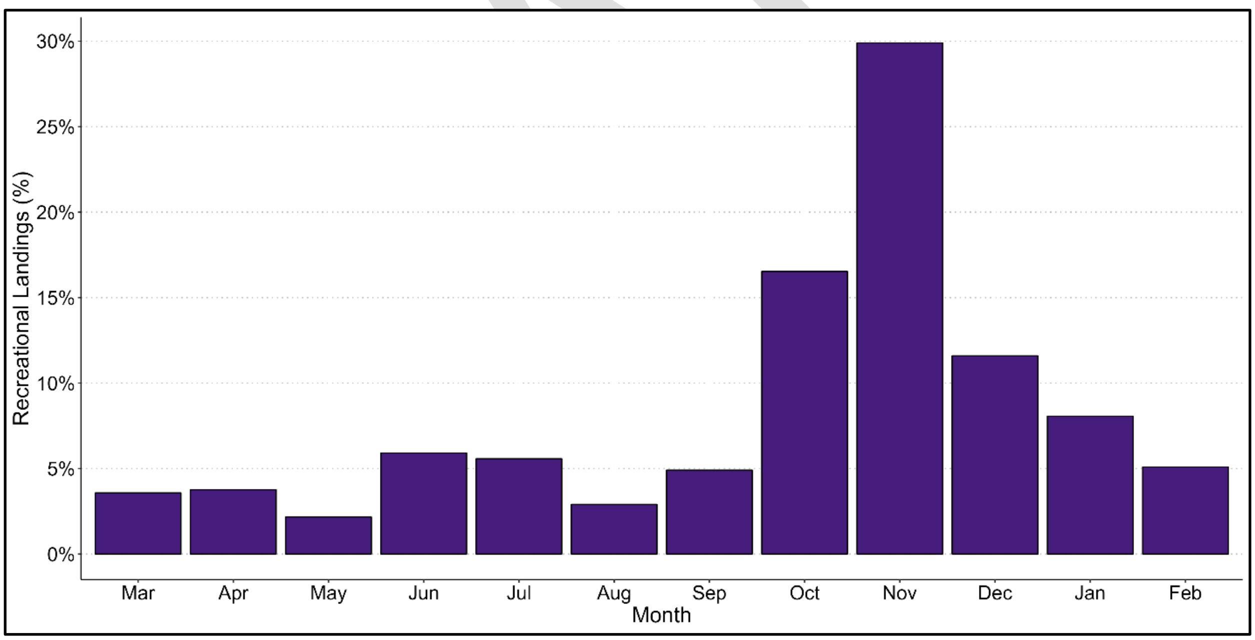


Figure 11. North Carolina average monthly Spotted Seatrout recreational landings proportion by month, 2012-2022. Months are ordered according to the biological year (March – February).

Recreational releases also occur throughout the year, however; releases are concentrated in October, November, and December. In recent years (2012–2022) a slightly larger proportion of fish are released in January compared to the rest of the year, but releases remain relatively consistent outside October, November, and December (Figure 1212).

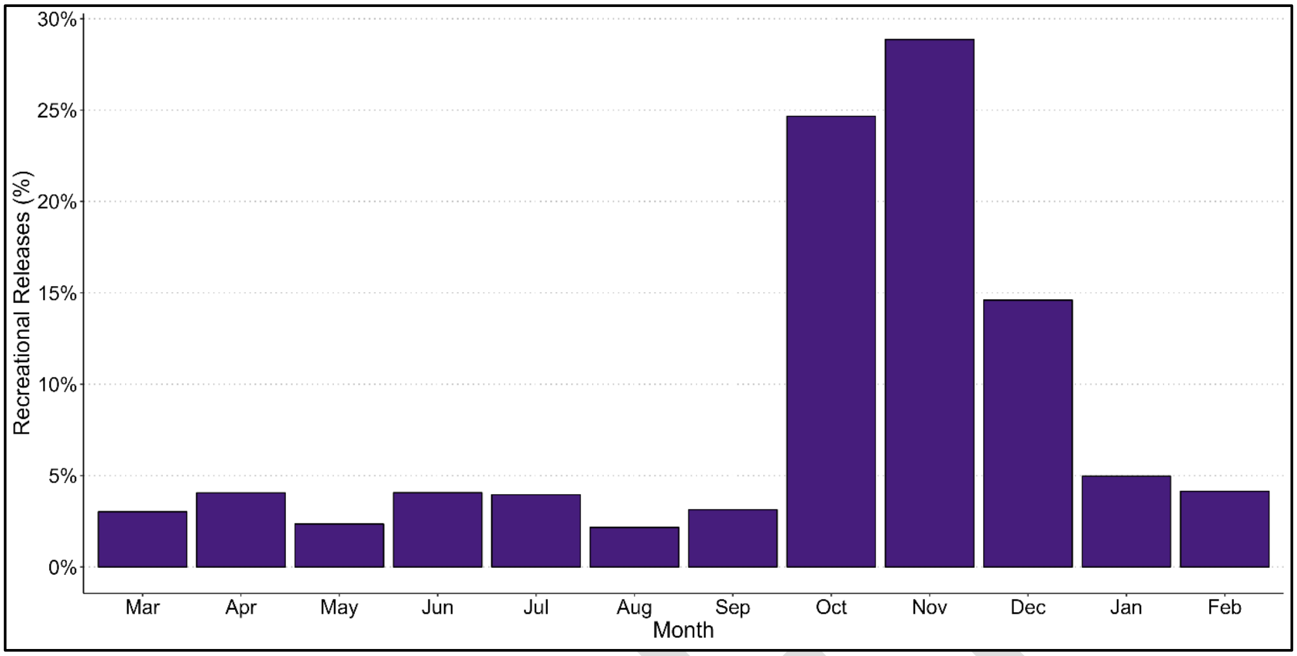


Figure 12. North Carolina average monthly Spotted Seatrout recreational releases proportion by month, 2012-2022. Months are ordered according to the biological year (March – February).

Summary of Economic Impact

Modeling software, IMPLAN, is used to estimate the economic impacts of an industry to the state at-large, accounting for revenues and participation. For a detailed explanation of the methodology used to estimate the economic impacts please refer to the North Carolina Division of Marine Fisheries (DMF) License and Statistics Section Annual Report. Due to the management options being considered, this analysis includes both the recreational and commercial industries.

Commercial

Commercial landings and effort data collected through the DMF trip ticket program are used to estimate the economic impact of the commercial fishing industry. For commercial fishing output, total impacts are estimated by incorporating modifiers from NOAA's Fisheries Economics of the United States reports from 2012-2020, which account for proportional expenditures and spillover impacts from related industries. By assuming the Spotted Seatrout commercial fishery's economic contribution is a proportion equal to its contribution to total commercial ex-vessel values, we can generate an estimate of the economic contribution of the commercial Spotted Seatrout fishery statewide.

From 2012 to 2022 Spotted Seatrout economic sales impacts have varied from a low of approximately $360,000 in 2015 to a high of $1.5 million dollars in 2022 and supports between 575 and 1,200 jobs annually. Annual sales impacts have varied over the decade but have averaged $5.9 million from 2012 to 2022.

Table 3. Annual economic contributions from the Spotted Seatrout commercial fishery to the state of North Carolina from 2012 to 2022 reported in 2022 dollars.

Year	Pounds Landed	Ex-Vessel Value	Job Impacts	Income Impacts	Value Added Impacts	Sales Impacts
2022	520,994	$1,480,294	834	$3,413,446	$5,432,284	$7,819,923
2021	654,327	$1,833,146	846	$4,305,885	$6,767,404	$9,880,173
2020	653,093	$1,709,539	862	$4,296,534	$6,965,574	$9,646,212
2019	443,629	$1,182,385	822	$2,986,277	$4,369,883	$6,959,060
2018	151,708	$461,888	575	$1,044,323	$1,717,370	$2,371,747
2017	259,432	$810,368	898	$2,100,330	$3,132,230	$4,835,802
2016	273,848	$864,570	775	$2,281,480	$3,515,818	$5,204,455
2015	115,547	$358,921	633	$938,109	$1,450,039	$2,135,390
2014	226,394	$671,553	846	$1,631,567	$2,455,165	$3,761,647
2013	364,123	$1,035,645	1,194	$2,528,888	$3,938,648	$5,769,680
2012	315,128	$811,864	1,081	$2,858,981	$3,908,590	$6,278,522

Recreational

Recreational effort data is provided from the Marine Recreational Information Program, the National Marine Fisheries Service (NMFS) as well as survey responses collected from North Carolina recreational fishing participants administered by the Fisheries Economics Program at DMF. For recreational fishing output, total impacts are estimated by incorporating modifiers from NOAA's Fisheries Economics of the United States reports from 2012 to 2020, which account for proportional recreational expenditures and spillover impacts from related industries. By assuming the Spotted Seatrout recreational fishery's contribution to expenditure categories is at a proportion equal to its contribution to total recreational trips and durable goods expenditure, we can generate an estimate of the total economic contribution of Spotted Seatrout in North Carolina.

From 2012 to 2022 Spotted Seatrout economic sales impacts have varied from a low of about $267 million in 2015 to a high of $581 million dollars in 2020. Similarly, job impacts span from approximately 2,700 to 5,500 jobs annually. Annual sales impacts have varied over the described time horizon but have averaged $438 million from 2012 to 2022.

Table 4. Annual economic contributions of the Spotted Seatrout recreational fishery to the state of North Carolina from 2012 to 2022 reported in 2022 dollars.

Year	Trips	Expenditure	Job Impacts	Income Impacts	Value Added Impacts	Sales Impacts
2022	2,952,725	$610,166,244	4556	$186,974,466	$287,883,774	$508,297,606
2021	2,254,224	$527,895,592	4318	$167,784,164	$253,959,746	$455,899,909
2020	2,719,670	$680,865,862	5486	$231,035,451	$328,868,972	$580,954,157
2019	2,528,247	$635,730,887	5252	$195,627,253	$296,435,669	$535,753,473
2018	1,773,091	$439,207,323	3185	$141,032,169	$213,419,087	$380,831,319
2017	1,555,087	$380,456,082	3573	$117,806,629	$177,609,593	$325,543,922
2016	2,091,731	$522,385,203	4526	$164,680,710	$244,974,745	$443,331,488
2015	1,295,843	$321,730,351	2709	$98,681,487	$160,541,925	$267,200,930
2014	1,510,415	$384,591,773	3635	$116,796,277	$173,912,242	$309,980,126
2013	2,065,210	$552,161,892	4451	$390,676,333	$248,904,256	$532,736,812
2012	2,112,138	$587,450,277	4679	$176,846,782	$263,358,908	$473,618,472

ECOSYSTEM PROTECTION AND IMPACT

Coastal Habitat Protection Plan

The Fishery Reform Act statutes require that a Coastal Habitat Protection Plan (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 in developing goals and recommendations for the continued protection and enhancement of fishery habitats in North Carolina. Habitat recommendations related to fishery management can be addressed directly by the North Carolina Marine Fisheries Commission (NCMFC). The NCMFC has passed rules that provide protection for Spotted Seatrout 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 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).

Spotted seatrout make use of a variety of habitats during their life history with variations in habitat preference due to location, season, and ontogenetic stage. They are found most often in habitats identified in the CHPP including water column, wetlands, submerged aquatic vegetation (SAV), soft bottom, and shell bottom (NCDEQ, 2016). Spotted Seatrout are found throughout estuarine systems and can migrate offshore to deeper marine soft bottom areas and beaches in response to falling temperatures (ASMFC, 1984; Mercer, 1984). Spotted Seatrout do, however, show a strong preference for low-flow areas with SAV or soft bottom (Tabb, 1958; Moulton et al., 2017). Growth and survival of Spotted Seatrout within the habitats they use are maximized when water quality parameters such as temperature, salinity, and dissolved oxygen are within optimal ranges. Maintenance and improvement of suitable estuarine habitat and water quality may be the most important factors in sustaining Spotted Seatrout stocks. Additional information on the habitats discussed below, threats to these habitats, water quality degradation, and how these topics relate to fisheries can be found in the CHPP (NCDEQ, 2016).

Threats and Alterations

Suitable habitat is a critical element in the ecology and productivity of estuarine systems. Degradation or improvement in one aspect of habitat may have a corresponding impact on water quality. All habitats used by Spotted Seatrout are threatened in some way.

Water Column

The water column habitat is defined as “the water covering a submerged surface and its physical, chemical, and biological characteristics” (NCDEQ, 2016). Spotted seatrout spawning is generally limited to estuarine waters in the late summer and early fall in response to temperature and salinity but can also include inlets in North Carolina (ASMFC, 1984; Mercer, 1984; Saucier & Baltz, 1992, 1993; Holt and Holt, 2003; Kupschus, 2004; Stewart & Scharf, 2008; Ricci et al., 2017). Spawning sites have been noted to include tidal passes, channels, river mouths, and waters in the vicinity of inlets (Saucier & Baltz, 1992, 1993; Roumillat et al., 1997; Luczkovich et al., 1999; Stewart & Scharf, 2008; Lowerre-Barbieri et al., 2009; Boucek et al., 2017). For the portion of the Spotted Seatrout population that spawns inshore or offshore of inlets, they are a critical component of water column habitat for Spotted Seatrout and the larvae that must pass through inlets to reach estuarine nursery areas (Churchill et al., 1997; Hare et al., 1999; Luettich et al., 1999). Due to the importance of inlets to the movement of larval Spotted Seatrout into nursery areas and of adult Spotted Seatrout out into to oceanic waters while avoiding lower estuarine temperatures, terminal groins may threaten Spotted Seatrout stocks by impeding recruitment and preventing adults from avoiding cold stuns, since they can obstruct inlet passage (Kapolnai et al., 1996; Churchill et al., 1997; Blanton et al., 1999). Inlets are hydraulically dredged on a regular basis to ensure safe passage for vessels of all sizes. Though DMF recommends an in-water-work moratorium of April 1 to July 30 to minimize impacts during peak biological activity, most projects are given moratorium relief due to public safety. Large hydraulic dredge boats are used inside the inlets and have the highest potential to draw in fishes and invertebrates of all life stages. However, this type of dredge is most impactful to eggs and larval fish, as their reduced swimming ability means they are unable to actively avoid the suction field (Todd et al., 2015).

Soft Bottom

Soft bottom habitat plays an important role in estuarine system function, acting as both a source and sink (storage) for nutrients, chemicals, and microbes. Estuarine soft bottom habitats, especially those adjacent to wetlands, act as Spotted Seatrout nursery areas, provide key food sources for all life stages, and refuge from large predators (Ross & Epperly, 1985; Noble & Monroe, 1991; Powers, 2012). Soft bottom sediments support algae and the benthic invertebrates that eat algae, which are important food sources for juvenile and adult Spotted Seatrout. Spotted Seatrout begin their lives eating primarily copepods and mysid shrimps before transitioning to penaeid and palaemonid shrimps (Peterson and Peterson 1979; Daniel 1988; McMichael and Peters 1989). Soft bottom habitat, along with SAV, are more heavily utilized by Spotted Seatrout than other habitat types (Tabb, 1958; Moulton et al., 2017). Dredging threatens soft bottom habitat, potentially affecting Spotted Seatrout food sources and water quality. Dredging removes all benthic infauna from the affected areas immediately, which reduces food availability temporarily to bottom feeding fish such as the Spotted Seatrout (NCDEQ, 2016).

In addition to estuarine soft bottom habitats, there are also surf zone and deeper marine soft bottom habitats used by adult Spotted Seatrout in North Carolina during late autumn temperature migrations (ASMFC, 1984; Mercer, 1984). The threats to ocean beaches and surf zone include beach nourishment and storm water outfalls.

Submerged Aquatic Vegetation

Submerged Aquatic Vegetation (SAV) is a fish habitat dominated by one or more species of underwater vascular plants and occurs in both subtidal and intertidal zones, sometimes over extensive areas (NCDEQ, 2016). SAV acts as a crucial structured habitat for fishes and invertebrates, providing refuge from predators and food sources such as epiphytic (living on the surface of vegetation) algae and animals. Spotted Seatrout use SAV as spawning sites, nurseries, forage areas, refuge areas, and for feeding on invertebrates on seagrasses and other structures. The Atlantic States Marine Fisheries Commission (ASMFC) lists SAV as a Habitat Area of Particular Concern (HAPC) for Spotted Seatrout (ASMFC, 1984). All life stages of Spotted Seatrout have been documented in mesohaline and polyhaline seagrass beds (Tabb, 1966; ASMFC, 1984; Mercer, 1984; Thayer, Kenworthy & Fonseca, 1984; McMichael & Peters, 1989; Rooker et al., 1998). Spotted Seatrout use SAV habitat as much, if not more, than other spawning sites (Ricci et al., 2017; Boucek et al., 2017). Juvenile Spotted Seatrout are abundant in high salinity SAV in both Pamlico and Core sounds (Purvis, 1976; Wolff, 1976) and juvenile abundances were found to be greater in SAV than soft bottom and oyster reef and were greater than or equivalent to abundances in wetland habitats (Minello, 1999; Minello et al., 2003). Seagrass beds are threatened by physical destruction from bottom disturbing fishing gear, dredging, and damage from boat use, as well as degradation of water quality. Declines in SAV, globally and in North Carolina, due to increased coastal development and decreased water quality, are also altering these ecosystems and their community structure.

Shell Bottom

Shell bottom is defined as estuarine intertidal or subtidal bottom made of surface shell concentrations of living or dead oysters, hard clams, and other shellfish (NCDEQ, 2016). This includes oyster beds and reefs and shell hash (a mixture of sediments and broken shell). Spawning aggregations of Spotted Seatrout have been documented over shell bottom areas in North Carolina including in the Neuse River (Barrios et al., 2006). Shell bottom habitats have been shown to provide an important forage base of invertebrates and small finfish for juvenile and adult Spotted Seatrout (Coen et al. 1999; ASMFC, 2007). Oyster reefs and shell hash areas can be damaged by bottom-disturbing fishing gears, disease, and overfishing.

Wetlands

Wetlands are areas that are inundated or saturated by the accumulation of surface or groundwater, enough to support a prevalence of vegetation typically adapted for life in saturated soil conditions (NCDEQ, 2016). Estuarine wetlands are tidal and are found in bays, sounds, and rivers in brackish waters. Freshwater wetlands include freshwater marshes, bottomland, hardwood forests, and swamp forests in low salinity to freshwater areas of creeks, streams, and rivers. Wetlands are particularly valuable as juvenile Spotted Seatrout appear to use estuarine wetlands, particularly the marsh edge habitat of salt/brackish marshes, as nurseries (Tabb, 1966; ASMFC, 1984; Mercer, 1984; Hettler 1989; Rakocinski et al., 1992; Baltz et al., 1993; Peterson & Turner, 1994). Abundances of juveniles in wetlands were found to be less than or equal to abundances in SAV (Minello, 1999; Minello et al., 2003). Wetlands are threatened by many human activities, including dredging for marinas and channels, filling for development, ditching and draining for agriculture, silviculture, channelization, and shoreline stabilization. Wetland loss and decreasing vegetative buffers can hasten excessive nutrient loading impacts to the surrounding water and other habitat types (NCDWQ, 2000a).

Water Quality Degradation

Good water quality is essential, both for supporting the various life stages of Spotted Seatrout and for maintaining their habitats. Naturally occurring and anthropogenic activities can alter the salinity and temperature conditions or elevate levels of toxins, nutrients, and turbidity, as well as lower dissolved oxygen levels, which can degrade water quality and impact Spotted Seatrout survival. Water quality degradation through stormwater runoff, discharges, toxic chemicals, sedimentation, and changes in turbidity can threaten Spotted Seatrout survival. Salinity particularly affects the eggs of Spotted Seatrout which rely on high spawning salinities to remain positively buoyant allowing for wind and tidally driven distribution throughout the estuary (Churchill et al., 1999; Holt & Holt, 2003); however, sudden salinity reductions cause Spotted Seatrout eggs to sink, thus reducing dispersal and survival (Holt & Holt, 2003).

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 in the NCDWQ guides on the NCDWQ website (NCDWQ, 2000b; NCDWQ, 2008) and in the CHPP (NCDEQ, 2016). More information about the water quality requirements for Spotted Seatrout can be found in the DESCRIPTION OF THE STOCK section of this FMP.

Gear Impacts on Habitat

Bottom disturbing fishing gear can impact ecosystem function through habitat degradation. Static (non-mobile) gears tend to have a lesser impact on habitat compared to mobile gears, as the amount of area affected by static gears tends to be insignificant when compared to that of mobile gears (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 Spotted Seatrout commercial fishery are estuarine gill nets (runaround, strike, or set), long haul seines, beach seines, and ocean gill nets. In the recreational fishery, rod and reel is the primary gear. Other gears that may harvest Spotted Seatrout as incidental catch include pounds nets, crab pots, drift gill nets, and fyke nets. Many gears that interact with Spotted Seatrout are considered static gear (Barnette, 2001; NCDEQ, 2016) and generally have minimal impact on habitat.

Beach seines and runaround gill nets are both mobile and may disturb local habitats. Impacts from mobile bottom-disturbing fishing gears such as seines and runaround gill nets include changes in community composition from the removal of species and physical disruption of the habitat (Barnette, 2001). Gears may damage or uproot SAV as they are dragged across the seafloor, potentially reducing productivity and destroying structures that provide feeding surfaces and shelter for Spotted Seatrout (NCDEQ, 2016). Gears that drag across the seafloor may also suspend sediments, temporarily increasing turbidity (Corbett et al., 2004) and reducing clarity, SAV growth, productivity, and survival (NCDEQ, 2016). Sediment suspended by bottom disturbing fishing gears and boat propeller wash may also bury SAV (Thayer et al., 1984), degrading habitat quality and reducing productivity.

Extreme Weather Events

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 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, soft bottom, and wetlands, that are critical to Spotted Seatrout throughout their life history. Potential increases in extreme weather events could have an inverse effect on the recruitment and survival of Spotted Seatrout in the estuarine system.

Included in extreme weather events are winter storms. Spotted seatrout display a greater sensitivity to sharp drops in water temperatures than many other species. Throughout their range, Spotted Seatrout are periodically exposed to water temperatures below their thermal tolerance (i.e., below temperatures they can tolerate without experiencing stress) because of prolonged cold air temperatures or from snow and ice melt after a winter storm. For more information on how Spotted Seatrout are affected by winter events, please see the Cold Stun Management issue paper in this FMP.

FINAL AMENDMENT ONE MANAGEMENT STRATEGY

****Section will be completed when the MFC selects preferred management and prior to DEQ secretary and legislative committees review****

The purpose of this section is for readers to see exactly how we are managing this fishery and what constitutes a change in management. It should include an overview and statement of policies, as well as any adaptive management. Present the management strategies in a clear, concise, and precise way.

MANAGEMENT CARRIED FORWARD

There are management measures from the original FMP to carry forward into Amendment 1. Management measures from the original Spotted Seatrout FMP that will be carried forward into Amendment 1 are:

- It is unlawful to set gill nets in Joint Fishing Waters from 12:01 A.M. on Saturday to 12:01 A.M. on Monday except in Albemarle and Currituck sounds.
- It is unlawful for a commercial fishing operation to possess or sell Spotted Seatrout taken from Joint Fishing Waters from 11:59 P.M. Friday to 12:01 A.M. Monday except in Albemarle and Currituck sounds.
- It is unlawful to possess more than the recreational bag limit of Spotted Seatrout per person per day taken by hook-and-line.
- It is unlawful to take more than the recreational bag limit of Spotted Seatrout per person per day for recreational purposes.

RESEARCH NEEDS

The research recommendations listed below are offered by the division to improve future management strategies of the Spotted Seatrout fishery. They are considered high priority as they will help to better understand the Spotted Seatrout fishery and meet the goal and objectives of the FMP. A more comprehensive list of research recommendations is provided in the Annual FMP Update and DMF Research Priorities documents.

- Integrate tagging data into stock assessment model so both tagging data and other data sources can work together to give a better picture of the population dynamics including estimates of survival and natural mortality.
- Conduct additional work to evaluate more fully the utility of the Program 120 survey and determine if alternative sampling methodologies or expanded sampling seasonality could provide a more robust index.
- Develop programs to incorporate information on size of recreational releases such as Citizen Science initiatives; Improve estimates of recreational discard mortality.
- Conduct a detailed analysis of the existing data (i.e. Program 915) to determine the extent to which late fall and spring provide insights into overwinter changes in abundance.
- Conduct research to generate accurate fecundity estimates for North Carolina Spotted Seatrout.

APPENDICES

Appendix 1: SMALL-MESH GILL NET CHARACTERIZATION IN THE NORTH CAROLINA SPOTTED SEATROUT FISHERY

ISSUE

The small-mesh gill-net fishery in North Carolina is managed and regulated by species-specific fishery management plans (FMPs), and numerous Marine Fisheries Commission (MFC) rules and Division of Marine Fisheries (DMF) proclamations. However, concerns about biological impacts from the use of small mesh gill nets remain. The primary issues to be addressed concern greater flexibility with constraining harvest in the Spotted Seatrout fishery, reducing bycatch, and to the greatest extent practical reducing conflict between gill-net users and other stakeholders. Specific management options for gill-net regulations can be found in Appendix 2: Sustainable Harvest Issue Paper.

ORIGINATION

The North Carolina Marine Fisheries Commission.

BACKGROUND

At their August 2021 business meeting, the MFC passed a motion to not initiate rulemaking on small-mesh gill nets but refer the issue through the FMP process for each species, and any issues or rules coming out of the species-specific FMP to be addressed at that time. In North Carolina, small-mesh gill nets are the predominant gear used to harvest Spotted Seatrout. Most Spotted Seatrout are harvested commercially using set gill nets or runaround gill nets. Per direction from the MFC, small-mesh gill nets must be addressed during review of the Spotted Seatrout FMP.

North Carolina General Statutes authorize the MFC to adopt rules for the management, protection, preservation, and enhancement of the marine and estuarine resources within its jurisdiction (G.S. 113-134; G.S. 143B-289.52). The MFC has authority to adopt FMPs and the DMF is charged with preparing them (G.S. 113-182.1; G.S. 143B-289.52). Further, the MFC may delegate to the DMF director in its rules the authority to issue proclamations suspending or implementing MFC rules that may be affected by variable conditions (G.S. 113-221.1; G.S. 143B-289.52). Variable conditions include compliance with FMPs, biological impacts, bycatch issues, and user conflict, among others (MFC Rule 15A NCAC 03H .0103). The estuarine gill-net fishery in North Carolina is managed and regulated by FMPs and numerous MFC rules and DMF proclamations. Rules are periodically amended to implement changes in management goals and strategies for various fisheries and are the primary mechanism for implementing FMPs under the Fisheries Reform Act of 1997 (FRA).

In recent years, modifications to gill-net management resulting from the adoption of FMPs or other circumstances have largely been implemented through the DMF director's proclamation authority, not through rulemaking. This is primarily due to the need to implement management changes in a timely fashion and to accommodate variable conditions. Over time, this has resulted in incongruent restrictions between rules and proclamations. Additionally, many of the rules related to small mesh gill nets were first developed prior to the FRA and have not been thoroughly evaluated since the addition of more recent rules developed through the FMP process.

The Spotted Seatrout small-mesh gill-net fishery operates year-round, but the type of gill net used varies by season and area (NCDMF 2018). Multiple species may be landed during a single trip; however, the target species usually dominates the catch (NCDMF 2008). In North Carolina, gill nets are restricted to a minimum mesh size of 2.5 inches stretched mesh [ISM; MFC Rule 15A NCAC 03J .0103(a)]. The DMF categorizes gill nets from 2.5 to less than 5 ISM as small-mesh (Daniel 2013). Although the rule uses "mesh length" and not "mesh size", their meanings are identical for the purpose of this document; this helps to demarcate the discussion of "mesh size" from "net length" throughout the document. Small-mesh gill nets are generally classified into three categories based on how the net is deployed and fished: set gill nets, runaround gill nets, and drift gill nets [Figure 1.1; Table 1.1; (Steve, et al. 2001)]. For the purposes of this document, "set" gill nets, or "set nets", includes anchored, fixed, and stationary gill nets.

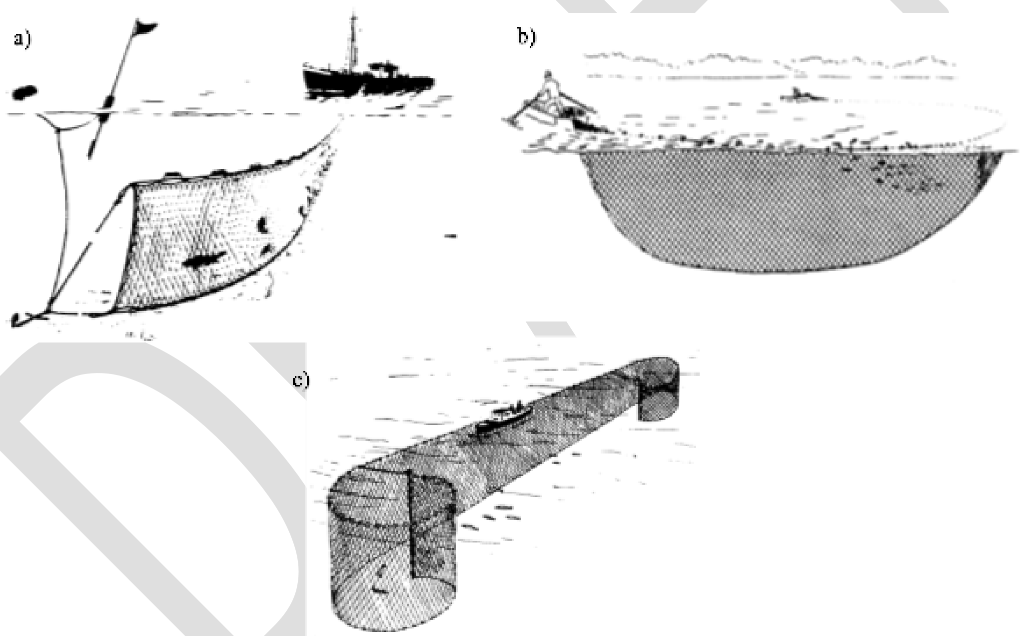


Figure 1. 1 Illustrations of (a) set, (b) runaround, and (c) drift gill nets extracted from Steve et al. (2001).

Set nets (Figure 1.1a) are the second most common gill-net type used for commercial Spotted Seatrout harvest in North Carolina. They are kept stationary with the use of anchors or stakes attached to the bottom or attached to some other structure attached to the bottom, at both ends of the net (MFC Rule 15A NCAC 03I .0101). Set nets can be further classified as sink or float gill nets (Steve et al. 2001). A sink gill-net fishes from the bottom up into the water column a fixed distance by having a lead line (bottom line) heavy enough to sink to the bottom. Depending on the height of the net and the depth of the water, the float line (top line) may or may not be submerged below the surface of the water. A float gill net may fish the entire water column by having the top line with buoys sufficient for floating on the surface of the water, or a portion of the water column depending on the depth of the net (number of meshes deep). Set nets are deployed by dropping one end of the net and running out the rest of the length of net usually in a line. Once deployed, soak times for fishing set nets vary depending on factors such as target species, water temperature, season, waterbody, and regulations (NCDMF 2018).

A runaround gill net is the most common gill-net method used for commercial Spotted Seatrout harvest in North Carolina. It is an actively fished gear used to encircle schools of fish (Figure 1.1b). They are deployed with a weight and a buoy at one end that enables the rest of the net to be fed out, creating a closed circle around the school of fish due to the vessel's path. Runaround gill nets tend to be deep nets capable of fishing the entire water column. Mesh sizes and net lengths vary depending on the target species (Steve et al. 2001). Another form of runaround gill net is the strike net or drop net. Rather than deploying the net in a circle, the net is set parallel to shore, often with one end anchored to the bank. Once the net is set, the boat is driven between the net and the shore to drive fish into the net (NCDMF 2018). Soak times for all types of runaround gill nets are almost always an hour or less.

Table 1. 1 Small-mesh gill net gear categories with descriptions and capture method descriptions.

<table>
<tr><th>Small-Mesh Gill Net Gear Categories</th><th>Sub-Categories</th><th>Gear Description</th><th>Capture Method</th></tr>
<tr><td rowspan="2">Anchored, Fixed, Stationary, Set</td><td>Sink</td><td>Attached to bottom or some other structure by anchors or stakes at both ends. Sink nets are fished from the bottom up into the water column</td><td rowspan="2">Passively Fished - For both sink and float set nets the gear is left in place for a period of time. Fish, if appropriately sized, swim into the net and are gilled.</td></tr>
<tr><td>Float</td><td>Attached to bottom or some other structure by anchors or stakes at both ends. Float nets are fished from the top down into the water column. Depending on target species, nets fish part of the water column or the entire water column.</td></tr>
<tr><td>Runaround</td><td>Circle</td><td>Attached to the bottom at one end. Once the end is set, the rest of the net is then fed out of a boat creating a circle and meeting back at the original set point. Generally, these nets fish the entire water column.</td><td>Actively Fished - Used to encircle a school of fish. Primary target species for this gear is Striped Mullet.</td></tr>
</table>

	Strike, Drop	Attached to the bottom at one end. Deployed along shore with the terminal end finishing at another point along the shore. The boat is driven into the blocked section to "drive" the fish into the net and are then retrieved.	Actively Fished - Used to corral or intercept a school of fish and then immediately retrieved. Primary target species for this gear is Striped Mullet, and Spotted Seatrout to a lesser extent.
Drift		Attached to boat or free-floating with close attendance. Lighter lead lines and no anchors allow the net to drift. Depending on target species and water depth, nets fish part of the water column or the entire water column. Primarily used in Pamlico Sound to target Spanish Mackerel and Bluefish.	Actively Fished - Drift with the water current with continuous attendance.

Drift gill nets are unanchored, non-stationary gill nets that are actively attended (i.e., remain attached to the vessel or the fishing operation remains within 100 yards of the gear; Figure 1.1c) and tend to have shorter soak times than set gill nets. They are constructed with lighter lead lines to allow for the net to drift with the current. The small-mesh drift gill nets currently employed in North Carolina estuaries are primarily used to target Spanish Mackerel and Bluefish in Pamlico Sound. This gear can also be used to target Spot (as a sink net) and Striped Mullet (typically fishing the entire water column) in areas primarily from Core Sound and south (Steve et al. 2001). Drift gill nets typically account for less than 0.5% of annual Spotted Seatrout landings. However, from 2019 through 2022 drift gill nets accounted for 2.5% of Spotted Seatrout landings.

METHODS

Information specific to the North Carolina gill net fishery was gathered from the N.C. Trip Ticket Program and two DMF sampling programs briefly described below:

N.C. Trip Ticket Program

The N.C. Trip Ticket Program began in 1994. This program requires licensed commercial fishermen to sell their catch to licensed fish dealers, who are then required to complete a trip ticket for every transaction. Data collected on trip tickets include gear type, area fished, species harvested, and total weights of each species. Information recorded on trip tickets for gear type and characteristics is self-reported by the dealer. This information may be verified by DMF fish house staff after the fact, but the potential exists that some trips may be mischaracterized by dealers. In 2004, trip tickets included mesh size categories for gill nets: small-mesh < 5-inch ISM and large-mesh ≥ 5-inch ISM. However, the use of this new field was not prevalent until about 2008 because dealers were still using old trip tickets they had on hand.

Commercial Fish House Sampling

Commercial fishing activity is monitored through fishery-dependent (fish house) sampling. Sampling occurs dockside as fish are landed. Commercial fishermen and/or dealers are interviewed by DMF staff, and the catch is sampled. Samplers collect data on location fished, effort (soak time, net length, etc.), gear characteristics (net type, net depth, mesh size, etc.), and the size distribution of landed species.

Commercial Observer Program

On board observations of commercial estuarine gill nets, primarily set gill nets, occur through Program 466. Observers collect data on effort (soak time, net length, etc.), location fished, gear characteristics, size, and the fate (harvest, discard, etc.) of captured species. The Observer Program was born out of the need to estimate incidental takes of protected species such as sea turtles and Atlantic sturgeon in estuarine set gill nets per the Endangered Species Act Section 10 Incidental Take Permits (NMFS 2013, 2014). As a result, observations of runaround or drift gill nets are rare.

The following analysis and information presented are used to characterize the Spotted Seatrout small-mesh gill-net fishery in North Carolina relative to time, area, configuration, and species composition of the harvested and discarded catch. Data from biological years 2012 through 2022 for these three programs were used to characterize the current North Carolina Spotted Seatrout small-mesh gill-net fisheries.

Using trip ticket data, trips where Spotted Seatrout were the species of highest abundance in landings or the most abundant finfish species of those species typically targeted with small-mesh gill nets were considered targeted Spotted Seatrout trips. Basing analysis on trips where Spotted Seatrout are the presumed target species allows for results that describe the gear parameters associated with the directed Spotted Seatrout fishery (see NCDMF 2008 for further description of methodology). Once targeted Spotted Seatrout trips were identified, the method of fishing (set gill net or runaround gill net), mesh size, and net length were characterized based on available fish house sampling data from 2012 through 2022. Analysis of fish house sampling data was limited to samples where only one gear was used on the trip.

Regional analysis of the Spotted Seatrout small-mesh gill-net fishery was investigated by waterbody of landing. Waterbodies were grouped into seven regions using distinct area boundaries or clear differences in fishing practices (Figure 1.2).

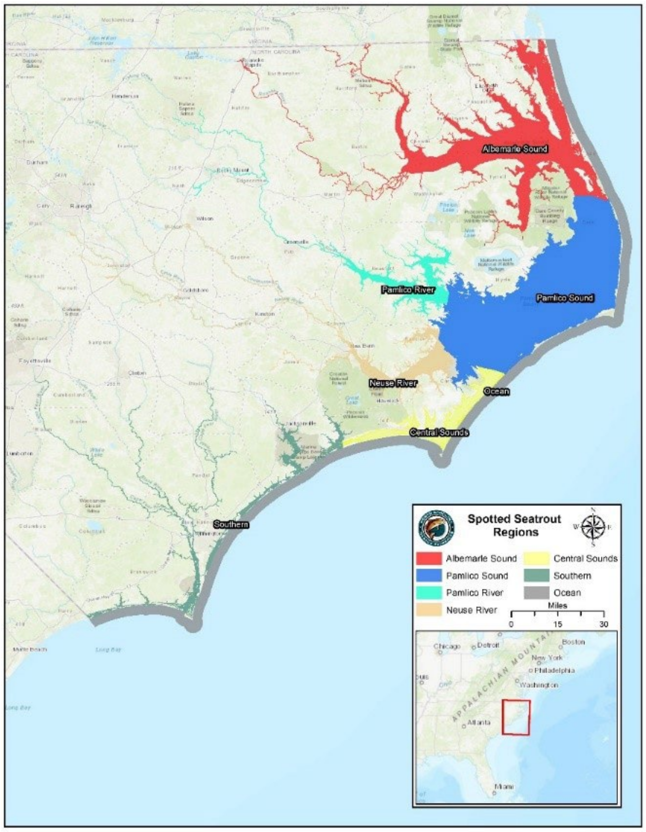


Figure 1. 2. Map of defined regions used for regional characterization of the Spotted Seatrout small-mesh gill-net fishery.

RESULTS

For information regarding characterization of small-mesh gill nets across all fisheries in North Carolina please refer to the [Small Mesh Gill Net Rule Modifications Information Paper] presented to the MFC at its August 2021 business meeting.

Spotted Seatrout Fishery General Characterization

The commercial Spotted Seatrout fishery is currently managed with a 14” minimum size limit and 75-fish daily trip limit (except for the stop net fishery). Since 2012, runaround gill net has been the primary gear used to harvest Spotted Seatrout in the commercial fishery, followed by small-mesh set gill net (Figures 1.3 and 1.4). From April through October, most Spotted Seatrout harvest comes from small-mesh set gill nets. However, from November through March, commercial landings switch to runaround gill nets as Spotted Seatrout aggregate in the fall and winter and are more easily targeted by commercial fishermen (Figure 1.5).

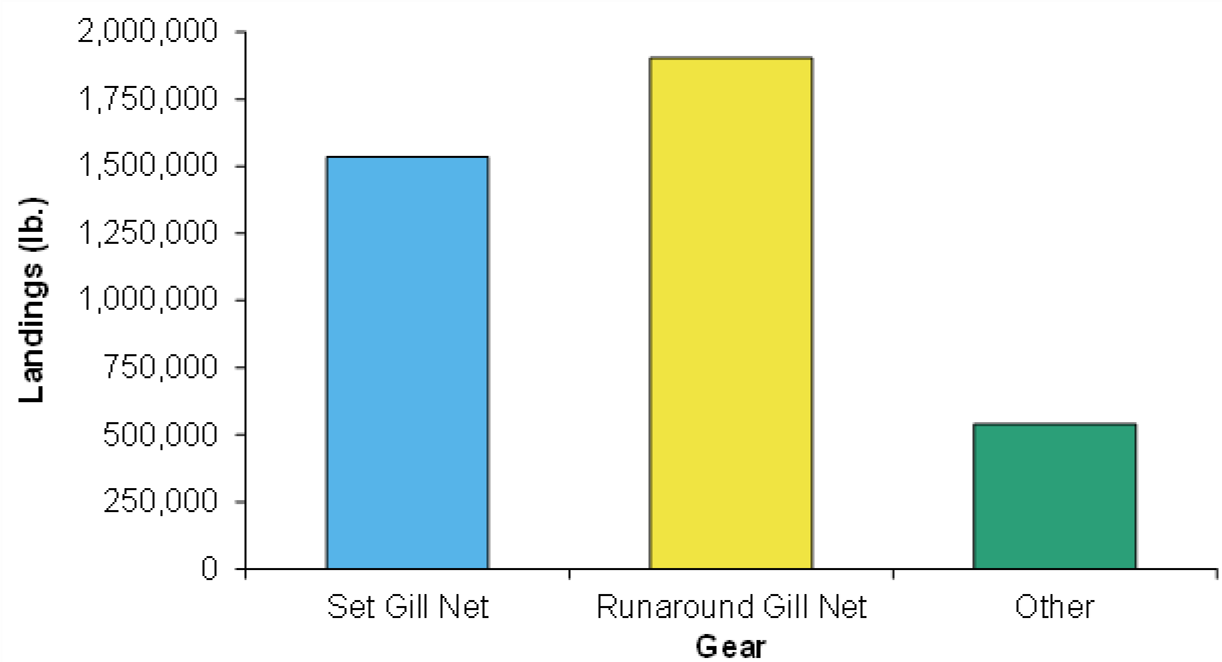


Figure 1. 3. Spotted Seatrout commercial landings by gear reported through the North Carolina Trip Ticket Program, 2012–2022.

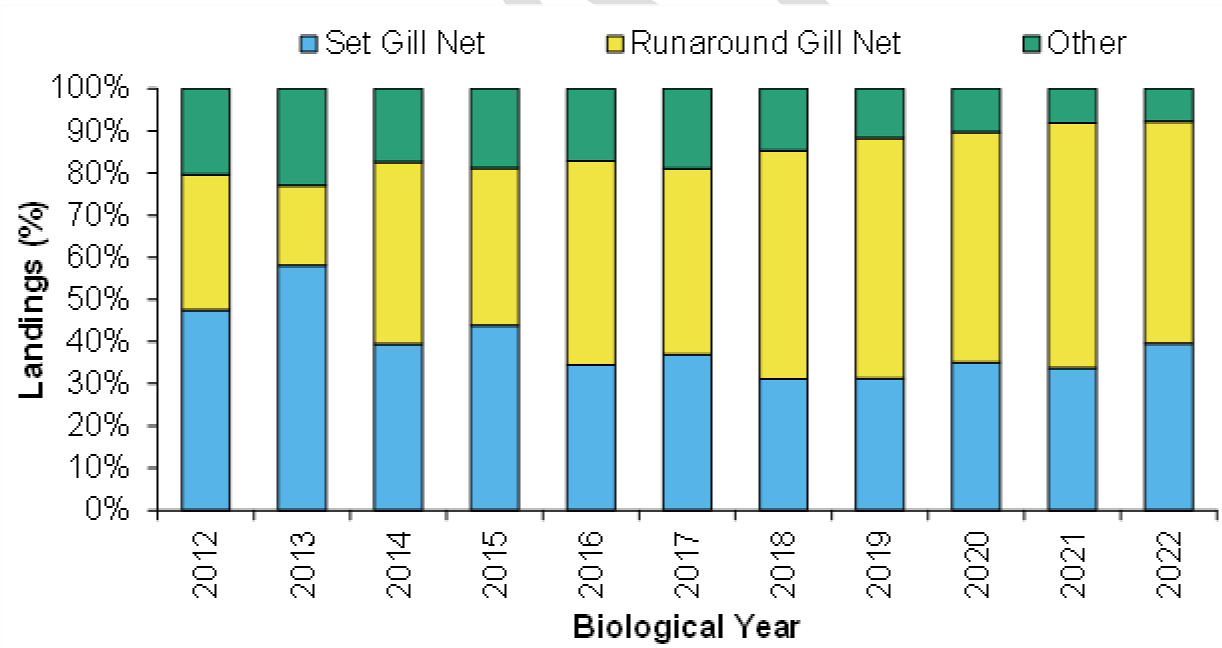


Figure 1. 4. Percent of Spotted Seatrout commercial landings by year and gear reported through the North Carolina Trip Ticket Program, 2012–2022.

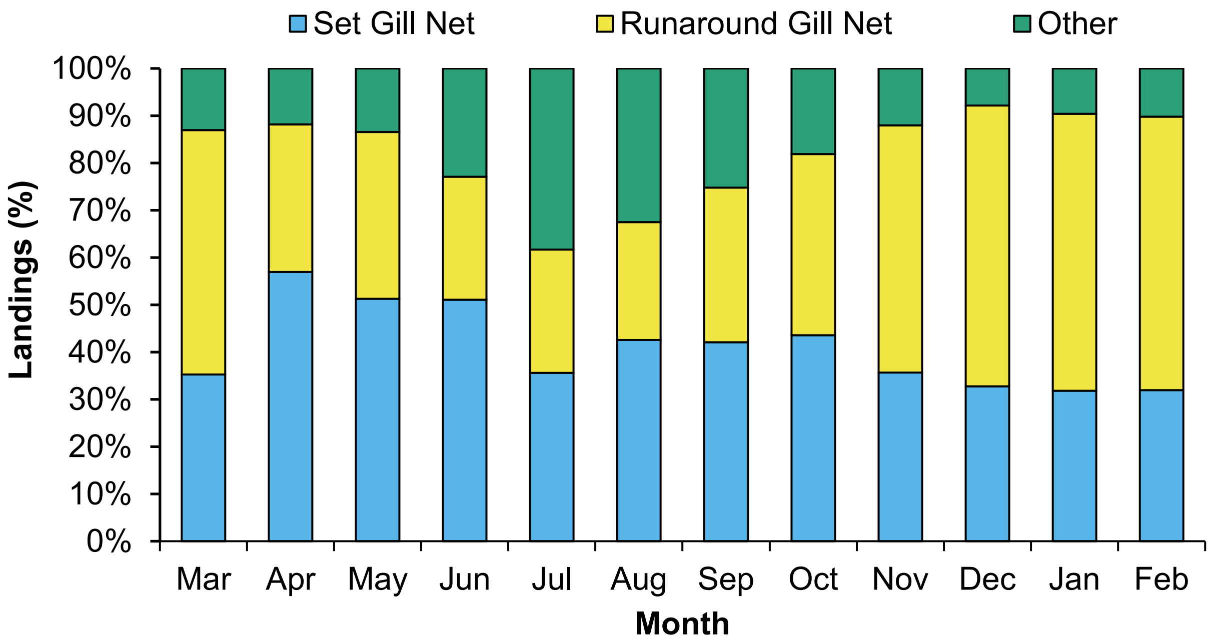


Figure 1. 5. Percent of Spotted Seatrout commercial landings by month and gear reported through the North Carolina Trip Ticket Program, 2012–2022.

Spotted Seatrout are caught in small-mesh gill nets with stretched mesh sizes ranging from 2.5 ISM to 4.88 ISM in North Carolina. Mesh size does not appreciably affect the overall size range of Spotted Seatrout caught in small-mesh gill nets (set and runaround; Figure 1.6). As stretched mesh size increases, the minimum size of Spotted Seatrout harvested increases to some degree but there is a lot of overlap in the size of Spotted Seatrout caught with various mesh sizes. An R^2 value of 0.17 indicates a weak linear relationship between mesh size and the size of Spotted Seatrout harvested. The lack of a strong relationship between mesh size and the size of Spotted Seatrout captured makes it difficult to increase the minimum size limit or implement a slot limit without tight mesh size restrictions to protect or select for specific sizes of Spotted Seatrout. The lack of selectivity is likely due to Spotted Seatrout having a relatively soft body resulting in a wide size range of fish able to become lodged in a particular mesh size. Also, Spotted Seatrout frequently become entangled in gill nets around the mouth area either by their teeth or jaw which results in larger Spotted Seatrout being captured than would typically become caught in the webbing of a gill net.

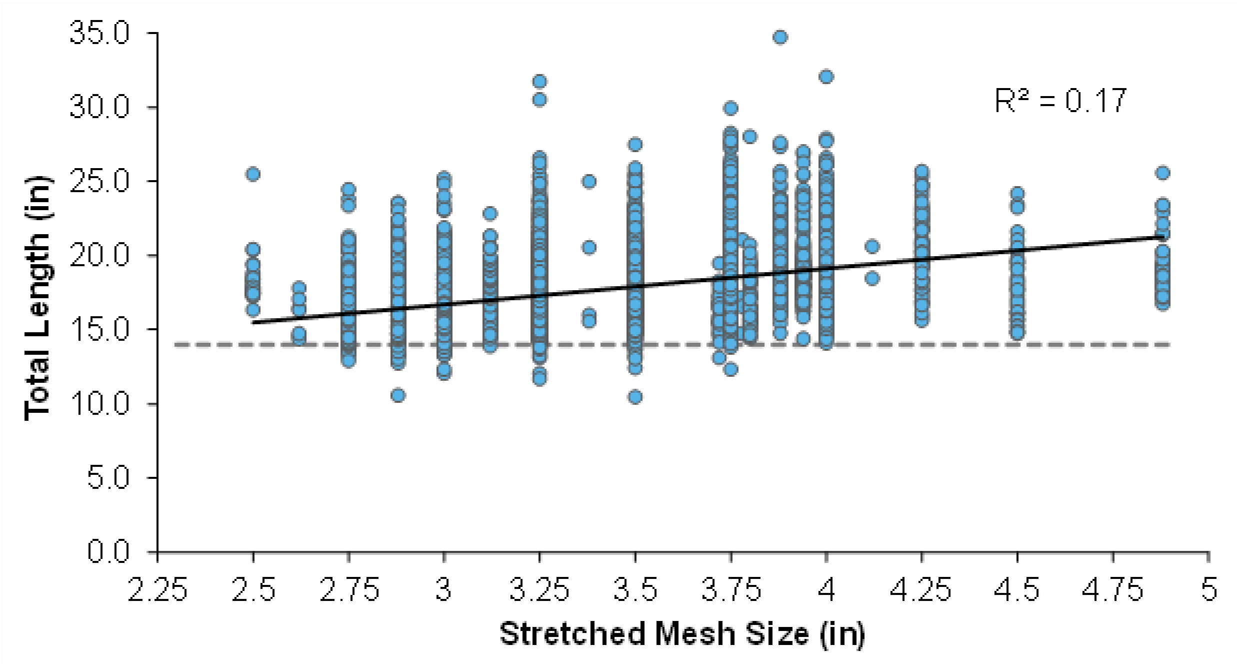


Figure 1. 6. Relationship of stretched mesh size versus total length of Spotted Seatrout sampled from the commercial fish house sampling program (2012-2022). A trendline is provided for reference. The dashed gray line shows the current 14-inch TL minimum size limit.

An example of the impact of increasing the minimum size limit from 14 inches to 15 inches is shown in Figure 1.7. As mesh size increases the percent of Spotted Seatrout under 15 inches (blue bars) that will be discarded decreases. From the Spotted Seatrout measured through division fish house sampling, approximately 22% of fish measured from 3 ISM gill nets are under 15 inches compared to 3% from 3.5 ISM gill nets. In this example, setting the minimum mesh size to harvest Spotted Seatrout at 3.5 ISM will result in a minimal increase in discards of sublegal fish and maximize the realized reduction if the minimum size limit is raised to 15 inches.

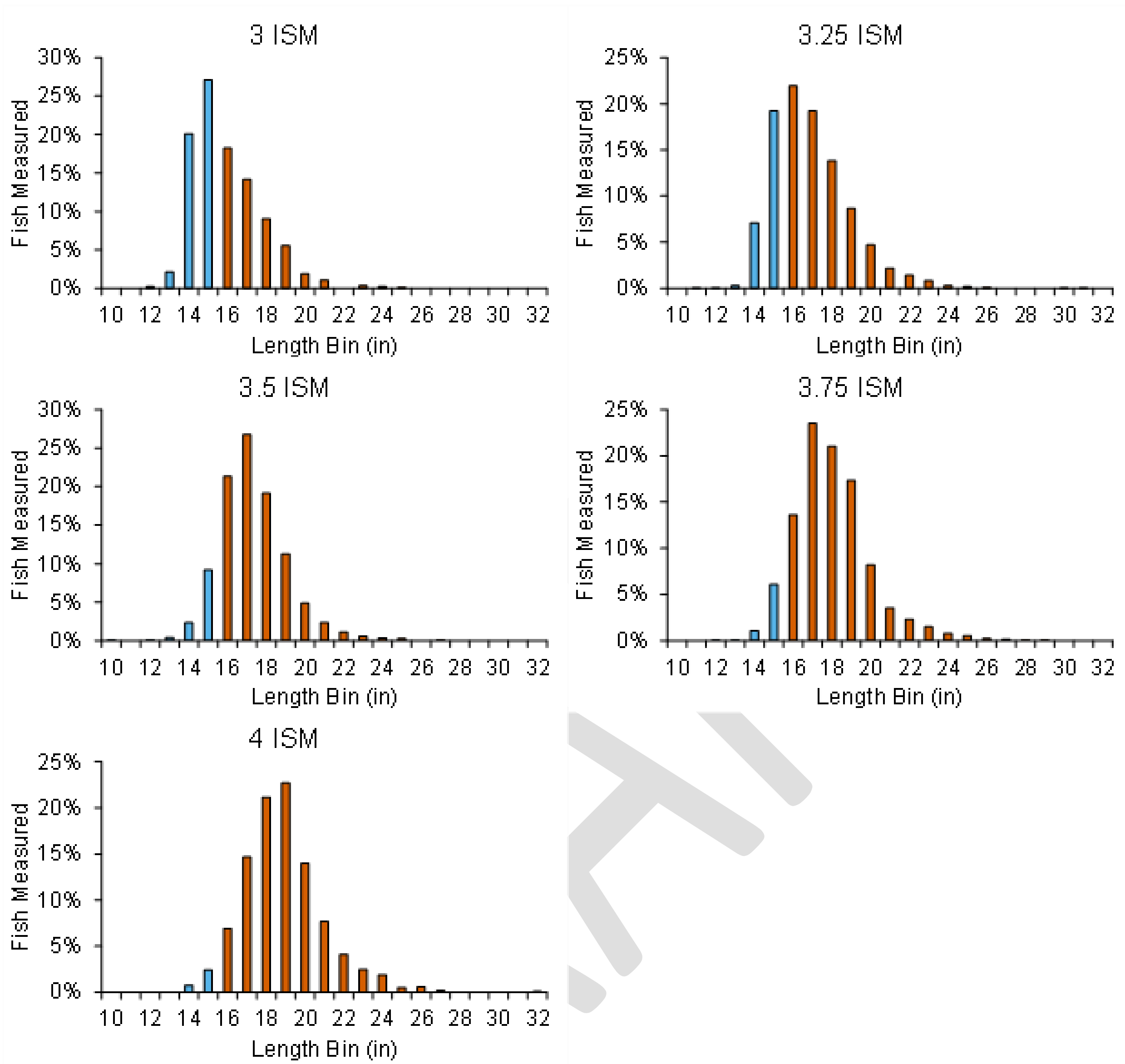


Figure 1. 7. Length distribution of Spotted Seatrout measured from the division's commercial fish house sampling programs by mesh size. Blue bars indicate percent of Spotted Seatrout by size bin below the minimum size limit if it is raised to 15 inches. Orange bars indicate the percent of Spotted Seatrout by size bin above the minimum size limit if it is raised to 15 inches.

When looking at a narrow slot limit, the mesh size restrictions will be more severe. For example, Figure 1.8 shows the impact of a harvest slot limit of 16 inches to 20 inches (fish 20 inches and larger cannot be harvested). The difficulty in implementing mesh size restrictions for a slot limit comes when trying to balance and minimize discards of fish both below slot and above slot size (blue bars). From division fish house sampling, approximately 4% of Spotted Seatrout measured from 3 ISM gill nets are 20 inches or larger but 50% of Spotted Seatrout are below 16 inches. In comparison, approximately 31% of Spotted Seatrout measured from 4 ISM are 20 inches or larger but only 3% are below 16 inches. In this example, limiting the gill net mesh sizes used to harvest Spotted

Seatrout from 3.5 to 3.75 ISM will best minimize discards of below slot and above slot size Spotted Seatrout.

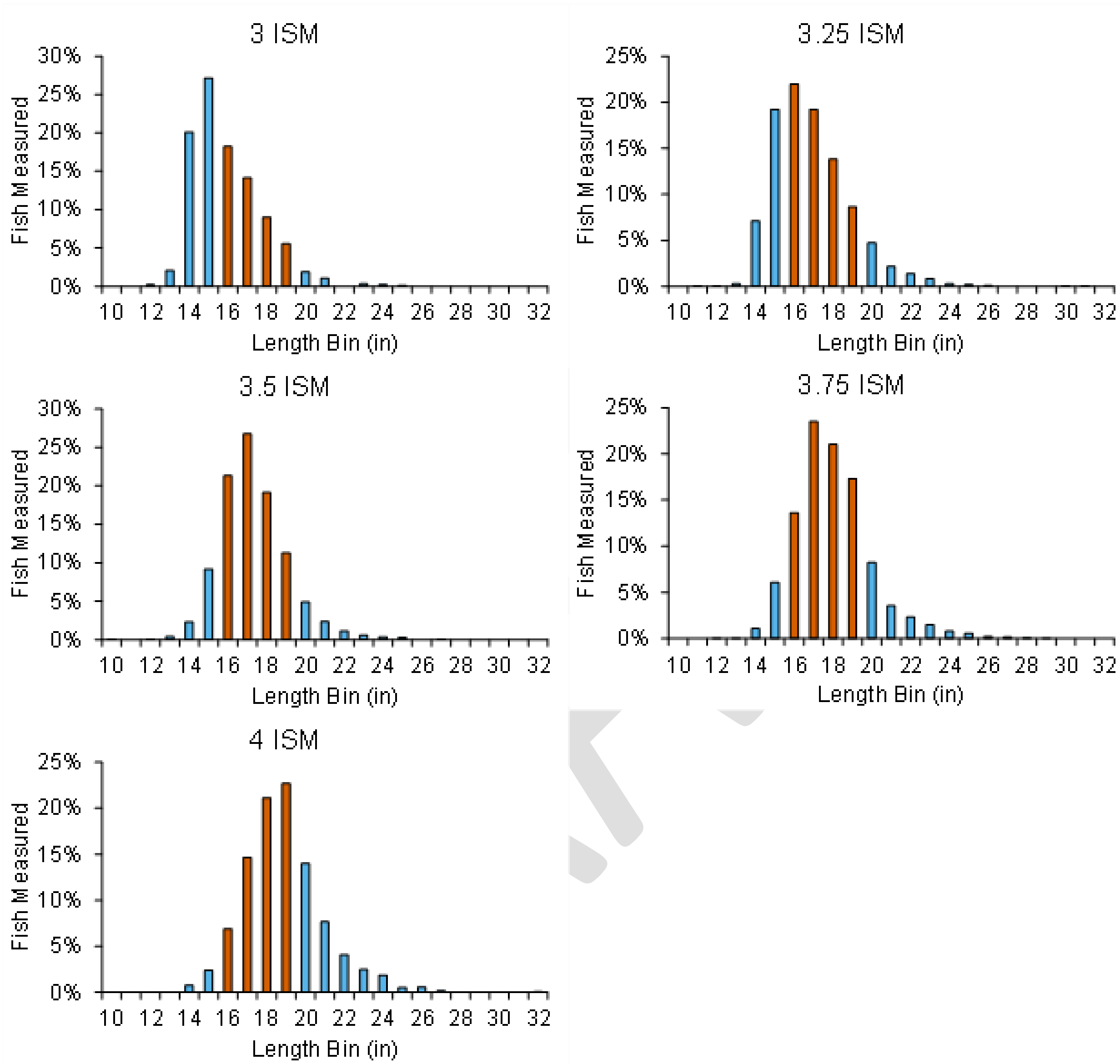


Figure 1. 8. Length distribution of Spotted Seatrout measured from the division's commercial fish house sampling programs by mesh size. Blue bars indicate percent of Spotted Seatrout by size bin below the minimum size limit if it is raised to 16 inches and above the maximum size limit if it is set at 20 inches. Orange bars indicate the percent of Spotted Seatrout by size bin above the minimum size limit if it is raised to 16 inches and below the maximum size limit if it is set at 20 inches (i.e., 16-20 slot limit).

Most Spotted Seatrout harvest occurs in Pamlico Sound (28%) and the Neuse and Bay rivers (24%; Figure 1.9). These areas are followed by the Central Sounds (13%), Southern (13%), Albemarle Sound (11%), and Pamlico and Pungo rivers (9%). Runaround gill net is the primary gear used to harvest Spotted Seatrout in the Neuse and

Bay rivers and Central Sounds regions. Small-mesh set gill net is the dominant gear in the other regions. (Figure 1.10). The increase in commercial landings beginning in 2019 is largely driven by an expansion of the Spotted Seatrout fishery in the Pamlico Sound, Neuse and Bay rivers, and Pamlico and Pungo rivers regions.

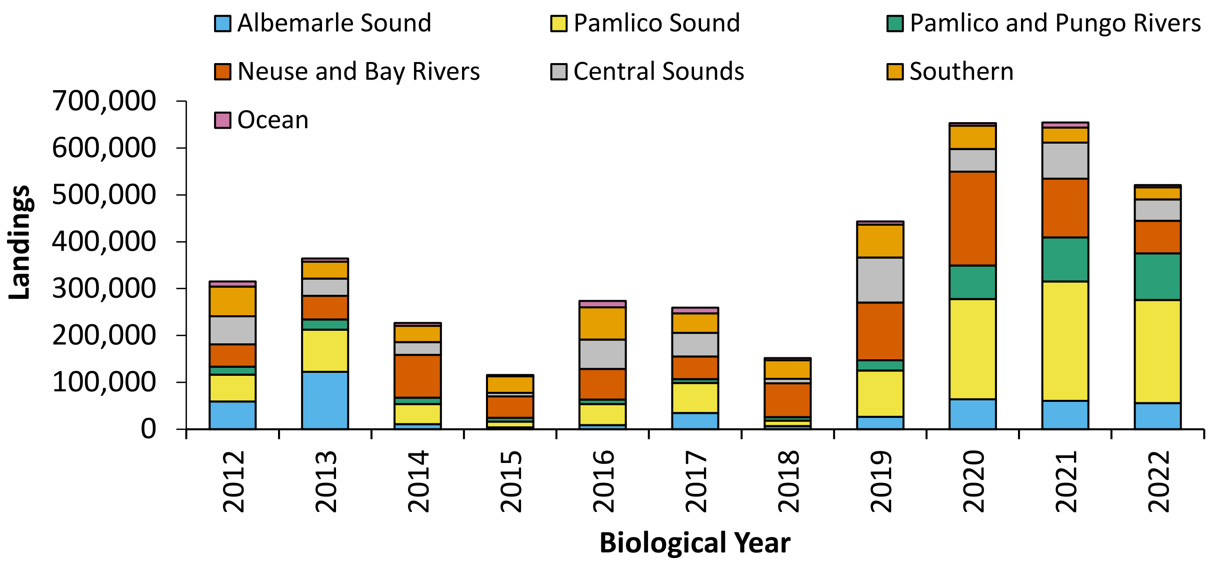


Figure 1. 9. Annual commercial landings of Spotted Seatrout commercial landings by region reported through the North Carolina Trip Ticket Program, 2012–2022.

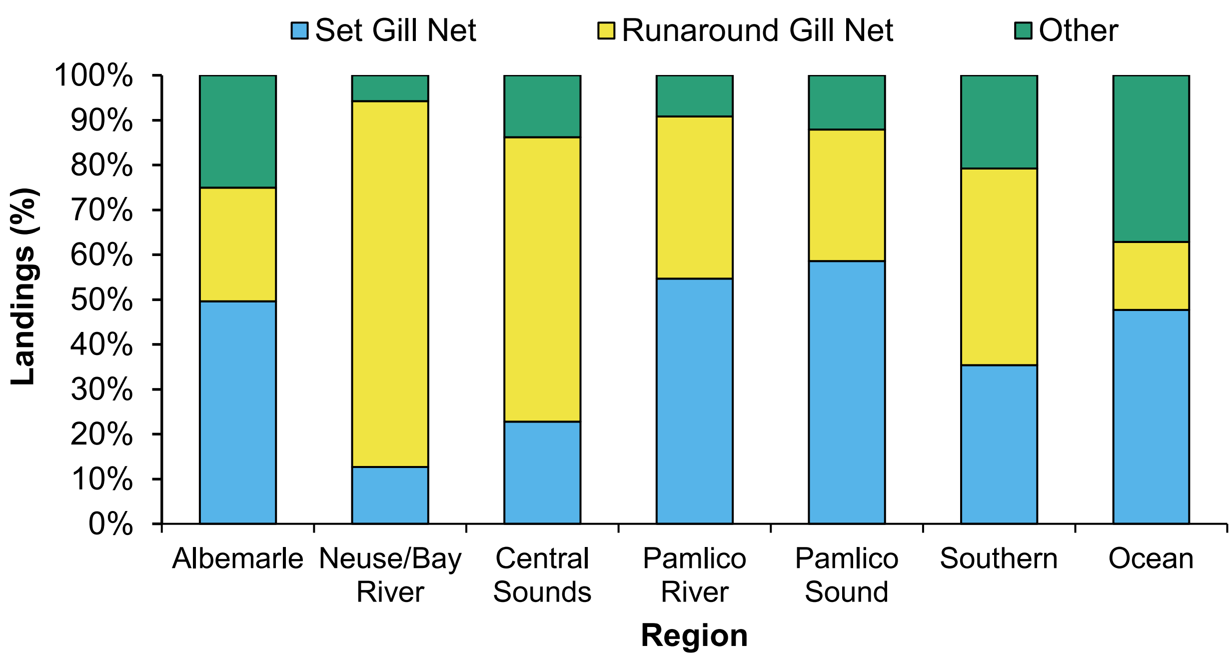


Figure 1. 10. Percent of total Spotted Seatrout commercial landings by gear for each area reported through the North Carolina Trip Ticket Program, 2012–2022.

Due to the low contribution of ocean waters to the Spotted Seatrout small-mesh gill-net fishery (Figure 1.9) it is excluded from the analysis in the following gear-specific sections.

Set Gill Nets

Spotted Seatrout targeted small-mesh set gill-net trips were defined as trips where Spotted Seatrout were the species of highest abundance or the most abundant finfish species. Small-mesh set gill nets are the second most common gear used to capture Spotted Seatrout (Figures 1.3 - 1.4) in North Carolina and are the dominant gear in the Albemarle Sound, Pamlico River, Pamlico Sound, and Ocean regions (Figure 1.10). Spotted Seatrout are the third most important species targeted in the North Carolina small-mesh set gill-net fishery behind Bluefish and Spanish Mackerel (Figure 1.11). They make up the largest proportion of monthly small-mesh set gill-net trips in November, December, and January.

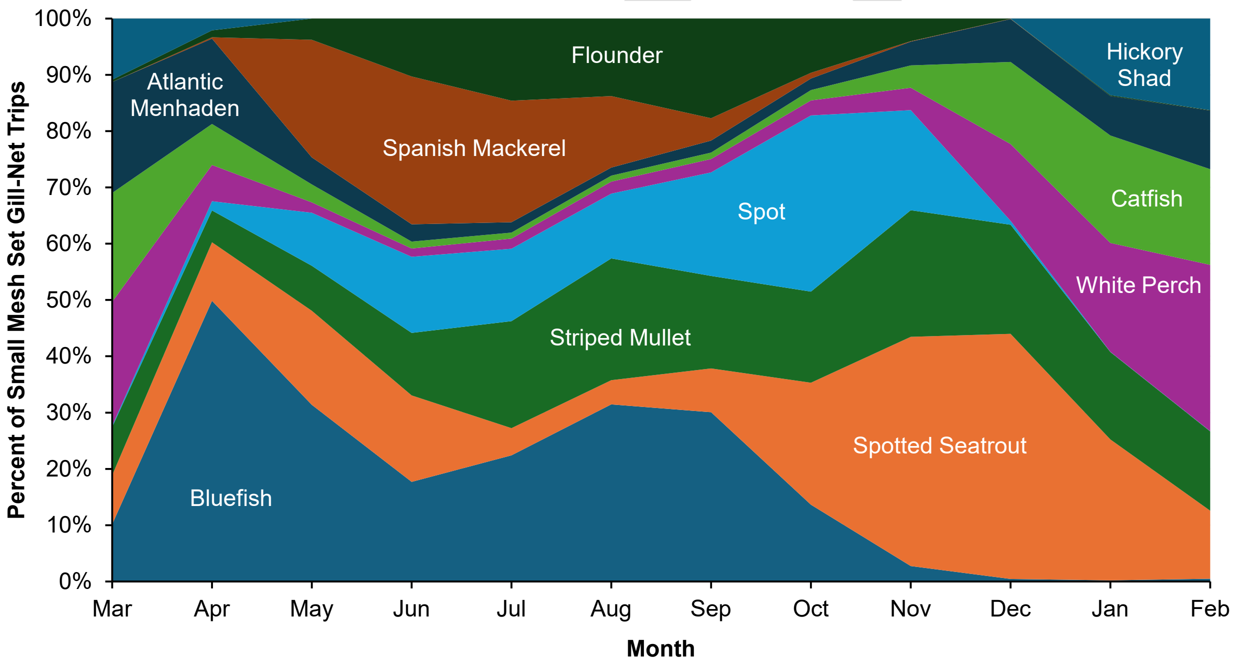


Figure 1. 11. Percentage of total set gill-net trips for each of the 10 primary target species across months in N.C. waters, 2012-2022.

Spotted Seatrout are primarily landed incidentally in the set gill-net fishery during most of the year, however they are targeted more in the fall and winter months as Spotted Seatrout aggregate in smaller waterbodies. From 2012 through 2018, the use of set gill nets to target Spotted Seatrout declined through 2018. Beginning in 2019, the number of trips increased and has remained higher, although the number of participants has remained steady since 2015 (Figure 1.12). This increase in trips matches well with the increase in landings in the Spotted Seatrout fishery over the same period.

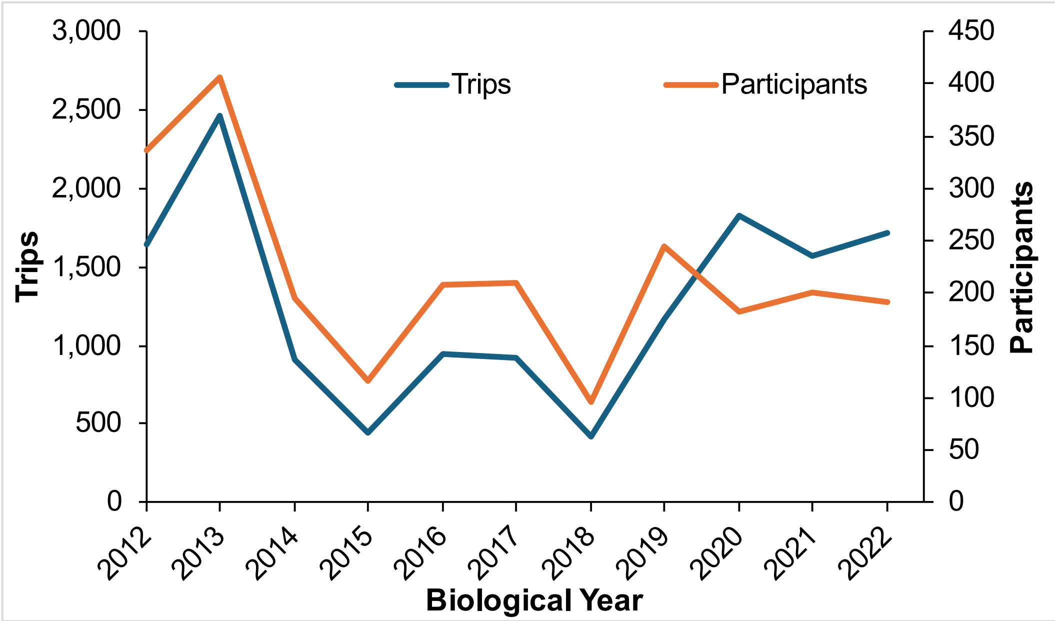


Figure 1. 12 Targeted trips and participants in the set small-mesh gill-net Spotted Seatrout fishery by year reported through the North Carolina Trip Ticket Program, 2012-2022.

Approximately 50% of targeted Spotted Seatrout small-mesh set gill-net trips land 30 or less Spotted Seatrout (Figure 1.13). However, roughly 24% of trips land more than 60 Spotted Seatrout and about 16% of trips land 71-75 Spotted Seatrout per trip. Most of these trips, roughly 70%, occur from October through January (Figure 1.14). Although approximately 20% of the trips occurring each month from November through March land 71-75 Spotted Seatrout per trip (Figure 1.13). Trips landing 71-75 Spotted Seatrout per trip account for approximately 35% of small-mesh set gill-net landings from targeted Spotted Seatrout trips (Figure 1.16).

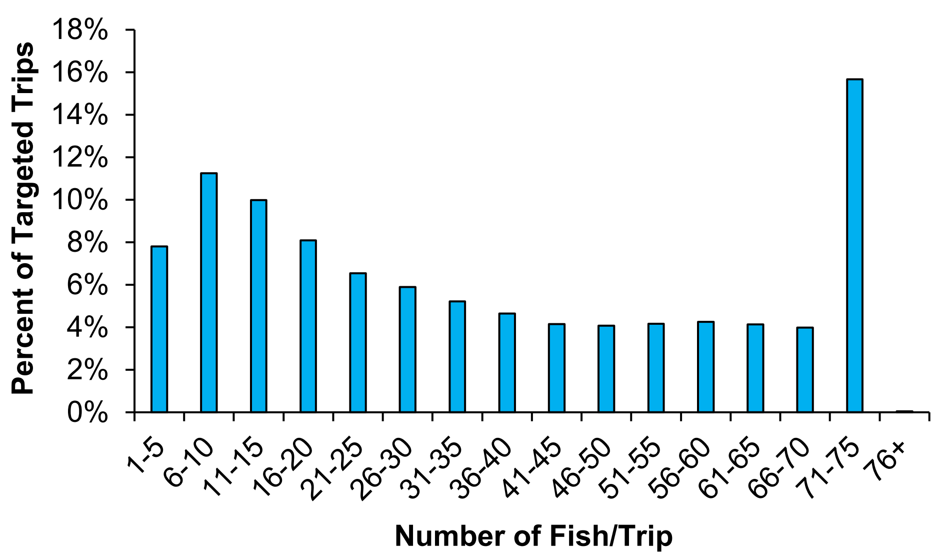


Figure 1. 13. Percent of targeted Spotted Seatrout trips grouped by number of fish landed per trip in the small-mesh set gill-net fishery reported through the North Carolina Trip Ticket Program, 2012–2022.

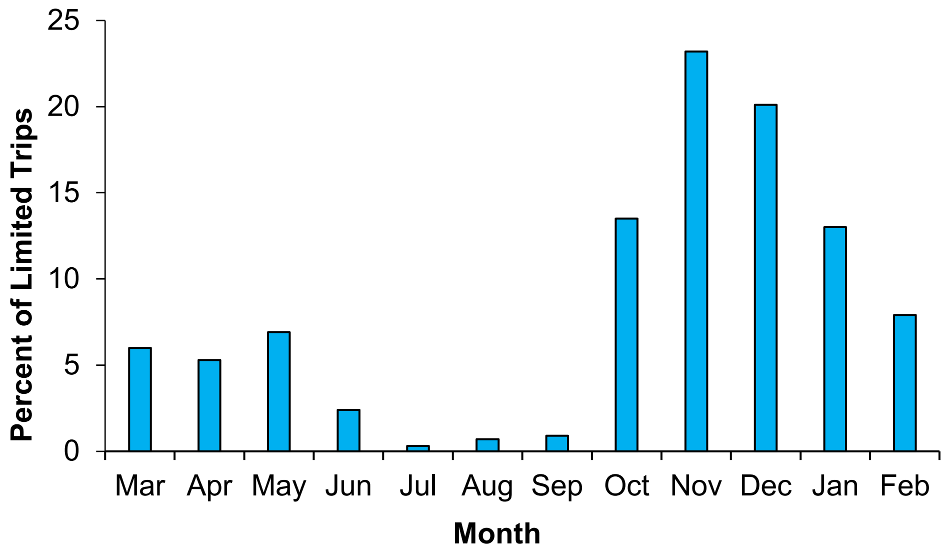


Figure 1. 14. Monthly distribution of total trips reaching the trip limit (71-75 fish estimated to be landed) for targeted Spotted Seatrout trips in the small mesh set gill net fishery reported through the North Carolina Trip Ticket Program, 2012–2022. For example, if there are 100 trips in a year that reached the trip limit and 10 of those trips occurred in March, then the percent of annual trip limit trips in March will be 10%.

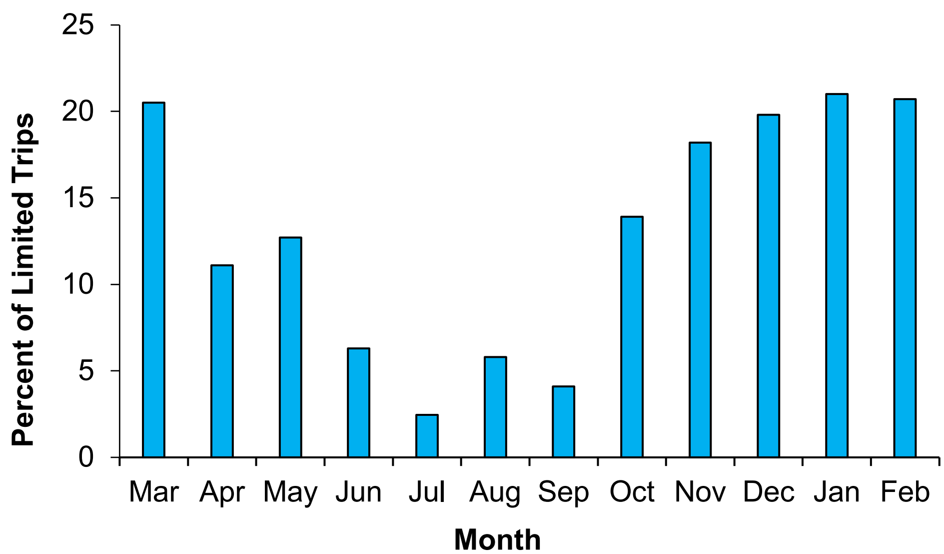


Figure 1. 15. Percent of monthly trips reaching the trip limit (71-75 fish estimated to be landed) for targeted Spotted Seatrout trips in the small mesh set gill net fishery reported through the North Carolina Trip Ticket Program, 2012–2022. For example, if there are 100 trips in March and 10 of those trips reached the trip limit, then the percent of trip limit trips in March will be 10%.

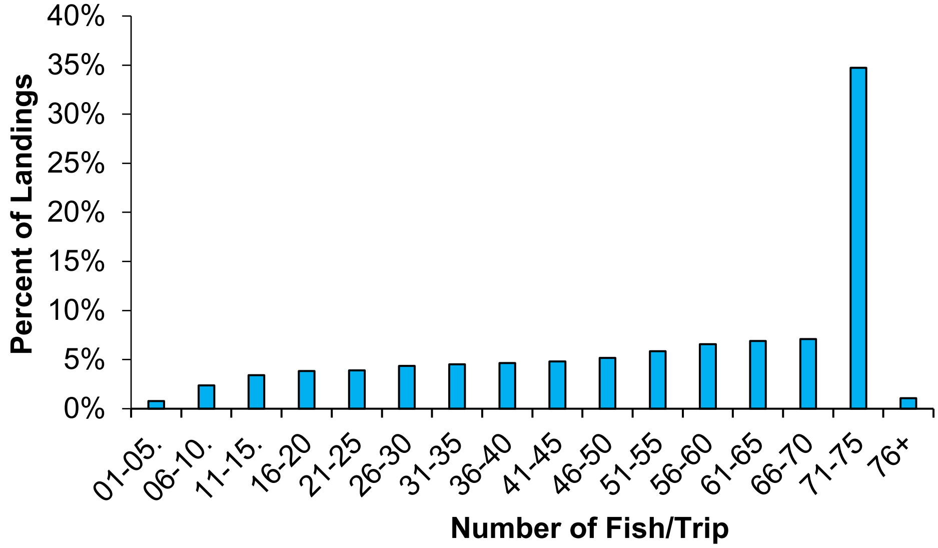


Figure 1. 16. Percent of total pounds landed grouped by number of fish landed per targeted Spotted Seatrout trip in the small mesh set gill net fishery reported through the North Carolina Trip Ticket Program, 2012–2022.

The modal mesh size used to catch Spotted Seatrout in the set gill net fishery was 3.0 ISM (Table 1.2). Average total net length was 691 yards, with a maximum of 3,000 yards. Approximately 42% of all set gill net trips fished 500 yards or less of gill net (Figure 1.17). For reference, small mesh gill nets are currently restricted to a maximum of 800 yards. Reducing the yardage fished could be a means to reduce harvest in this fishery. Yardage restrictions would be best used in conjunction with trip limits to ensure minimal discards. For more information on possible management applications of set gill net yardage restrictions, see Appendix 2.

Table 1. 2. Small mesh (<5 inch ISM) set gill net trips in North Carolina using data from the N.C. Trip Ticket Program with associated gear characteristics from commercial fish house sampling, 2012-2022.

Species	Trips	Avg/Yr.	Modal Mesh	Avg Yds	Max Yds
Spotted seatrout	14,224	1,293	3.0	696	3,000

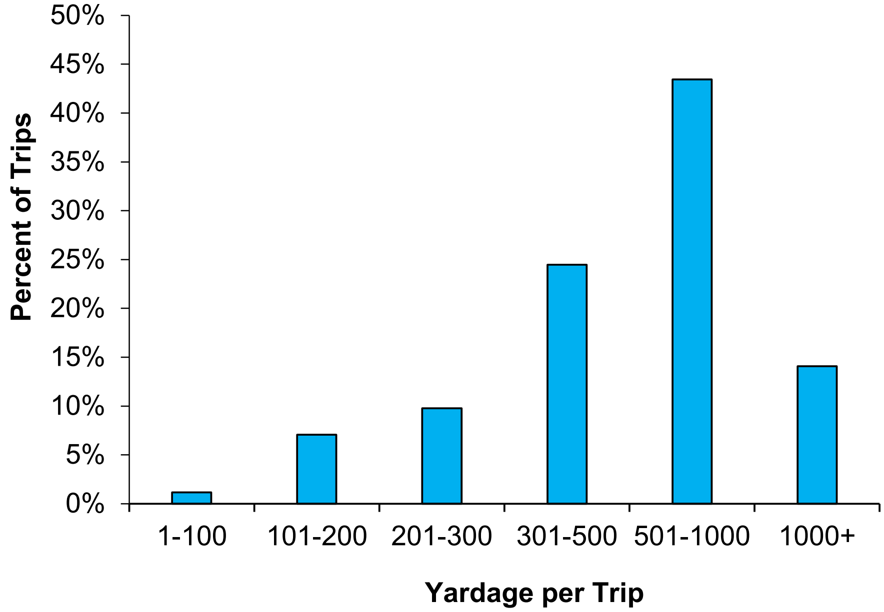


Figure 1. 17. Percent of total trips sampled grouped by yards fished per trip in the Spotted Seatrout small mesh set gill net fishery using data from the commercial fish house sampling program, 2012–2022.

When targeting Spotted Seatrout with small-mesh set gill nets, it is common to catch other species incidentally. The most common species landed incidentally when targeting Spotted Seatrout with set gill nets are Striped Mullet, Bluefish, Red Drum, White Perch, Black Drum, and Spot (Figure 1.18). Conversely, Spotted Seatrout are most commonly caught incidentally when set gill net fishermen are targeting Bluefish, Striped Mullet, and Spot (NC trip ticket data). This overlap between the Spotted Seatrout and Bluefish, Striped Mullet, and Spot set gill net fisheries could have management implications for these fisheries if gear restrictions are put in place to restrict Spotted Seatrout harvest.

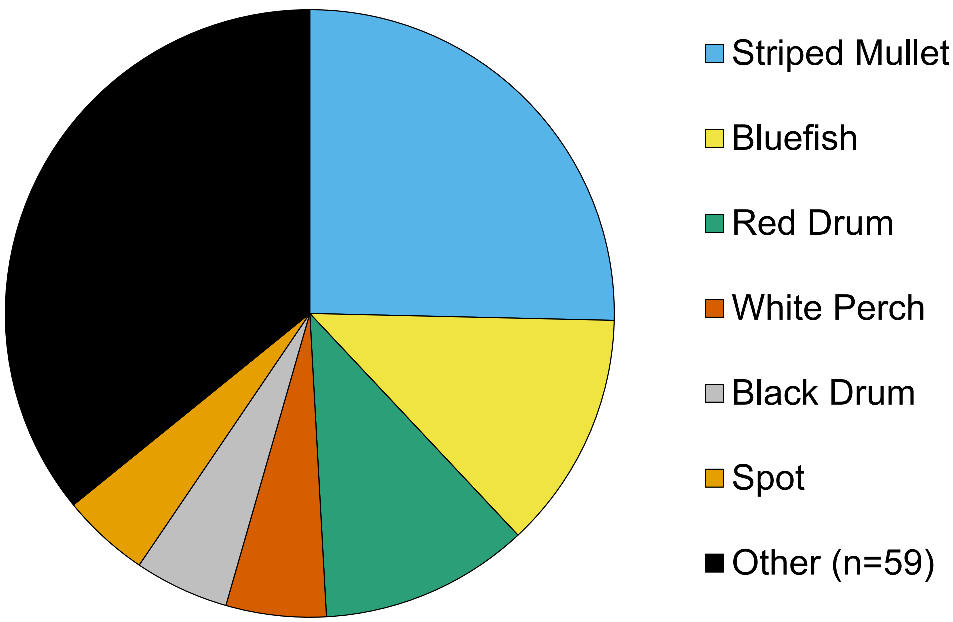


Figure 1. 18. Proportion of incidental catch landed by species in the set small-mesh set gill-net Spotted Seatrout fishery reported through the North Carolina Trip Ticket Program, 2012–2022.

Spotted seatrout discards in the set gill-net fishery are difficult to characterize due to limited data but appear to be minimal based on observations from the commercial observer program. Of the over 3,400 Spotted Seatrout observed in set small-mesh gill nets (2012-2022), 392 fish were discarded. A discard rate of 11.3%. The low rate of Spotted Seatrout discards in the set small-mesh fishery is likely due to there being an adequate trip limit for commercial harvest. Increased restrictions on Spotted Seatrout harvest could increase discards in this fishery. For more information on Spotted Seatrout bycatch in the set gill-net fishery, please refer to the Spotted Seatrout Bycatch section of the FMP.

Discards of other species from Spotted Seatrout targeted small mesh set gill net trips could not be characterized due to limited data. Of the 1,044 observed small mesh set gill net trips observed from the observer program (2012-2022), only 114 Spotted Seatrout targeted trips have been observed. In those trips, 18 managed species were discarded, including Atlantic Menhaden, Red Drum, Black Drum, Blue Crab, and Southern Flounder.

Runaround Gill Nets

Spotted Seatrout targeted runaround gill-net trips were defined as trips where Spotted Seatrout were the species of highest abundance in landings or were the most abundant finfish species. Runaround gill nets are the predominant gear used to catch Spotted Seatrout in North Carolina (Figures 1.3 and 1.4) and the dominant gear in the Neuse and Bay rivers, Central Sounds, and Southern regions (Figure 1.10). The runaround gill-net fishery is more targeted than the set gill-net fishery and is the main gear used to catch Spotted Seatrout when they form aggregations in smaller waterbodies from November through March (Figure 1.5). During this time, catches from runaround gill nets can be higher as fishermen target Spotted Seatrout after the fall Striped Mullet season. Spotted seatrout is the second most targeted species in the North Carolina runaround gill-net fishery (Figure 1.19). Spotted seatrout targeted trips make up the largest proportion of runaround gill-net trips from December through March.

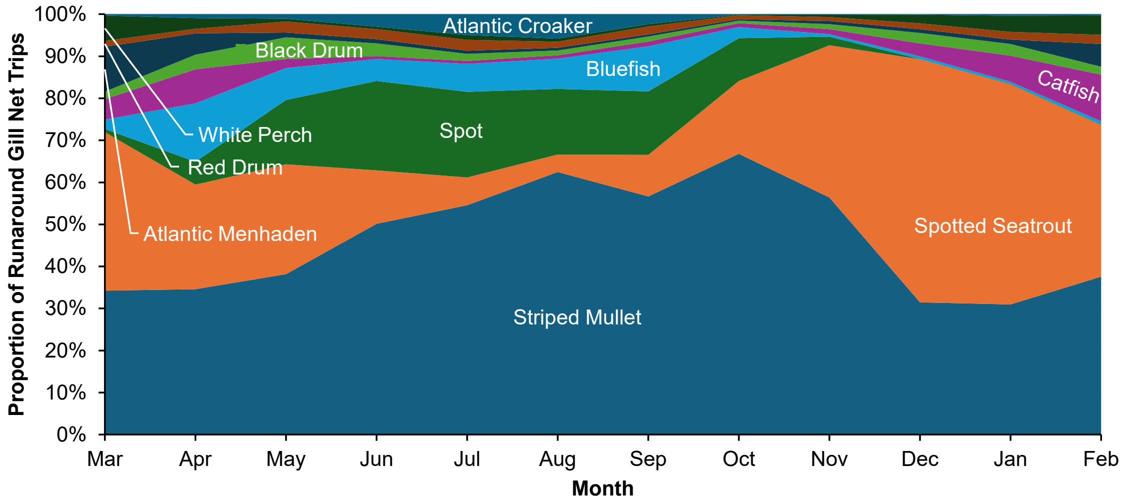


Figure 1. 19. Percent of total runaround gill-net trips for each of the 10 primary target species across months in N.C. waters during 2012-2022.

From 2012 through 2018, effort and participation in this fishery remained relatively consistent, then increased sharply in 2019 and has remained high through 2022 (Figure 1.20). The increase in targeted Spotted Seatrout trips could be due to fishermen shifting to the fishery from other more restricted fisheries.

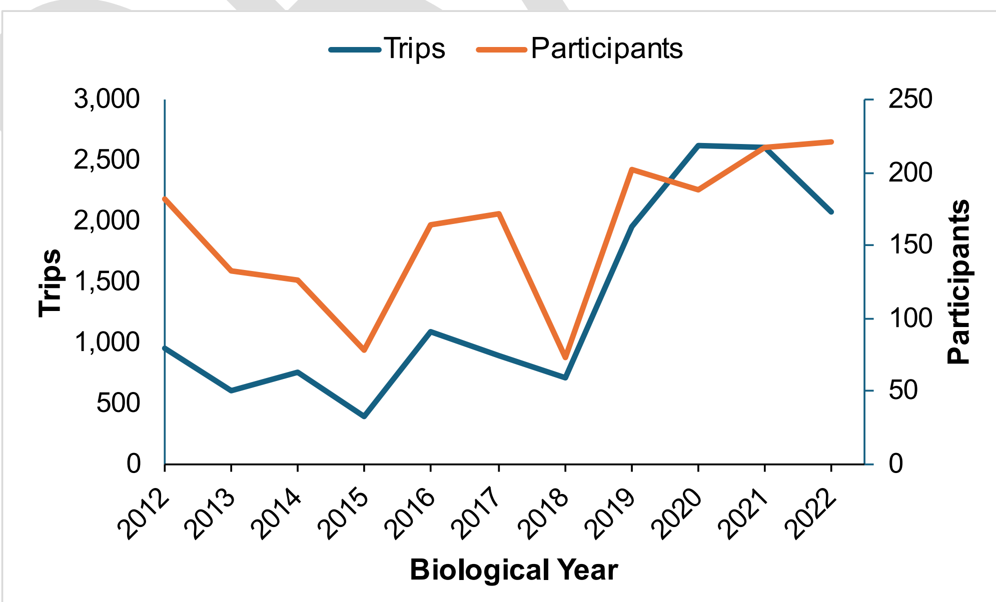


Figure 1. 20. Targeted trips and participants in the runaround gill-net Spotted Seatrout fishery by year reported through the North Carolina Trip Ticket Program, 2012–2022.

Runaround gill nets tend to land more Spotted Seatrout per trip than set gill nets, with roughly 33% of trips landing 30 or less Spotted Seatrout. Approximately 38% of targeted Spotted Seatrout runaround gill-net trips land more than 60 Spotted Seatrout with 27% of targeted trips landing 71-75 Spotted Seatrout (Figure 1.21). This is likely due to runaround gill nets being able to better target Spotted Seatrout aggregation areas in the fall and winter months. Most of these trips, roughly 73%, occur from October through January (Figure 1.22). Although, approximately 30% of the trips occurring each month from November through March land 71-75 Spotted Seatrout per trip (Figure 1.23). Trips landing 71-75 Spotted Seatrout per trip account for approximately 47% of runaround gill-net landings from targeted Spotted Seatrout trips (Figure 1.24).

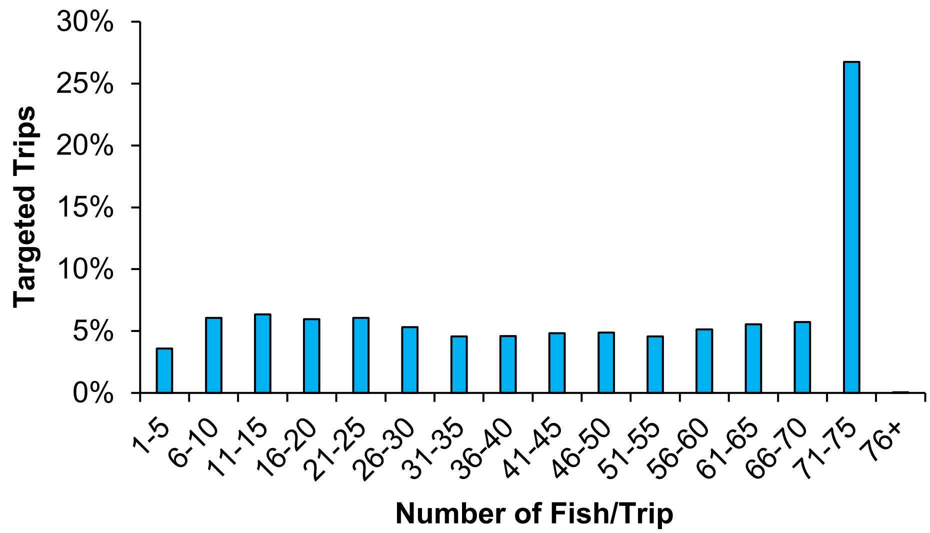
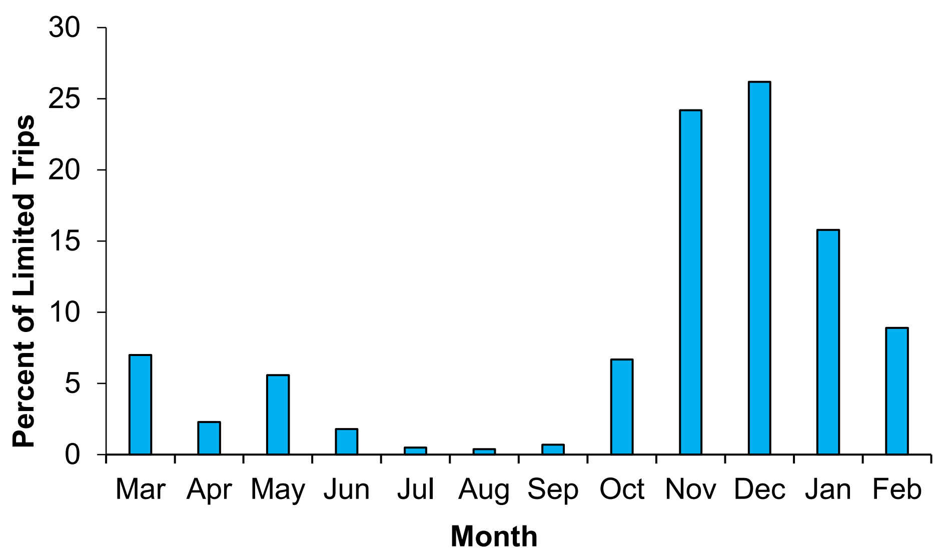


Figure 1. 21. Percent of targeted Spotted Seatrout trips grouped by number of fish landed per trip in the runaround gill-net fishery reported through the North Carolina Trip Ticket Program, 2012–2022.



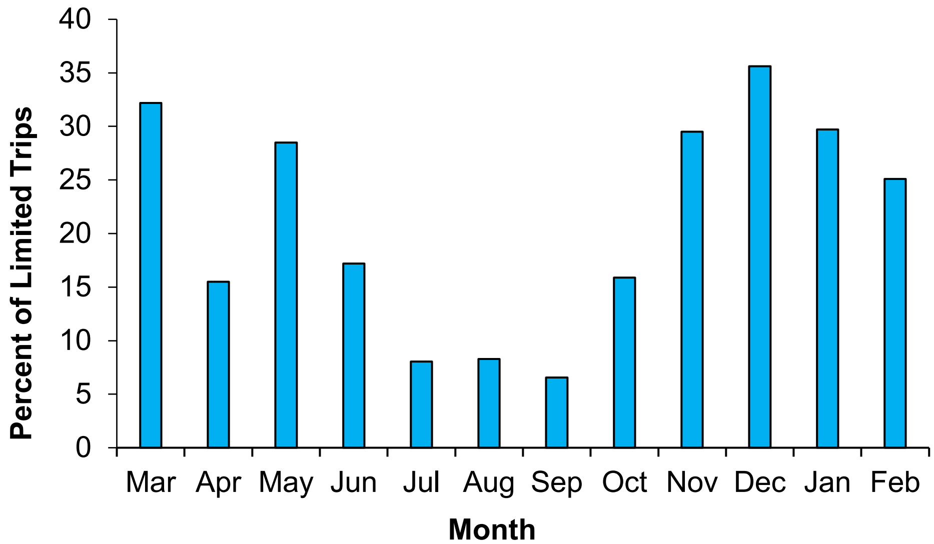


Figure 1. 22. Monthly distribution of total trips reaching the trip limit (71-75 fish estimated to be landed) for targeted Spotted Seatrout trips in the runaround gill-net fishery reported through the North Carolina Trip Ticket Program, 2012–2022. For example, if there are 100 trips in a year that reached the trip limit and 10 of those trips occurred in March, then the percentage of annual trip limit trips in March will be 10%.

Figure 1. 23. Percent of monthly trips reaching the trip limit (71-75 fish estimated to be landed) for targeted Spotted Seatrout trips in the runaround gill-net fishery reported through the North Carolina Trip Ticket Program, 2012–2022. For example, if there are 100 total trips in March and 10 of those trips reached the trip limit, then the percentage of trip limit trips in March will be 10%.

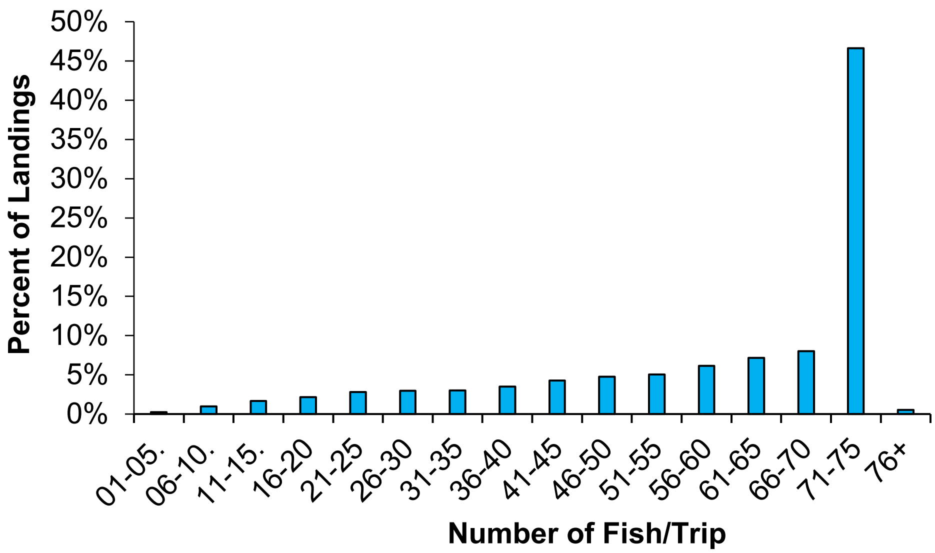


Figure 1. 24. Percent of total pounds landed grouped by number of fish landed per targeted Spotted Seatrout trip in the runaround gill-net fishery reported through the North Carolina Trip Ticket Program, 2012–2022.

Runaround gill nets have a higher modal mesh size (3.75 ISM) than set small-mesh gill nets (3.0 ISM; Table 1.3). The average net length is 430 yards with a maximum of 3,000 yards, with 72% of trips fishing 500 yards (Figure 1.25). Runaround gill nets tend to be shorter than set gill nets because runaround gill nets are actively fished to encircle schools of fish. This allows for less yardage needed to catch the fish than the passively fished set gill nets. Since the runaround gill nets are already significantly shorter, and can be fished several times consecutively, maximum yardage restrictions may not be effective in restricting harvest in this fishery. For more information on possible management applications of runaround gill net yardage restrictions, see Appendix 2.

Table 1. 3. Small-mesh (<5 inch ISM) runaround gill-net trips in North Carolina using data from the N.C. Trip Ticket Program with associated gear characteristics from fish house sampling, 2012-2022.

Species	Trips	Avg/Yr.	Modal Mesh	Avg Yds	Max Yds
Spotted seatrout	14,749	1,340	3.75	430	3,000

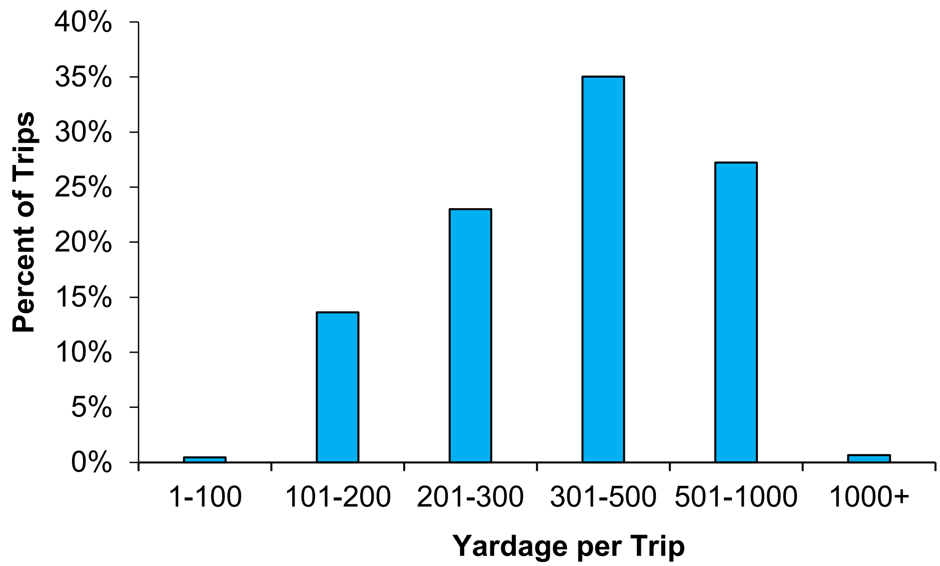


Figure 1. 25. Percent of total trips sampled grouped by yards fished per trip in the Spotted Seatrout runaround gill net fishery using data from the commercial fish house sampling program, 2012–2022.

When targeting Spotted Seatrout with runaround gill nets, it is common to catch other species incidentally. The most common species landed incidentally when targeting Spotted Seatrout with runaround gill nets are Striped Mullet, Red Drum, Black Drum, Bluefish, White Perch, and Spot (Figure 1.26). Conversely, Spotted Seatrout are most commonly caught incidentally when runaround gill-net fishermen are targeting Striped Mullet, Spot, and Bluefish (NC trip ticket data). This overlap between the Spotted Seatrout and Striped Mullet, Spot, and Bluefish runaround gill-net fisheries could have management implications for these fisheries if gear restrictions are put in place to restrict Spotted Seatrout harvest.

No data is available to characterize discards in this fishery because the observer program does not prioritize observing runaround gill-net trips.

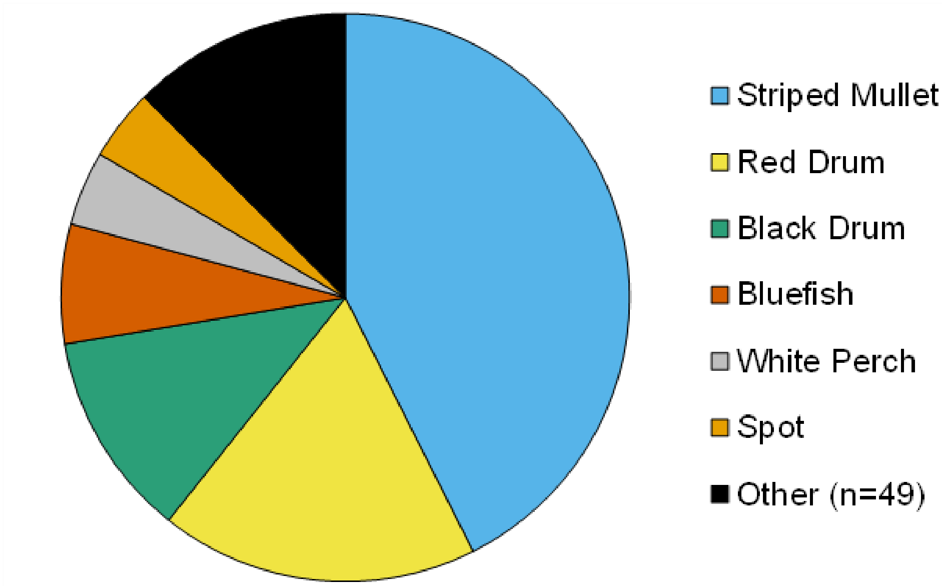


Figure 1. 26. Proportion of incidental catch landed by species in the runaround gill-net Spotted Seatrout fishery reported through the North Carolina Trip Ticket Program, 2012–2022.

Appendix 2: ACHIEVING SUSTAINABLE HARVEST IN THE NORTH CAROLINA SPOTTED SEATROUT FISHERY

ISSUE

Implement management measures to end overfishing and achieve sustainable harvest in the North Carolina Spotted Seatrout fishery.

ORIGINATION

The North Carolina Division of Marine Fisheries (DMF).

BACKGROUND

North Carolina and Virginia tagging studies indicate Spotted Seatrout in North Carolina coastal waters are part of a combined North Carolina and Virginia stock (Ellis 2014). The 2022 North Carolina Spotted Seatrout benchmark stock assessment indicated the Spotted Seatrout stock in North Carolina and Virginia waters is not overfished; however, overfishing is occurring (NCDMF 2022). Reference point thresholds for the Spotted Seatrout stock status are based on a 20% spawning potential ratio which is the comparison of spawning stock biomass (SSB) under a specific fishing regime – i.e., 20% – to a hypothetical unfished SSB. If SSB is below this ratio, the stock is overfished. If fishing mortality (F) is above the level that would lead to this ratio, overfishing is occurring. Due to large uncertainty in the stock assessment terminal year (2019) and based on the recommendation of the external, independent peer review panel, a weighted average of F and SSB from 2017-2019 was used to represent the terminal year and to estimate the threshold and target reference points (NCDMF 2022). The SSB target ($SSB_{30\%}$) and SSB threshold ($SSB_{20\%}$) were estimated at 3,778,723 pounds and 2,519,884 pounds respectively and both were based on 2017-2019 averages. The estimated $SSB_{2019Avg}$ was 4,980,243 pounds which indicates the Spotted Seatrout stock is not overfished (Figure 1). The F target ($F_{30\%}$) and F threshold ($F_{20\%}$) were estimated at 0.38 and 0.60 respectively and were also based on 2017-2019 averages. $F_{2019Avg}$ was estimated at 0.75 which is above the threshold indicating overfishing is occurring (Figure 2.1).

The General Statutes of North Carolina require a Fishery Management Plan to specify a timeframe not to exceed two years from the date of adoption of the plan to end overfishing (G.S. 113-182.1). A harvest reduction of 19.9% is required to reach the $F_{20\%}$ threshold while a harvest reduction of 53.9% will reach the $F_{30\%}$ target. A harvest reduction of at least 19.9% meets the statutory requirement to end overfishing. In developing management measures in Amendment 1 to end overfishing, only harvest reductions from the North Carolina portion of Spotted Seatrout harvest were considered. The original Spotted Seatrout FMP and Supplement A management will remain in place until adoption of Amendment 1 to the Spotted Seatrout Fishery Management Plan.

Discussion of management measures focuses on quantifiable measures that meet the reductions necessary to comply with statutory requirements. Harvest of Spotted Seatrout primarily occurs in the recreational fishery, however; harvest in both the recreational and commercial fisheries increased sharply in 2019 and has remained high through 2022

(Figure 2.1). As such, discussion will focus on both sectors. Management measures considered include seasonal closures, size limits, trip/creel limits, and combinations of these management measures. For an in-depth characterization of the commercial and recreational fisheries as well as management measures intended to support sustainable harvest, please see Appendix 1: Small Mesh Gill Net Characterization in the North Carolina Spotted Seatrout Fishery and Appendix 3: Supplemental Management Options in the North Carolina Spotted Seatrout Fishery. Single solution management measures that do not meet the necessary reductions to comply with statutory requirements will still be discussed here. Such measures may be included in combination management options but will not be presented as single solution management options.

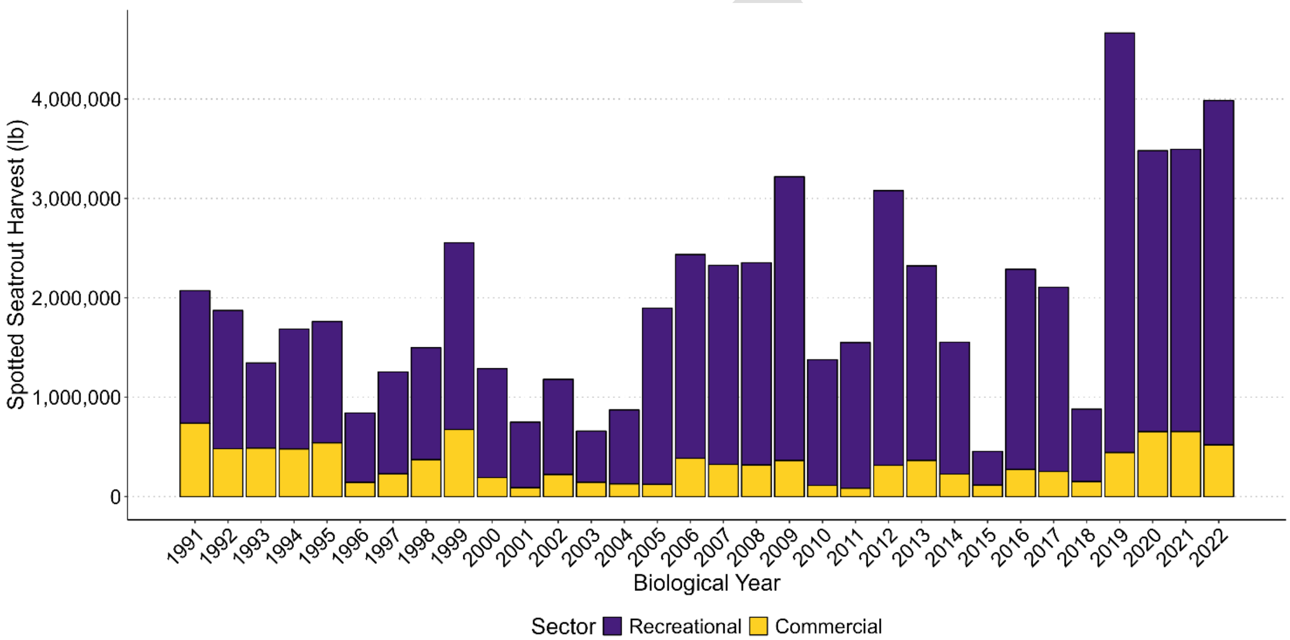


Figure 2.1. Annual harvest of Spotted Seatrout in pounds by biological year (March–February) and sector, 1991–2022. Bars are total annual harvest with commercial harvest as the yellow portion and recreational harvest as the purple portion of the total.

AUTHORITY

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
15A NCAC 03H .0103 PROCLAMATIONS, GENERAL
15A NCAC 03M .0512 COMPLIANCE WITH FISHERY MANAGEMENT PLANS
15A NCAC 03M .0522 SPOTTED SEATROUT

DISCUSSION

Management carried forward

There are management measures from the original FMP to carry forward into Amendment 1. Management measures from the original Spotted Seatrout FMP that will be carried forward into Amendment 1 are:

- It is unlawful to set gill nets in Joint Fishing Waters from 12:01 A.M. on Saturday to 12:01 A.M. on Monday except in Albemarle and Currituck sounds.
- It is unlawful for a commercial fishing operation to possess or sell Spotted Seatrout taken from Joint Fishing Waters from 11:59 P.M. Friday to 12:01 A.M. Monday except in Albemarle and Currituck sounds.
- It is unlawful for a commercial fishing operation to possess more than the recreational bag limit of Spotted Seatrout per person per day taken by hook-and-line.
- It is unlawful to take more than the recreational bag limit of Spotted Seatrout per person per day for recreational purposes.

Size Limits

Throughout this section, unless otherwise specified, all lengths refer to total length (TL) which is a measurement from the tip of the snout to the tip of the compressed tail.

Size limits are a common fisheries management tool designed to protect smaller, juvenile fish from harvest until at least a portion of these fish are large enough to spawn and thus contribute to sustaining the population. Size limits should be set based on management objectives and species life history as these factors influence the effectiveness of the management. For example, setting a size limit below the length at which 50% of females are mature (L_{50}) does not allow most females to be large enough to spawn prior to being harvested. The Atlantic States Marine Fisheries Commission (ASMFC) manages Spotted Seatrout in all Atlantic states who have a declared interest in the species under the Omnibus Amendment to the Interstate Fishery Management Plans for Spanish Mackerel, Spot, and Spotted Seatrout (ASMFC 2012). The Omnibus Amendment sets a minimum size limit of 12 inches. In North Carolina, female Spotted Seatrout L_{50} is estimated at 9.88 inches (NCDMF 2022) with nearly all female Spotted Seatrout mature by the time they are recruited to the fishery at 14 inches (Roumillat and Brouwer 2004; Jensen 2009).

Spotted Seatrout fecundity has been shown to increase with fish size as larger females produce more eggs and spawn more frequently (Brown-Peterson and Warren 2001; Nieland et al. 2002; Roumillat and Brouwer 2004; Murphy et al. 2010). In many species, due to their increased reproductive capacity, large, female fish are expected to have a disproportionately large contribution to populations (Froese 2004; Berkeley et al. 2004; Barneche et al. 2018). More recently however, the general impact of size-specific contributions of individual fish to populations has come into question with some evidence that the collective reproductive output of many, smaller, mature fish may contribute more to populations compared to the reproductive output of fewer, larger fish (Barneche et al. 2018; Lavin et al. 2021) indicating that simply protecting “BOFFFs” (big old fat fecund female fish) may not have the desired conservation effect.

Generally, recreational anglers and commercial fishers in North Carolina target any Spotted Seatrout of legal size. Fish harvested commercially tend to be slightly larger than those harvested recreationally (Table 2.1). There is a dedicated catch and release segment of the recreational fishery (see Recreational Fishery section for more detail). Spotted Seatrout are harvested for consumption regardless of sector.

Slot limits are a specific type of size limit where harvest is restricted to fish above a minimum size but below a maximum size. Sometimes slot limit management will include a trophy limit which allows limited harvest of fish above the maximum size. A slot limit for Spotted Seatrout could protect fish below the minimum size that are not large enough to spawn and fish above the maximum size that may spawn more often and produce more eggs per batch (Brown-Peterson and Warren 2001; Nieland et al. 2002; Roumillat and Brouwer 2004; Murphy et al. 2010). Slot limits can help balance various competing interests that may exist in a fishery and provide a path to achieve management goals (Ahrens et al. 2020). For example, the Spotted Seatrout fishery includes part-time and full-time commercial fishers and part-time and full-time charter guides interested in the economic benefits of the fishery and recreational anglers who may want a robust trophy fishery or to maximize harvest potential, among a variety of other interests (Ahrens et al. 2020).

Table 2.1 Mean, minimum, and maximum lengths (fork length, inches) of Spotted Seatrout measured from the commercial and recreational fisheries, calendar years 2012–2022.

Year	Commercial				Recreational			
	Mean Length	Min Length	Max Length	Total Number Measured	Mean Length	Min Length	Max Length	Total Number Measured
2012	16.5	7.4	31.1	4,822	16.5	13.0	24.1	939
2013	16.7	8.7	28.5	6,144	16.8	10.1	23.5	865
2014	17.3	5.5	28.3	3,321	17.6	13.1	26.0	381
2015	18.3	8.9	30.9	2,676	16.9	12.8	25.0	154
2016	17.3	9.4	31.7	3,025	16.8	13.0	25.2	647
2017	17.6	7.6	32.9	3,066	17.0	11.6	25.8	864
2018	17.2	10.5	28.0	1,180	15.7	9.3	23.3	274
2019	17.3	10.1	28.9	2,622	16.7	10.7	24.6	1,574
2020	17.5	10.9	33.4	2,851	17.0	12.1	26.8	1,119
2021	17.5	10.9	29.9	3,432	17.0	11.1	26.5	1,019
2022	17.9	13.2	28.3	3,314	17.4	12.6	28.0	632

As a standalone management measure, changes to the current Spotted Seatrout minimum size limit are unlikely to reach the necessary harvest reductions to meet statutory requirements. Reductions from increasing the minimum size limit are most likely to be achieved in the short term while long term harvest reductions are lower with some portion of harvest recouped. A delay in harvest could allow more fish to spawn prior to harvest, providing non-quantifiable benefits to the stock. However, Spotted Seatrout growth rates would likely minimize the non-quantifiable benefits from harvest delay as sub-legal fish are recruited to the fishery within a spawning season. Increasing the minimum size limit to 15 inches appears to result in an 8.6% harvest reduction. On average, Spotted Seatrout grow 4.5 inches between year one and year two (Table 2.2) meaning a 14-inch fish at the beginning of the biological year (March) is likely to be well over a 15-inch minimum size during the spawning season (May-August). Most harvest occurs in October, November, and December which means fish well below a 15” minimum size will likely enter the fishery prior to the end of the fishing year but may have a chance to spawn prior to being subject to harvest in the fall. Fish of sub-legal size in the fall would probably not recruit to the fishery until the following spring allowing for some reduction in harvest. As females grow faster than males, sub-legal female fish will recruit to the fishery more rapidly diminishing any potential quantifiable or non-quantifiable benefits from a size limit increase. With the current minimum size at L_{100} and the growth rates of Spotted Seatrout, an increase in the minimum size may be less effective at reducing harvest than anticipated but may have unquantifiable benefits. Increasing the minimum size limit should be considered in conjunction with other measures as means to ensure sustainable harvest.

Table 2.2. Average length at age in inches for female and pooled (male and female) Spotted Seatrout calculated using von Bertalanffy growth parameters from 2022 stock assessment (NCDMF 2022).

Age	Mean Length (female)	Mean Length (pooled)
0	7.6	6.6
1	14.3	12.1
2	19.4	16.6
3	23.1	20.1
4	25.9	23.0
5	28.0	25.3
6	29.6	27.2
7	30.8	28.7
8	31.6	29.9
9	32.8	30.8

Implementing a slot limit alone will not reduce fishing mortality below the threshold unless the size range available for harvest is very limited (Table 2.3), but reductions from a slot limit are more likely to be realized over the long-term than reductions from increasing the minimum size. Rapid growth early in life means Spotted Seatrout recruit to the fishery quickly but will also quickly grow out of a narrow slot limit. The average length of a one-year-old female fish is 14.3 inches and average length increases to 19.4 inches and 23.1 inches by ages two and three respectively (Table 2.2). On average, a female Spotted Seatrout will be recruited to the fishery with a narrow slot range for about one or two years. The probability of a relatively short harvest window of each year class, particularly for female fish, makes a slot limit a potentially useful management measure especially when combined with other measures. Allowing the harvest of a “trophy”, or over slot fish, should be considered with caution. Relatively few Spotted Seatrout over 24” are harvested meaning a trophy allowance of less than 24” will result in a minimal overall harvest reduction. Most of the reduction in harvest gained from a 14”–20” slot limit is from fish between 20” - 22” with almost all the harvest reduction coming from fish less than 26” (Table 2.3). A trophy limit with a higher minimum trophy size (e.g., allowing harvest of one fish over 24” or over 33.5” which is the length of the current state record Spotted Seatrout) would maintain most of the harvest reductions gained from a traditional slot limit while still allowing for the harvest of “a fish of a lifetime” or the setting of a new Spotted Seatrout state record.

Anecdotally, the practice of “high grading” is common in the Spotted Seatrout fishery. High grading is where someone catches a legal limit of fish, keeps that limit in their possession, and continues fishing for larger or higher quality fish. Upon catching such a fish, the smaller or lower quality fish are discarded, and the larger or higher quality fish are kept. These discarded fish have higher than usual mortality rates (Nelson et al. 2021). “Possession” is defined in NCMFC rule as “actual or constructive holding whether under claim of ownership or not” [NCMFC Rule 15A NCAC 03I .0101 (2)(g)] making the practice of high grading illegal as it involves possessing more than a legal limit of Spotted Seatrout. For example, an angler who catches a four fish limit of Spotted Seatrout and keeps those fish in a live well, but continues fishing until catching a larger Spotted Seatrout, then discards one of the fish from the live well has possessed five fish or one fish more than the legal possession limit for Spotted Seatrout, even if only for a short period of time. Despite the illegality of high grading, enforcement is exceedingly difficult. A traditional slot limit would likely reduce instances of high grading, but a trophy limit could encourage more anglers to participate in this behavior and subsequently decrease potential reductions by increasing dead discards in the fishery though it is impossible to quantify by how much.

Table 2.3. Expected reductions in harvest from various size limits in the North Carolina Spotted Seatrout fishery. The only realistic size limit change that will end overfishing as a standalone measure is a narrow slot limit with no trophy allowance or a trophy allowance of 24” or longer. Rec Reduction (lb) is based on average recreational landings from 2019 to 2022. *Total % Reduction includes a 24,424lb (4.3%) reduction in commercial harvest for 15” minimum size and a 36,921lb (6.5%) reduction in commercial harvest for 16” minimum size based on average commercial landings from 2019 to 2022. Commercial harvest reduction is 0% in all other cases.

Size limit examples (inches Total Length)			
Size Limit	Recreational Reduction (lb)	Recreational Reduction (%)	Total % Reduction
15” minimum	183,693	5.5	5.3*
16” minimum	554,420	16.6	15.1*
14”–20”	617,878	18.5	15.8
14”–22”	240,471	7.2	6.2
14”–24”	106,876	3.2	2.7
14”-20” with one fish over 24”	507,662	15.2	13.0
14”–20” with one fish over 26”	601,178	18.0	15.4
14”–20” with one fish over 30”	617,878	18.5	15.8
15”–20” with one fish over 24”	731,433	21.9	18.7
16”–20” with one fish over 24”	1,102,159	33.0	28.2

A slot limit could be implemented either in the recreational sector or across both the recreational and commercial sectors. A recreational slot limit might lead to increased dead discards. Though the expected discard mortality rate for Spotted Seatrout caught with hook and line is low and the discard mortality rate for larger Spotted Seatrout may be lower than the average rate (Gearhart 2002), the already high number of discarded Spotted Seatrout underscores the importance of considering release mortality when exploring management options. Gear requirements (e.g., circle hooks when fishing live or natural bait) and continued ethical angling education could help minimize dead discards in the recreational fishery. Similarly, a commercial slot limit would likely lead to increased dead discards. North Carolina specific estimates for total mortality (at-net mortality plus delayed mortality) of discarded Spotted Seatrout only exist for the anchored small-mesh gill-net fishery and vary depending on mesh size with an average of 79% (Price and Gearhart 2002). Though anchored small-mesh gill nets have historically been the predominate gear in this fishery, recently runaround gill nets have become increasingly common. Data characterizing dead discards in the commercial fishery are limited though Observer Program data shows limited discards in the anchored gill-net fishery and about 84% of total trips land less than the 75 fish limit (Appendix 1). These data indicate dead discards are likely low under current management. However, it is unclear if dead discards will increase if management changes. Pairing a commercial slot limit with corresponding mesh size changes may not be effective in reducing discards due to the lack of size selectivity across various mesh sizes for Spotted Seatrout (see Appendix 1). Prohibiting commercial gear based on reducing dead discards in the Spotted Seatrout fishery would affect a variety of other fisheries. Since implementing a commercial slot limit would either broadly affect other fisheries or likely increase dead discards, thus reducing the effectiveness of management, a commercial slot limit is not the most effective management option to reduce commercial harvest. Implementing a slot limit for the recreational sector only may simply shift the harvest of large fish to the commercial fishery resulting in the projected harvest reduction not being realized, though quantifying this shift is not possible.

A narrow slot limit with a trophy allowance of one fish over 24” implemented just for the recreational sector could reduce total harvest below the level of harvest that would lead to $F_{Threshold}$ (total harvest reduction of 28.2%, Table 2.3). It is possible that reduction may be less than expected due to increased dead discards in the recreational sector and a portion of that reduction would be recouped by the commercial sector resulting in a realized reduction less than 28.2%. As such, more conservative management measures to buffer overall harvest reductions should be considered if a slot limit is implemented. For example, a recreational slot limit of 16”–20” with an allowance for one fish over 24” paired with a commercial minimum size of 16” would reduce total harvest by 29.1% which would reduce F below the threshold and minimize some of the recoupment potential in the commercial sector. If combined with changes to the allowable stretched mesh size for commercial harvest of Spotted Seatrout, it should be possible to reduce harvest and minimize dead discards in the commercial sector. However, such a measure would not address the potential for increased dead discards from the release of out of slot fish, the high recoupment in the commercial sector if commercial harvest significantly shifted toward larger fish, and the recent trend of increased effort in both sectors.

Option 1: Size Limit Options

a. *Status Quo – no change to the 14” minimum commercial size limit. Consider recreational size limit changes as a part of the overall management strategy to achieve sustainable harvest but not as a single solution option.*
b. *Recreational 16”–20” slot limit with allowance for one fish over 24” and commercial 16” minimum size limit*

Seasonal Closures

The Spotted Seatrout fishery in North Carolina predominantly occurs in fall across both the recreational and commercial sectors (Figure 2.2). For a more detailed description of seasonal harvest, see the Commercial and Recreational Fishery sections of Amendment 1. While there might be small regional variations in these seasonal patterns, broadly the patterns are consistent statewide.

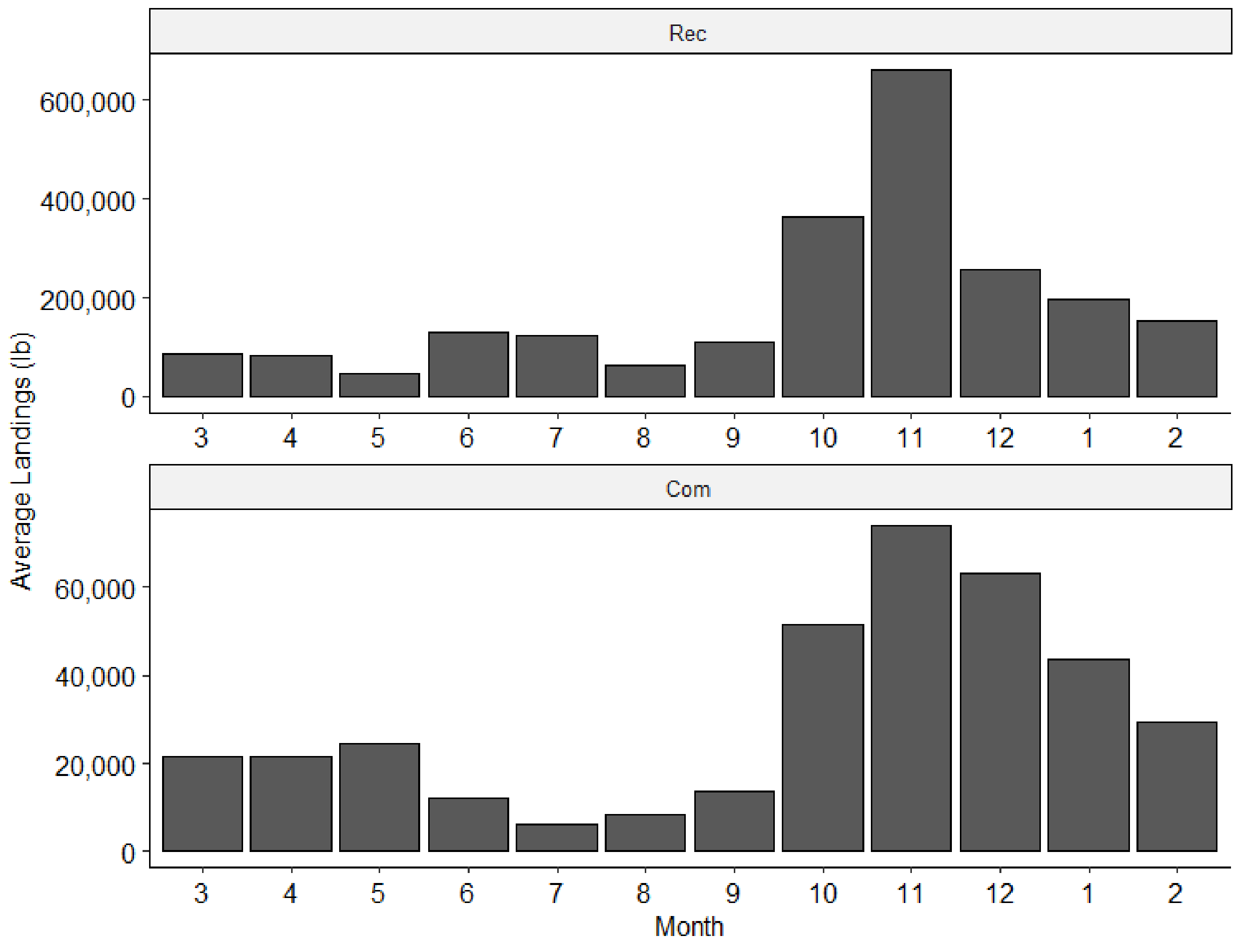


Figure 2.2 Average monthly harvest of Spotted Seatrout in pounds by sector from Biological Year 2012–2022. The top panel is recreational harvest, and the bottom panel is commercial harvest. Note: the vertical axis scale is different between panels to illustrate seasonal variation. The Biological Year is March – February.

Seasonal closures can be an effective way of limiting harvest, especially when closures are at the end of the fishing year to prevent recoupment of harvest. Closures prior to the end of the fishing year should include a buffer above the desired reduction to account for recoupment. It is possible to end overfishing in the Spotted Seatrout fishery through seasonal closures. In theory, a closure that spans the spawning season could reduce overall harvest enough to reach the threshold F (Table 2.4) and provide the added benefit of allowing more Spotted Seatrout to spawn each season. Though 2022 spawning stock biomass does not indicate the need for additional spawning protections, reducing harvest during the spawning season would have non-quantifiable benefits to the Spotted Seatrout stock. A spawning season closure, however, is not at the end of the fishing year therefore it is likely some amount of recoupment would occur after the season closure. A spawning season closure would also have to be longer than a winter closure to reduce harvest to a level that will meet management objectives (Table 2.4). Because recoupment is likely with a spawning season closure or closures that extend past the end of the biological year the closure should be extended, or other management options considered in tandem with the closure to ensure harvest reductions end overfishing. For example, during the AC Workshop there was discussion about a January–March commercial season closure (Table 2.4). While the bulk of reductions from such a closure come from January and February, the reductions gained in March are likely to be recouped throughout the year though some fish are likely to spawn prior to being harvested providing additional benefits to the stock. Extending the January–March closure or including additional management strategies should be considered to increase the likelihood of reaching management objectives. Input received during the public scoping period and from discussions with the Spotted Seatrout FMP Advisory Committee indicate that stakeholders would prefer a shorter season closure if possible. A winter closure at the end of the biological year could reach similar harvest reductions as a spawning season closure over a shorter timeframe with no recoupment of harvest.

Table 2.4. Expected reductions in harvest for each sector from seasonal closures in the North Carolina Spotted Seatrout fishery. Reduction in pounds are based on average harvest from 2019 to 2022. Unless otherwise noted, monthly closures are for the entire month and day of week closures begin at 11:59 p.m. the day prior to the beginning and end at 12:01 a.m. the day after the end (e.g., for a Sat-Sun closure, the fishery will close at 11:59 p.m. Friday and reopen at 12:01 a.m. Monday). A reduction of at least 19.9% (threshold) is needed to end overfishing. *Day of week closures are only calculated for commercial sector. **Reduction for period does not meet the harvest reduction necessary to meet the F threshold.

Season Closure Examples						
Month Closures	Day of Week Closures*	Recreational Reduction (lb)	Recreational Reduction (%)	Commercial Reduction (lb)	Commercial Reduction (%)	Total Reduction (%)
-	Jan–Sep, Sat–Sun; Oct–Dec, Sat–Mon	0.00**	0.0**	172,107	30.3	4.4**
Jan–Feb	-	581,139	17.4**	122,690	21.6	18.0**
Apr–Jul	Oct–Dec, Sat–Mon	584,479	17.5**	213,572	37.6	20.4
Jan–Mar	-	741,538	22.3	153,363	27.0	23.0
Dec 16–Feb	-	738,113	22.1	168,131	29.6	23.2

Jan–Feb	Oct–Dec, Sat–Mon	581,139	17.4**	228,340	40.2	28.2
Nov–Feb	-	1,843,613	55.2	323,198	56.9	55.4
May 16–Sep	-	714,734	21.4	80,657	14.2**	20.4

A seasonal closure could be over the same timeframe for the commercial and recreational sectors or could vary depending on sector. A consistent season for both sectors is easier for recreational anglers and commercial fishers to understand, would ease the enforcement burden, and can decrease user group conflict. Ending overfishing in both sectors is more complicated with the same season across sectors as is ensuring a similar reduction for each sector. For example, if the Spotted Seatrout fishery is closed January 1 and does not reopen until the end of February, there would be a 21.6% reduction in commercial harvest (ends overfishing in the commercial sector), but only a 17.4% reduction in recreational harvest (does not end overfishing in the recreational sector). Different seasons for each sector could help ensure parity between sectors and that harvest is reduced enough to reach the threshold or target F but could cause confusion for stakeholders though there is precedent for different recreational and commercial seasons in multiple N.C. fisheries (e.g., Southern Flounder and Striped Bass).

Though the general seasonal pattern of Spotted Seatrout harvest is consistent across the state, season closures could have unexpected outcomes due to small, regional differences in these broad patterns. For example, anecdotal reports from the for-hire industry indicate the importance of the small June and July harvest increase (Figure 2.2) to charter captains in the northern region of the state. A harvest closure during the spawning season could have a larger than expected impact on the northern for-hire fleet, though data to determine the extent of any impact is unavailable. A season closure outside the spawning season – e.g., a season closure at the end of the biological year – could mitigate the financial impact to the northern for-hire fleet while also reducing the potential for recoupment and length of a harvest closure.

It is also important to consider other potential target species during a proposed closed season. The most common species landed on commercial trips that land Spotted Seatrout is Striped Mullet (see Appendix 1). Similarly, Spotted Seatrout is the most common species landed on commercial trips that land Striped Mullet. Fishers in both fisheries use similar gear types with runaround gill nets becoming more common in recent years but anchored small mesh gill nets still common. The overlap in gear types and landings provides strong evidence that the Spotted Seatrout and Striped Mullet commercial fisheries operate alongside each other underscoring the importance of considering how management changes in the recently adopted Amendment 2 to the Striped Mullet FMP might affect Spotted Seatrout harvest and vice versa. The selected sustainable harvest management option in the Striped Mullet FMP is weekend commercial harvest closures on Saturday and Sunday January through September and Saturday through Monday October through December. Mirroring these weekend closures for the Spotted Seatrout commercial fishery would simplify management, could theoretically end overfishing in the commercial sector (Table 2.4), and reduce the potential for dead discards in both fisheries. However, if commercial fishers increase effort during the week to compensate for lost weekend days harvest recoupment is likely. Striped Mullet offshore spawning migrations in the fall largely coincide with wind events providing an opportunity for large numbers of fish to avoid harvest when a “mullet blow” occurs during a closed weekend period. Spotted Seatrout do not have this same migratory behavior. In fact, Spotted Seatrout overwinter in sometimes large aggregations in the upper estuary and begin forming these aggregations in the fall. Such aggregations allow for easier targeting of large numbers of Spotted Seatrout and could lead to a much greater degree of harvest recoupment from a shift in fishing effort compared to Striped Mullet. Day of the week closures could be considered in tandem with other management measures to ensure overfishing is ended. For example, combining the weekend closures adopted in Amendment 2 to the Striped Mullet FMP with a January–February harvest closure would give an on paper commercial harvest reduction of around 47% (46.8%). Even though it is unlikely that full harvest reduction is reached, the January–February harvest closure would provide a buffer and increase the likelihood of ending overfishing. However, if the reduction in recreational harvest were less than 47%, the perception could exist of the commercial sector taking a larger harvest reduction despite the commercial sector accounting for a smaller proportion of overall landings even though the realized reduction would probably fall well below the on-paper reduction. Mirroring a portion of the Striped Mullet regulations could act to balance the benefits of similar management across FMPs and the perception of a lack of parity between sectors. For example, implementing the same management as the Striped Mullet FMP during the peak harvest for both species (Saturday–Monday harvest closure October–December) with an additional Spotted Seatrout harvest closure January–February would match management between FMPs during the timeframe when most harvest occurs and result in a 40.2% on paper reduction in Spotted Seatrout harvest. This would reduce dead discards in both fisheries and decrease possible confusion caused by different management measures for each fishery during peak harvest seasons while still providing additional Spotted Seatrout management beyond weekend closures to account for expected recoupment in that fishery. Even if recreational management is expected to result in a harvest reduction less than 40%, it is likely the realized reduction percentages would be closer offering less of a chance for perceived lack of parity between sectors.

The types of baits and gear used in the recreational fishery are also commonly used when targeting Red Drum, Striped Bass, Southern Flounder, and Black Drum. When open, Striped Bass and Southern Flounder are quota managed species, therefore harvest of these species could not increase if effort shifts occur. If recreational anglers unable to target Spotted Seatrout due to a seasonal closure instead targeted Red Drum or Black Drum, this could lead to an increase in harvest. It is not possible to predict how angler behavior might change when regulations change, however; the seasonality of the Red Drum and Black Drum fisheries could be considered when determining the timeframe for a Spotted Seatrout seasonal closure.

Option 2: Seasonal Closure Options

a. *Status Quo – manage fishery without seasonal harvest closure*
b. *Dec 16 – Feb 28/29 harvest closure (both sectors)*
c. *11:59 p.m. Friday–12:01 a.m. Tuesday commercial harvest closure October 1–December 31 and Jan 1–February commercial harvest closure.* Consider

recreational seasonal closures as a part of the overall management strategy to achieve sustainable harvest but not as a single solution option.

d. *Nov 1 – Feb 28/29 harvest closure (both sectors)*

Bag and Trip Limits

The recreational bag limit for Spotted Seatrout is currently 4 fish per person per day. Most recreational anglers, however, harvest less than their limit of Spotted Seatrout. From 2019-2022 – just over 73% of anglers harvested two or fewer Spotted Seatrout and nearly 48% of anglers harvested just one Spotted Seatrout. Harvest reductions needed to reach the F threshold could be achieved in the recreational fishery through bag limit changes, but harvest reductions needed to reach the F target are not possible with bag limit changes as a standalone measure (Table 2.5). Reducing recreational harvest to reach the F threshold would require decreasing the recreational bag limit to two fish per person per day. Reducing the allowable bag limit to meet the minimum reduction necessary to end overfishing in the recreational sector would enact management that is easy to understand, easy to enforce, and straightforward. Even though a two fish bag limit would result in a 27.7% reduction (Table 2.5), the public could potentially conflate the number of fish an angler is theoretically allowed to harvest with the number of fish most anglers actually harvest leading to the misperception that a two fish bag limit is a 50% reduction (Figure 2.3).

Table 2.5. Expected reductions in recreational harvest and total harvest from bag limit changes. Reductions in pounds are based on average recreational harvest from 2019 to 2022. Total harvest reductions assume no other management is implemented. Reductions of at least 19.9% (threshold) up to 53.9% (target) are needed to end overfishing. *Reduction does not meet the 19.9% (3 fish bag limit) or 53.9% (1 fish bag limit) harvest reduction necessary to reach $F_{Threshold}$ or F_{Target}.

Bag Limit Reduction Examples			
Bag Limit	Recreational Reduction (lb)	Recreational Reduction (%)	Total Harvest Reduction
3	394,106	11.8*	10.1*
2	925,146	27.7	23.7
1	1,760,116	52.7*	45.0*

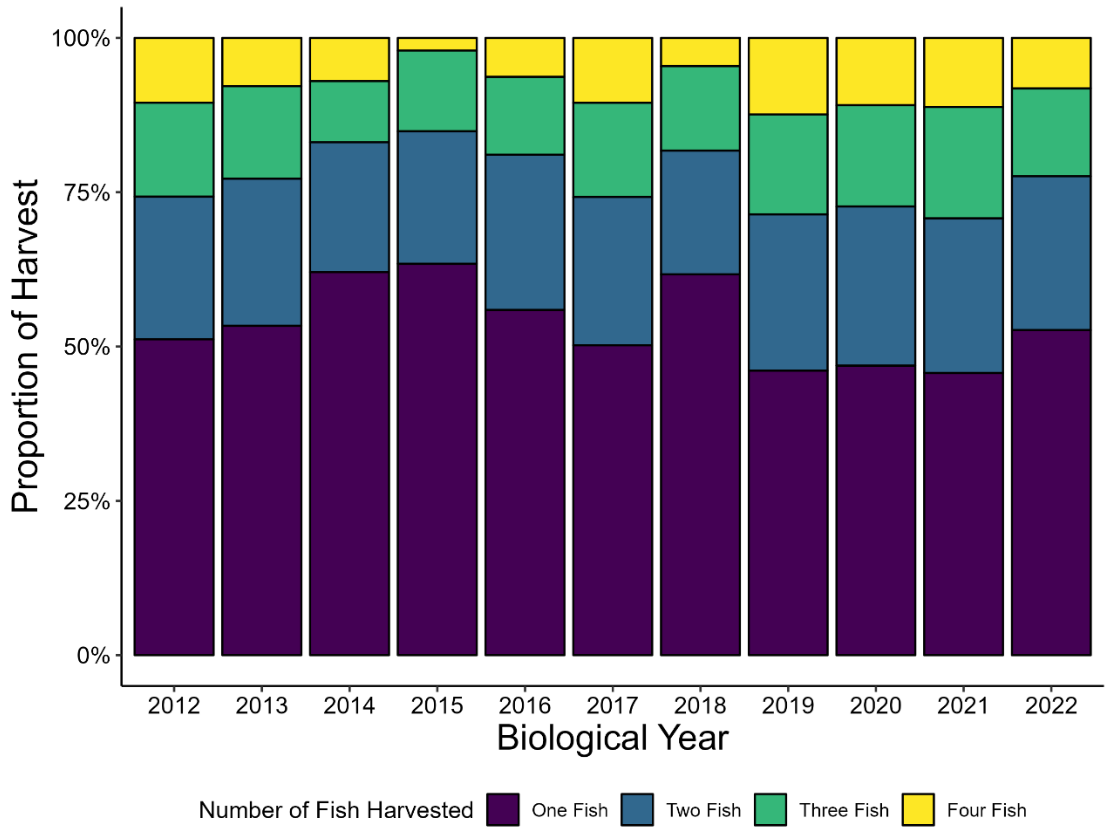


Figure 2.3. The proportion of total recreational Spotted Seatrout harvest where bar color refers to the number of fish harvested. Though the specific proportions of total harvest from each harvest bin vary year to year, approximately 75% of recreational anglers consistently harvest two or fewer Spotted Seatrout.

Currently there is a 75 fish commercial trip limit for Spotted Seatrout. Approximately 16% of commercial trips reach that limit with about half (52%) harvesting 30 or less Spotted Seatrout and over three quarters (84%) harvesting 70 or fewer fish. Reductions to the threshold in the commercial sector could be achieved through lowering the commercial trip limit as a standalone measure but, while technically possible, it is unlikely the necessary trip limit (<20 fish) to approach the target is realistic (Table 2.6). Regardless of whether commercial harvest is reduced to the threshold or the target level, management to reduce commercial harvest would not end overfishing in the combined Spotted Seatrout fishery. Like the recreational sector, there exists the potential for public misperception about harvest reductions stemming from changes to trip limits. For example, reducing the commercial trip limit to 45 fish results in a 21.5% reduction in commercial harvest (Table 2.6) but could be incorrectly perceived as a larger reduction if commercial fishers conflate the actual harvest reduction with the theoretical reduction in allowable harvest (40%).

Table 2.6. Expected reductions in commercial harvest from trip limit changes. Reductions in pounds are based on average commercial harvest from 2019 to 2022. Total harvest reductions assume no other management is implemented. Reductions of at least 19.9% (threshold) up to 53.9% (target) are needed to end overfishing. *Reduction does not meet the 19.9% (55 fish trip limit) or 53.9% (20 fish trip limit) harvest reduction necessary to reach $F_{Threshold}$ or F_{Target}.

Trip Limit Reduction Examples			
Trip Limit	Commercial Reduction (lb)	Commercial Reduction (%)	Total Harvest Reduction (%)
55	70,433	12.4*	1.8
45	122,122	21.5	3.1
20	301,046	53.0*	7.7

Lowering the Spotted Seatrout recreational bag limit or commercial trip limit would probably cause increased dead discards of Spotted Seatrout in both sectors of the fishery which can act to decrease the effectiveness of management changes. Changes to bag limits could be paired with gear requirements (see Appendix 3) and commercial trip limit changes could be accompanied by changes or limits to allowable gear (see Appendix 1) to mitigate dead discards in the fishery.

Option 3: Bag and Trip Limit Options

a. *Status Quo – manage commercial fishery with no changes to the 75 fish trip limit and consider recreational bag limit changes as a part of the overall management strategy to achieve sustainable harvest but not as a single solution option.*
b. *Reduce recreational bag limit to 2 fish and commercial trip limit to 45 fish*

Stop Nets

The stop net fishery is a modification of a traditional beach seine that primarily targets Striped Mullet and is unique to Bogue Banks. This fishery holds historic and cultural value in North Carolina and especially Carteret County (See Striped Mullet FMP and Amendment 1 for review of historical significance of stop net fishery). Where traditional beach seine fisheries involve setting and hauling a net from the beach, the stop net fishery adds a stationary “stop net” set perpendicular to the beach in an L-shape (see Spotted Seatrout FMP for more detail on the execution of the stop net fishery). The 2012 Spotted Seatrout FMP implemented a 75 fish commercial trip limit, but it was noted in the plan there was the potential for dead discards to exceed harvest in high-volume fisheries like the stop net fishery (NCDMF 2012). The MFC tasked the DMF Director with addressing the stop net fishery outside of the 2012 FMP. Since 2013, the stop net fishery has opened and closed by proclamation and operates under an annual Memorandum of Agreement (MOA) signed by a party of the combined fishing operation and the DMF Fisheries Management Section Chief. The MOA sets a 4,595 lb. Spotted Seatrout season quota, requires a party to the stop net fishery to alert DMF prior to fishing the stop nets, and requires reporting of Spotted Seatrout landings in pounds the same day the stop nets are fished. In recent years the stop net fishery has opened around October 15 and closed on December 31. Additionally, stop nets are limited to a maximum of four stop nets between Beaufort Inlet and Bogue Inlet at any one time with each combined fishing operation allowed to set a maximum of two stop nets.

Since implementation of current management in 2013, the stop net fishery has never reached their 4,595 lb. quota. Stop net landings represent a very minor proportion of Spotted Seatrout commercial landings and an even smaller portion of total commercial and recreational landings. For example, the highest stop net landings from 2013 through 2022 were 3,700 lb. which accounted for 1.4% of commercial landings and 0.2% of total landings in that year. Most years the stop net fishery accounts for less than half a percent of commercial landings and less than a tenth of a percent of combined landings. Due to the strict existing management of the stop net fishery, the potential for additional harvest reductions from the recently adopted Amendment 2 to the Striped Mullet FMP, and the low contribution to Spotted Seatrout landings under the current stop net fishery management, additional harvest restrictions may not be necessary in the stop net fishery. However, formalizing current management of the stop net fishery should be considered in this amendment.

Option 4: Stop Net Management Options

a) *Status quo – 4,595 lb. season quota with terms and conditions of stop net fishery and responsibilities of the stop net crew outlined in Memorandum of Agreement.*
b) *Stop nets are restricted to the Atlantic Ocean on Bogue Banks with a 4,595 lb. Spotted Seatrout season quota. The season will open no sooner than October 15 and close when the Spotted Seatrout quota is reached or no later than December 31. Any weekend closures to commercial harvest implemented in Option 2 will also apply to the Bogue Banks stop net fishery. Stop net crews must contact N.C. DMF Marine Patrol Communication each time a stop net is set and at least two hours prior to each time a stop net is fished. The same day a stop net is fished and the catch is landed at the fish house, a representative of the stop net crew must contact DMF Fisheries Management Section to report the daily total of Spotted Seatrout in pounds as it appears on the trip ticket. Same day reporting is required even if zero Spotted Seatrout are harvested. Failure to follow reporting requirements will result in an immediate closure of the stop net fishery. The stop net fishery will be managed by proclamation consistent with but not limited to previous proclamations.*

Combination Management Measures

Combining multiple strategies to achieve management goals is common in fisheries management including in the original Spotted Seatrout Fishery Management Plan which combines size limits with trip and bag limits and weekend prohibitions on commercial harvest or possession of Spotted Seatrout in joint waters. Multiple management measures rather than a single, standalone management measure allow for more specific, targeted management to account for a variety of factors including species life history and biology, differences in the fishery (e.g., industry, regional, etc.), or competing interests in the fishery. As there are few standalone management measures to end overfishing in the Spotted Seatrout fishery, combination measures will help ensure management is realistic and management objectives are more likely to be achieved. Additionally, a management strategy comprised of more than one management measure can allow for increased or more consistent access to the fishery (Tables 2.7 and 2.8). For example, implementing a slot limit along with a seasonal closure in the Spotted Seatrout recreational fishery would allow for a shortened closure period when compared to a seasonal closure as a standalone measure.

Table 2.7. Combination management measures to end overfishing and achieve sustainable harvest. The Total % Reduction column shows the total percent reduction if no changes to commercial management are implemented. Unless otherwise noted, season closures or bag limit reductions include the entirety of the month. *Total reduction does not reduce F to the 19.9% threshold (options 1.a, and 1.b). Harvest reductions in pounds are based on 2019–2022 average recreational harvest.

Option #	Season Closure	Bag Limit (number of fish)	Size Limit	Recreational Reduction (lb)	Recreational Reduction (%)	Total % Reduction
5.a	Jan–Feb	Oct-Dec 3 fish	-	738,113	22.1	18.9*
5.b		Nov-Feb 3fish	16” minimum	741,453	22.2	19.0*
5.c	-	Oct-Feb 3 fish	14–20”, 1 over 26”	824,950	24.7	21.1
5.d	Jan 16–Feb	-	14–20”, 1 over 26”	935,166	28.0	23.9
5.e	Dec 16–Feb	3 fish	-	1,015,323	30.4	26.0
5.f	Jan–Feb	-	14–20”, 1 over 26”	1,078,781	32.3	27.6
5.g	Jan–Feb	Oct-Dec 3 fish	14–20”, 1 over 26”	1,205,696	36.1	30.9
5.h	Apr–Jun	3 fish	14–20”, 1 over 26”	1,292,533	38.7	33.1
5.i	Jan–Feb	3 fish	14–20”, 1 over 26”	1,319,252	39.5	33.8
5.j	Dec 16–Feb	3 fish	14–20”, 1 over 26”	1,436,148	43.0	36.7
5.k	Apr–Jul	3 fish	14–20”, 1 over 26”	1,439,488	43.1	36.8
5.l	Dec–Feb	2 fish	14–20”, 1 over 26”	1,923,770	57.6	49.2

Table 2.8. Combination management measures to end overfishing and achieve sustainable harvest. The Total % Reduction column shows the total percent reduction if no recreational management changes are implemented. No management options applied solely to the commercial sector reduce *total* harvest to a level where F meets the 19.9% threshold. Unless otherwise noted, seasonal closures include the entirety of the month. Harvest reductions in pounds are based on 2019–2022 average commercial harvest.

Option #	Season Closure	Trip Limit (number of fish)	Size Limit	Commercial Reduction (lb)	Commercial Reduction (%)	Total % Reduction
6.a	Jan 16-Feb	60	-	131,210	23.1	3.4
6.b	Jan-Feb	65	-	145,979	25.7	3.7
6.c	Jan-Feb	-	16” min	149,955	26.4	3.8
6.d	Feb	45	-	164,155	28.9	4.2
6.e	Jan 16-Feb	45	-	193,124	34.0	4.9
6.f	Jan-Feb	50	-	197,100	34.7	5.0
6.g	Dec 16-Feb	60	-	202,780	35.7	5.2
6.h	Dec-Feb	40	-	314,110	55.3	8.0

Multiple strategies to manage a fishery can be especially helpful when considering different and potentially competing stakeholder objectives as well as ensuring management objectives are realistic for different sectors and therefore more likely to be achieved. However, combining multiple strategies can also lead to more complex management potentially resulting in stakeholder confusion and enforcement difficulties. It is important to balance the increasing complexity of multiple management layers with stakeholder and management objectives.

Options 5/6: Combination Management Options

a) *Option 5.h with commercial management handled through seasonal closures as a standalone measure (see Option 2.c)*

Adaptive Management

The current Spotted Seatrout adaptive management framework needs to be updated. Adaptive management is a structured decision-making process when uncertainty exists, with the objective of reducing uncertainty through time with monitoring. Adaptive management provides flexibility to incorporate new information and accommodate alternative and/or additional actions. The original FMP included adaptive management to “achieve one half of the reductions necessary and to reassess after three years to evaluate the effectiveness of the measures to reduce harvest” and for the Director to “intervene in the event of a catastrophic” cold stun event (NCDMF 2012).

While success or failure of any given management strategy to sustain the stock is best determined through a quantitative stock assessment the ability to adjust management between stock assessments based on evidence of management strategies not sustaining the stock can be an important conservation tool. For example, by itself failure to achieve projected harvest reductions does not necessarily indicate failure of a management measure but could conversely indicate improving stock conditions. However, failure to achieve harvest reductions combined with warning signs in dependent or independent sampling (e.g., a decrease in independent sampling abundance or a truncation of age or length distributions in dependent or independent catch) could indicate a need to adjust management strategies. Peer reviewed stock assessments and stock assessment updates should continue to be used to guide management decisions for the Spotted Seatrout stock. The 2022 peer reviewed stock assessment (NCDMF 2022) should be updated, at least once between full reviews of the plan to gauge success in maintaining sustainable harvest and to monitor changes in *F.* The 2022 stock assessment had a terminal year of 2019 and Amendment 1 management measures will be implemented, at the earliest, in 2025. Given this timeline, the earliest a stock assessment update should be completed is during 2026 with the inclusion of data from 2025. The timing of a stock assessment update is at the discretion of the Division and will consider stock trends and the timing of prior management when determining the appropriate schedule. An assessment update will best determine if management goals are being met, but an adaptive management structure that allows for needed adjustments to management measures between stock assessment updates is an important tool for attaining management goals.

The existing Spotted Seatrout rule, 15A NCAC 03M .0522, provides the Fisheries Director proclamation authority pursuant to 15A NCAC 03H .0103 to impose any of the following restrictions on the taking of Spotted Seatrout:

1) Specify time;
2) Specify area;
3) Specify means and methods;
4) Specify season;
5) Specify size; and
6) Specify quantity.

Upon adoption of Amendment 1, the adaptive management framework will consist of the following:

Option 7: Adaptive Management Framework

1) The adaptive management framework allows for adjusting management measures outside of an updated stock assessment to ensure compliance with and effectiveness of management strategies adopted in Amendment 1 and is a tool to respond to concerns with stock conditions and fishery trends. Upon evaluation by the division, if the management strategy implemented to achieve sustainable harvest (either through Amendment 1 or a subsequent revision) is not achieving the intended purpose, management measures may be revised or removed and replaced using adaptive management; provided it conforms to part 2.
2) Management measures that may be adjusted using adaptive management include:
    a. Season closures
    b. Day of week closures
    c. Trip or vessel limits
    d. Size limits
    e. Bag or vessel limits
    f. Gear restrictions in support of the measures listed in a-e

MANAGEMENT OPTIONS

Table 2.9. Management options to achieve sustainable harvest in the Spotted Seatrout fishery.

Topic	Option	Description
Size limits	1.a	Status quo – no change to commercial size limit. Consider recreational size limit changes as a part of the overall management strategy to achieve sustainable harvest but not as a single solution option.
	1.b	Recreational 16”–20” slot limit with allowance for one fish over 24” and commercial 16” minimum size limit
Season closure	2.a	Status quo – no season closure as standalone measure
	2.b	Statewide season closure Dec 16 – Feb 28/29 (both sectors)
	2.c	11:59 p.m. Friday-12:01 a.m. Tuesday statewide commercial harvest closure Oct-Dec and Jan-Feb commercial harvest closure. Consider recreational season closures as a part of the overall management strategy to achieve sustainable harvest but not as a single solution option.
	2.d	Statewide season closure Nov 1 – Feb (both sectors)
Bag and trip limits	3.a	Status quo – no change to commercial trip limit. Consider recreational bag limit changes as a part of the overall management strategy to achieve sustainable harvest but not as a single solution option.
	3.b	Reduce recreational bag limit to 2 fish and commercial trip limit to 45 fish
Stop net	4.a	Status quo – no change
	4.b	No change to quota but formalize management in FMP
Combinations	5.a-j & 6.a-h	See tables 2.8 and 2.9
Adaptive management	7	

Table 2.10. Expected reduction in recreational and commercial harvest from management examples organized by single solution ideas including size limit changes (SL.1–10), seasonal or day of the week closures (SC.1–11), commercial trip limit changes (TL.1–6), and recreational bag limit changes (BL.1–6) and combination management ideas including recreational combination management ideas (5.a–l) and commercial combination management ideas (6.a–h). These management examples can be found in Tables 2.3–2.8 but are included in this table for ease of reference. Reductions in pounds are based on average recreational or commercial harvest from 2019 to 2022. Total harvest reductions assume no other management is implemented. Reductions of at least 19.9% (threshold) up to 53.9% (target) are needed to end overfishing. Important table notes: Management examples presented here are not additive. In other words, an overall total expected harvest reduction for combinations of single solution ideas cannot be reached by adding together the Total % Reduction of each individual single solution ideas. **Management examples that do not reach *at least* a 19.9% reduction in harvest will not meet the statutory requirement of ending overfishing.** *Day of week harvest closures are only for commercial harvest, therefore any harvest reduction from day of week closures only includes reductions in commercial harvest.

Management Examples	Month Closure	Day of Week Closure	Bag Limit (number of fish)	Trip Limit (number of fish)	Size Limit	Recreational Reduction (lb)	Recreational Reduction (%)	Commercial Reduction (lb)	Commercial Reduction (%)	Total % Reduction
Single Solution Ideas										
SL.1	-	-	-	-	14”–24”	106,876	3.2	26,696	4.7	3.4
SL.2	-	-	-	-	15” minimum	183,693	5.5	24,424	4.3	5.3
SL.3	-	-	-	-	16” minimum	554,420	16.6	39,921	6.5	6.2
SL.4	-	-	-	-	14”–22”	240,471	7.2	65,321	11.5	7.8
SL.5	-	-	-	-	14”–20”, 1 >24”	507,662	15.2	0	0	13.0
SL.6	-	-	-	-	14”–20”, 1 >26”	601,178	18.0	0	0	15.4
SL.7	-	-	-	-	14”–20”, 1 >30”	617,878	18.5	0	0	15.8
SL.8	-	-	-	-	15”–20”, 1 >24”	731,433	21.9	0	0	18.7
SL.9	-	-	-	-	14”–20”	617,878	18.5	202,212	35.6	21.0
SL.10	-	-	-	-	16”–20”, 1 >24”	1,102,159	33.0	0	0	28.2
SC.1	-	Jan–Sep, Sat–Sun; Oct–Dec, Sat–Mon	-	-	-	0	0	172,107	30.3	4.4
SC.2	Apr–Jun	-	-	-	-	407,465	12.2	99,970	17.6	13.0
SC.3	Apr–Jun	Oct–Dec, Sat–Mon*	-	-	-	407,465	12.2	213,572	37.6	15.7
SC.4	Apr–Jul	-	-	-	-	584,478	17.5	107,922	19.0	17.7
SC.5	Jan–Feb	-	-	-	-	581,139	17.4	122,690	21.6	18.0
SC.6	Apr–Jul	Oct–Dec, Sat–Mon*	-	-	-	584,479	17.5	213,572	37.6	20.4

Management Examples	Month Closure	Day of Week Closure	Bag Limit (number of fish)	Trip Limit (number of fish)	Size Limit	Recreational Reduction (lb)	Recreational Reduction (%)	Commercial Reduction (lb)	Commercial Reduction (%)	Total % Reduction
SC.7	May 16–Sep	-	-	-	-	714,734	21.4	80,657	14.2	20.4
SC.8	Jan–Mar	-	-	-	-	741,453	22.2	153,363	27.0	22.9
SC.9	Dec 16–Feb	-	-	-	-	738,113	22.1	168,131	29.6	23.2
SC.10	Jan–Feb	Oct–Dec, Sat–Mon*	-	-	-	581,139	17.4	228,340	40.2	28.2
SC.11	Nov–Feb	-	-	-	-	1,843,613	55.2	323,198	56.9	55.4
TL.1	-	-	-	65	-	0	0	29,537	5.2	0.8
TL.2	-	-	-	60	-	0	0	48,849	8.6	1.3
TL.3	-	-	-	55	-	0	0	70,433	12.4	1.8
TL.4	-	-	-	45	-	0	0	122,122	21.5	3.1
TL.5	-	-	-	40	-	0	0	151,659	26.7	3.9
TL.6	-	-	-	20	-	0	0	301,046	53.0	7.7
BL.1	-	-	Oct–Dec 3 fish	-	-	190,373	5.7	0	0	4.9
BL.2	-	-	Nov–Feb 3 fish	-	-	223,772	6.7	0	0	5.7
BL.3	-	-	Oct–Feb 3 fish	-	-	273,870	8.2	0	0	7.0
BL.4	-	-	3 fish	-	-	394,106	11.8	0	0	10.1
BL.5	-	-	2 fish	-	-	925,146	27.7	0	0	32.7
BL.6	-	-	1 fish	-	-	1,1760,116	52.7	0	0	45.0
Rec Combo Ideas										
5.a	Jan–Feb	-	Oct–Dec 3 fish	-	-	738,113	22.1	0	0	18.9
5.b	-	-	Nov–Feb 3 fish	-	16” minimum	741,453	22.2	0	0	19.0
5.c	-	-	Oct–Feb 3 fish	-	14”–20”, 1 >26”	824,950	24.7	0	0	21.1
5.d	Jan 16–Feb	-	-	-	14”–20”, 1 >26”	935,166	28.0	0	0	23.9
5.e	Dec 16–Feb	-	3 fish	-	-	1,015,323	30.4	0	0	26.0
5.f	Jan–Feb	-	-	-	14”–20”, 1 >26”	1,078,781	32.3	0	0	27.6

Management Examples	Month Closure	Day of Week Closure	Bag Limit (number of fish)	Trip Limit (number of fish)	Size Limit	Recreational Reduction (lb)	Recreational Reduction (%)	Commercial Reduction (lb)	Commercial Reduction (%)	Total % Reduction
5.g	Jan–Feb	-	Oct–Dec 3 fish	-	14”–20”, 1 >26”	1,205,696	36.1	0	0	30.9
5.h	Apr–Jun	-	3 fish	-	14”–20”, 1 >26”	1,292,533	38.7	0	0	33.1
5.i	Jan–Feb	-	3 fish	-	14”–20”, 1 >26”	1,319,252	39.5	0	0	33.8
5.j	Dec 16–Feb		3 fish		14”–20”, 1 >26”	1,436,148	43.0	0	0	36.7
5.k	Apr–Jul	-	3 fish	-	14”–20”, 1 >26”	1,439,488	43.1	0	0	36.8
5.l	Dec–Feb	-	2 fish	-	14”–20”, 1 >26”	1,923,770	57.6	0	0	49.2
Com Combo Ideas										
6.a	Jan 16–Feb	-	-	60	-	0	0	131,210	23.1	3.4
6.b	Jan–Feb	-	-	65	-	0	0	145,979	25.7	3.7
6.c	Jan–Feb	-	-	-	16” min	0	0	149,955	26.4	3.8
6.d	Feb	-	-	45	-	0	0	164,155	28.9	4.2
6.e	Jan 16–Feb	-	-	45	-	0	0	193,124	34.0	4.9
6.f	Jan–Feb	-	-	50	-	0	0	197,100	34.7	5.0
6.g	Dec 16–Feb	-	-	60	-	0	0	202,780	35.7	5.2
6.h	Dec–Feb	-	-	40	-	0	0	314,110	55.3	8.0

RECOMMENDATIONS

DMF Initial Recommendation:

The DMF recommends the following options that are projected to end overfishing with a greater than 70% probability of keeping SSB above the target:

Option 2.c Seasonal Closures

- Oct–Dec, 11:59 p.m. Friday to 12:01 a.m. Tuesday statewide commercial harvest closure
- Jan–Feb statewide commercial harvest closure
- No change to 75 fish commercial trip limit or 14” commercial minimum size limit

Option 4.b Stop Net Management

- *Stop nets are restricted to the Atlantic Ocean on Bogue Banks and maintain a 4,595 lb. Spotted Seatrout season quota.*
- *The season will open no sooner than October 15 and close when the Spotted Seatrout quota is reached or no later than December 31.*
- *Stop net crews must contact N.C. DMF Marine Patrol Communication each time a stop net is set and two hours prior to each time a stop net is fished.*
- *The same day a stop net is fished and the catch is landed at the fish house, a representative of the stop net crew must contact DMF Fisheries Management Section to report the daily total of Spotted Seatrout in pounds as it appears on the trip ticket. Same day reporting is required even if zero Spotted Seatrout are harvested.*
- *Failure to follow reporting requirements will result in an immediate closure of the stop net fishery.*
- *The Bogue Banks stop net fishery will be managed by proclamation consistent with but not limited to prior proclamations.*

Option 5.h Combination Management Measures

- 3 fish recreational bag limit
- 14”–20” recreational slot limit with allowance for one fish >26”
- Jan–Feb statewide recreational harvest closure

Option 7 Adaptive Management Framework

Appendix 3: SUPPLEMENTAL MANAGEMENT OPTIONS IN THE NORTH CAROLINA SPOTTED SEATROUT FISHERY

ISSUE

The results of qualitative management measures on the North Carolina Spotted Seatrout stock cannot be quantified but implementing these management measures may serve to reduce dead discards, reduce harvest by an unknown amount, and improve the overall Spotted Seatrout stock.

ORIGINATION

The North Carolina Division of Marine Fisheries (DMF).

BACKGROUND

As outlined in Appendix 2, total Spotted Seatrout harvest increased sharply in 2019 and has remained high in the ensuing years through 2022. Most harvest occurs October – December each year. The recreational fishery includes a robust catch and release segment. Since 2012 the recreational sector has accounted for, on average, approximately 85% of Spotted Seatrout harvest (Appendix 2) and the number of recreational trips targeting Spotted Seatrout increased in recent years with biological years 2019 through 2022 representing the four highest numbers of trips since 2012 (Figure 3.1). The proportion of trips that are successful (i.e., anglers are targeting Spotted Seatrout and catch Spotted Seatrout) has remained relatively steady since 2012. The high number of trips targeting Spotted Seatrout has led to not only increased harvest, but also increased dead discards – or fish that are released alive but ultimately die because of the fishing interaction – though on an individual basis discard mortality depends on a variety of factors and is likely low (Gearhart 2002; James et al. 2007; NCDMF 2022). Though the commercial fishery has only accounted for about 15% of total harvest since 2012, commercial landings have also increased in recent years. While commercial dead discards are likely minimal, changes to commercial management (e.g., decreasing trip limits) could cause an unintended increase in dead discards.

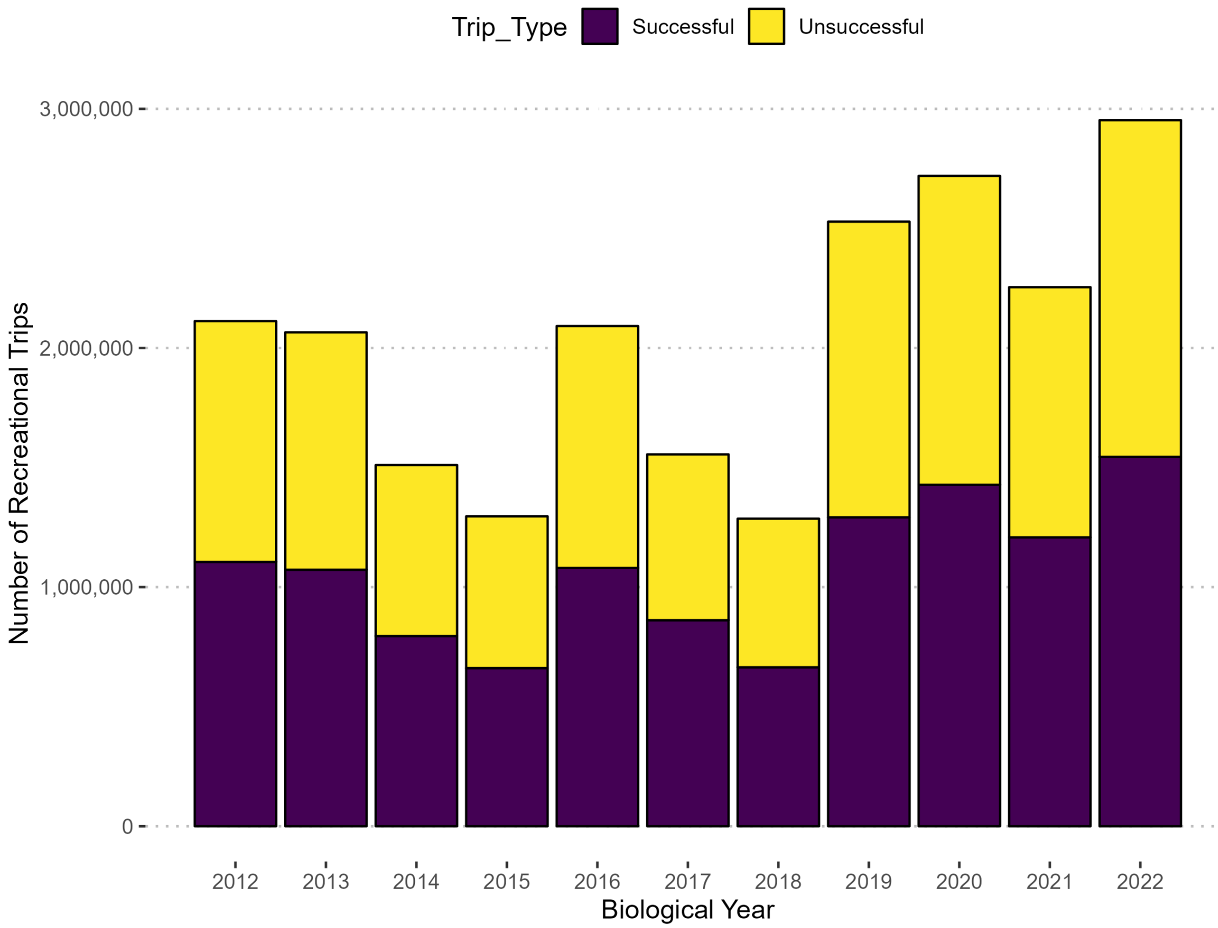


Figure 3.1. Annual MRIP trips where Spotted Seatrout were reported as the primary or secondary target by Biological Year (March–February). Bars are total annual trips with "successful" trips (i.e., a Spotted Seatrout was either harvested or released on the trip) as the purple portion and "unsuccessful" trips (i.e., no Spotted Seatrout were caught) as the yellow portion of the total.

As a result of the popularity of Spotted Seatrout as a targeted species; Marine Fisheries Commission (MFC) commissioners, MFC Advisory Committee members, and the public have mentioned a wide variety of potential recreational and commercial management strategies that could benefit the Spotted Seatrout stock but the scope of which are not immediately quantifiable. The increase in recreational trips targeting Spotted Seatrout and increased total Spotted Seatrout harvest in recent years combined with the presence of a dedicated catch and release segment of the recreational fishery suggest that even management measures lacking immediately quantifiable benefits are worth exploring. Additionally, there are management measures that could provide supplementary benefits when paired with sustainable harvest measures discussed in Appendix 2. For example, gear requirements designed to reduce recreational discard mortality would not provide a quantifiable benefit to the Spotted Seatrout stock, but when paired with a seasonal fishery closure could help prevent an increase in dead discards during the closed season. Discussion will focus on measures specific to the Spotted Seatrout recreational fishery, those more broadly affecting multiple recreational fisheries, and measures specific to the commercial fishery not discussed in Appendix 1.

AUTHORITY

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
15A NCAC 03H .0103 PROCLAMATIONS, GENERAL
15A NCAC 03M .0512 COMPLIANCE WITH FISHERY MANAGEMENT PLANS
15A NCAC 03M .0522 SPOTTED SEATROUT

DISCUSSION

Carry Forward Items from Original FMP

The prohibition on commercial harvest and sale of Spotted Seatrout taken in joint waters on weekends as outlined in the original Spotted Seatrout Fishery Management Plan will carry forward into Amendment 1 to the Spotted Seatrout Fishery Management Plan.

Spotted Seatrout Specific Recreational Management

<u>Recreational Vessel limits</u>

Limiting the harvest of fish through a vessel limit less than the sum of individual bag limits when multiple anglers are on a vessel is a common practice in many state and federal fisheries. Spotted seatrout recreational harvest is limited to four fish per person per day. When multiple anglers are fishing from the same vessel, the anglers may keep the individual bag limit for each angler on board. For example, eight anglers fishing from one boat could harvest eight times the individual bag limit or 32 Spotted Seatrout. Similarly, charter captains and any crew are allowed to harvest their own recreational limit of Spotted Seatrout while running charter trips. The prevalence of multiple anglers on private or for-hire boats harvesting multiple individual limits is unknown but implementing a boat limit and/or eliminating the charter captain and crew allowance should aid in meeting sustainability goals. During the Spotted Seatrout public scoping period, Division staff received public comments suggesting vessel limits and suggesting eliminating the captain/crew allowance. Conversely, during the Spotted Seatrout Advisory Committee Workshop, committee members generally spoke out against vessel limits in the fishery but indicated input members had received from the for-hire industry was generally supportive of eliminating the captain/crew allowance for Spotted Seatrout.

There are anecdotal reports of charter captains and crew harvesting multiple bag limits when running more than one trip in a day (DMF Staff, personal communication) though it is not clear how prevalent this behavior is nor is it possible to assess the impact such behavior has on managed fish stocks. Harvesting multiple charter captain/crew allowances in a day is not legal and leads to unreported harvest of managed fish species.

However, enforcement to ensure a single charter captain/crew allowance is difficult as it would require proof that a captain or crew harvested their personal bag limit on a trip previously taken that same day. During the Spotted Seatrout Public Scoping period there was support voiced for eliminating the captain/crew allowance for Spotted Seatrout, but Spotted Seatrout are not the only species in North Carolina where a charter captain/crew allowance is permitted. Changes to the captain/crew allowance in the Spotted Seatrout fishery could lead to confusion about when a captain/crew allowance is permitted, but there is a precedent for eliminating the captain/crew allowance for a single species in other states. The Louisiana Department of Wildlife and Fisheries included a ban on charter captains/crew harvesting Spotted Seatrout while on a for-hire trip in their November 2023 regulation changes. In its most recent Spotted Seatrout regulation changes, the Florida Fish and Wildlife Conservation Commission implemented similar regulations prohibiting captain/crew harvest while engaged in a for-hire trip. Since addressing the charter captain/crew allowance for multiple species is outside the scope of this amendment, management options here will deal specifically with the Spotted Seatrout fishery.

Option 1: Recreational Vessel Limit Options

a) *Status Quo – Manage fishery without changes to vessel limit or for-hire captain/crew allowance*
b) *Eliminate captain/crew allowance for Spotted Seatrout on for-hire trips with no broader vessel limit*
c) *Implement 8 fish Spotted Seatrout vessel limit with captain/crew allowance on for-hire trips counted as part of vessel limit.*

<u>Effort Controls</u>

One way to reduce harvest in a fishery is to limit those able to participate in the fishery. There are a multitude of ways to limit entry to a fishery and measures to limit recreational participation in the Spotted Seatrout fishery would reduce harvest pressure and would probably reduce fishing effort. G.S. 113-182.1(g) gives authority to the MFC to limit entry into a fishery, however; the authority granted by this statute is limited only to cases where "the Commission determines that sustainable harvest cannot otherwise be achieved." Participation in the fishery increased markedly in biological year 2019 and has remained high since, but Spotted Seatrout life history allows this species to readily recover from periods of high mortality (e.g., cold stuns). Furthermore, Appendix 2 presents multiple options with an at least 50% chance of ending overfishing within a two-year timeframe of plan implementation (G.S. 113-182 .1). The combination of current stock status, species life history, and other available options expected to end overfishing make the Spotted Seatrout fishery unlikely to meet the level required for the MFC to limit entry.

Recreational management beyond Spotted Seatrout

<u>Gear Requirements</u>

Recreational catch and release fishing for Spotted Seatrout has increased in popularity in recent years whether from anglers switching to catch and release fishing after harvesting their limit or from dedicated catch and release anglers. Released Spotted Seatrout have far outpaced harvested fish. From 2017-2019, recreational anglers released almost six times as many fish as were harvested (Table 3.1). Delayed mortality, or discard mortality, is the measure of how many fish released alive ultimately die because of the fishing interaction and, on an individual basis, is likely low for Spotted Seatrout (Murphy et al. 1995; Gearhart 2002; James et al. 2007). Conversely, delayed mortality for throat or gut hooked fish is quite high. Delayed mortality is also dependent on factors such as salinity, dissolved oxygen levels, and length or health of fish (Gearhart 2002; James et al. 2007). Spotted Seatrout aggregations in the small creeks and bays of the upper estuary during winter months could potentially have a larger than expected impact on dead discards in the fishery as anglers are able to fish more efficiently on schools at smaller spatial scales than other times of the year, though any such effects could be mitigated by lower water temperatures and higher dissolved oxygen levels during the winter months. Even with low individual discard mortality rates, the sheer number of releases in recent years makes the cumulative number of dead discards impactful and management to reduce the delayed mortality rate worth discussing.

Table 3.1. Harvest and releases of Spotted Seatrout in numbers of fish for biological years 2017-2022.

Biological Year	Harvest	Release
2017	1,054,500	4,725,746
2018	499,560	16,426,444
2019	2,415,394	7,050,238
2020	1,605,723	5,428,133
2021	1,495,385	6,859,777
2022	1,852,135	11,468,873

Studies of gear requirements that could reduce recreational discard mortality are severely lacking outside of those studies examining the differences in discard mortality when using circle hooks or “J” hooks. Although there are not specific studies exploring differences in circle and J hook mortality rates for Spotted Seatrout, hooking location and the severity of injuries related to hooking are important factors impacting Spotted Seatrout delayed mortality (Murphy et al. 1995; Gearhart 2002; Stunz and McKee 2006; James et al. 2007) and generally studies show circle hooks reduce hooking injuries compared to J hooks in marine species (Skomal et al. 2002; Cooke et al. 2003; Millard et al. 2005; Vecchio and Wenner 2007). In theory, other gear requirements such as eliminating the use of treble hooks with natural baits, using barbless treble hooks or inline hooks on artificial baits, and requiring rubberized landing nets when handling fish should help reduce discard mortality as well, however; there are few studies that attempt to quantify the benefits of these measures.

Implementing gear requirements in the Spotted Seatrout fishery to reduce mortality of released fish would benefit the stock, but single species gear requirements in multi-species fisheries like the Spotted Seatrout fishery can introduce difficulties in enforcement and decrease compliance with the requirements. Enforcement is difficult because it requires proof of an angler’s intent to fish for Spotted Seatrout and the enforcement difficulty provides a built-in loophole for anglers to avoid gear requirements. For example, requiring circle hooks when fishing with natural or artificial baits in the Spotted Seatrout fishery could also affect other robust recreational fisheries like Sheepshead, Red Drum, Estuarine Striped Bass, Summer Flounder, and Kingfishes regardless of whether anglers in these fisheries target Spotted Seatrout as well. If anglers follow Spotted Seatrout gear requirements when fishing for these other species, there could be decreases in recreational discard mortality across multiple fisheries. However, if anglers use these other fisheries to avoid Spotted Seatrout gear requirements, the discard mortality benefit in the Spotted Seatrout fishery would be reduced. Regardless of angler behavior, enforcement remains difficult. Implementing gear requirements such as requiring circle hooks across multiple fisheries could be a way to improve angler compliance, simplify enforcement, and gain the benefit of reduced discard mortality in these fisheries. Circle hooks could be required when fishing with any natural or artificial bait, when using natural or artificial baits in certain areas (e.g., the sounds or rivers), when using natural or artificial baits in combination with hooks of a certain size, or when using natural or artificial baits where the fishing method is similar. The latter two examples could help provide exceptions for instances where circle hooks could significantly affect angler efficiency such as when anglers are targeting Sheepshead or offshore trolling. Gear requirements are likely better discussed outside of species-specific FMPs because of the wide-ranging effects of requirements across multiple fisheries and species-specific FMPs.

Tournaments

Spotted Seatrout are either directly or indirectly a popular target for many saltwater fishing tournaments in North Carolina. DMF does not formally track or register saltwater fishing tournaments though if tournaments wish to sell their catch – common with billfish or King Mackerel tournaments – they must obtain a license from DMF. Additionally, DMF does obtain age samples from some tournaments, mostly billfish or King Mackerel tournaments. The last time DMF staff attempted to generate a list of saltwater fishing tournaments was 2021 and staff learned of 154 tournaments, however Division staff did not consider the list exhaustive. Of the 154 tournaments, 49 either directly targeted Spotted Seatrout or had categories specifically for Spotted Seatrout and 32 tournaments took place where Spotted Seatrout were likely to be encountered even if it was unclear whether a Spotted Seatrout category existed. In other words, over half of the saltwater tournaments the DMF was aware of in 2021 either targeted or had a high likelihood of encountering Spotted Seatrout.

Understanding the impact of fishing tournaments on Spotted Seatrout or other marine and estuarine fish species would require a catalogue of North Carolina saltwater fishing tournaments that does not exist at this time, an idea of the number of participants in each tournament, information on the type of tournament (e.g., catch and release or harvest), data on the number and species of fish caught in each tournament, and additional research. Most existing research exploring the effects of tournaments on fish populations, fish behavior, immediate mortality, and post release mortality have focused on freshwater systems though there have been some recent attempts to understand the impacts of saltwater tournaments on estuarine fish species. Specifically in Texas and Alabama, studies examining initial and post-release mortality of Spotted Seatrout from live-release tournaments found mortality rates well above recent estimates of recreational release mortality (James et al. 2007; Nelson et al. 2021). The same study in Alabama found similar mortality rates as recent estimates of recreational release mortality for Red Drum (Nelson et al. 2021) implying that the effect of tournaments may vary by species. Requiring a license or some sort of registration process with DMF in order to hold a saltwater fishing tournament in North Carolina could help in gathering these necessary data.

However, the 81 saltwater fishing tournaments known to the Division in 2021 targeting or likely to encounter Spotted Seatrout directly targeted or were also likely to encounter other fish species regularly found in similar habitats such as Red Drum, Striped Bass, Black Drum, flounder, Bluefish, Weakfish, and Sheepshead among many other fish species. The other 73 tournaments were predominately King Mackerel, billfish, or Dolphin/Wahoo tournaments which also target regulated species. The diversity of target species and broad spatial range of saltwater fishing tournaments – from many miles up local creeks to many miles offshore – make the potential effects of these tournaments much further reaching than just the Spotted Seatrout fishery. The effects of any attempt to manage saltwater tournaments based on the Spotted Seatrout fishery could have unforeseen influence on other fisheries. For example, if tournaments could not target Spotted Seatrout as a reward category or had to register to do so, this could potentially cause tournament organizers to focus on a different species thus increasing the impact of saltwater tournaments on that species. In order to better understand the current effect saltwater tournaments have on a variety of North Carolina fishes and to better predict how a system of tournament registration or licensing would affect tournaments, this issue should be examined on a broader basis across multiple fisheries. A separate information paper – rather than this amendment – may be the appropriate place for that exploration.

Spotted Seatrout Specific Commercial Management

<u>Hook and Line Harvest</u>

During the Spotted Seatrout Public Scoping Period recreational anglers and commercial fishers regularly expressed interest in a commercial hook and line fishery. The context of interest in a commercial hook and line fishery varied from making the trip limit the same regardless of gear to making the hook and line trip limit consistent with the broader commercial trip limit but prohibiting gill nets as a legal harvest gear to prohibiting gill nets as a legal harvest gear but keeping the hook and line trip limit consistent with the recreational bag limit and other variations on these ideas. Spotted Seatrout Advisory Committee members also discussed commercial hook and line harvest and generally expressed support for the idea with a similar range of context for that support. There is precedent in other states for allowing increased harvest of Spotted Seatrout by hook and line. Some states combine their hook and line allowance with gill net prohibitions (e.g., Florida and Louisiana) while other states allow both hook and line and gill net harvest (e.g., Mississippi). Commercial harvest in other states is minimal, however, and there does not appear to be a directed Spotted Seatrout fishery outside of North Carolina.

Ultimately, it is unclear how changes to the commercial hook and line trip limit would affect the sustainability of Spotted Seatrout harvest. It is likely the benefits or detriments resulting from changes would largely depend on fisher behavior and the specific implementation of such changes. A decrease to the general trip limit would increase dead discards making management less effective, but if a general trip limit decrease were paired with an exclusively hook and line fishery, the potential increase in dead discards could be greatly mitigated (see Appendix 2 for a more detailed discussion on anchored gill net and hook and line discard mortality). Raising the hook and line trip limit in the absence of other gear limitations should be considered with caution since it is unclear the effect such a change would have on current commercial fisher behavior. In theory, consistent trip limits regardless of gear could increase the number of participants in the fishery as fishers with the expertise to fish gill nets would likely continue doing so, fishers without that expertise would no longer be held to the recreational bag limit when fishing with hook and line, and generally increase the areas accessible for commercial harvest (e.g., areas currently closed to gill net harvest or where fishers cannot set gill nets because of environmental conditions such as heavy tides). A hook and line trip limit consistent with other commercial gears could encourage recreational anglers to obtain a commercial license to keep the commercial limit of Spotted Seatrout. A higher hook and line commercial trip limit could also encourage for-hire captains who currently hold a commercial license to use it to allow their clients to keep a commercial limit. Similarly, for-hire captains who do not currently hold a commercial license could be encouraged to obtain one for the same reasons. These scenarios could increase commercial harvest, though if and how much would depend on other management implemented. For example, a hook and line fishery combined with a decreased trip limit could discourage some of this behavior. Changes to the commercial hook and line limit should be preceded by further outreach and stakeholder engagement to help determine the logistics and sustainability of a commercial hook and line fishery.

The potential issues and benefits of a hook and line commercial fishery are not unique to the Spotted Seatrout fishery. The benefits to other species would likely be similar and, depending on the management conditions (e.g., a mismatch of bag and trip limits or open and closed season between the recreational and commercial sectors), the concerns with developing hook and line fisheries are also the same. There are anecdotal reports of recreational anglers using commercial licenses to harvest commercial limits in the cobia and flounder fisheries though the extent of this practice is unclear. Since the issues surrounding hook and line commercial fisheries are the same across the span of multiple species, it may make more sense to discuss commercial hook and line harvest more broadly outside of species-specific FMPs.

<u>Commercial Vessel Limits</u>

At their April 2014 meeting, the MFC Finfish Advisory Committee, while acting as the Striped Mullet Advisory Committee, passed a motion to recommend allowing two commercial fishing license holders fishing from the same vessel using one set of gear to harvest two commercial limits of spotted seatrout. Discussion around this recommendation centered on increased safety – especially in the winter – as well as decreasing the amount of gear in the water. The Finfish recommendation was presented to the MFC at their May 2014 business meeting; however, as addressing this recommendation immediately would have required reopening the Spotted Seatrout FMP for an amendment, the MFC instead voted to include discussion of the Finfish Advisory

Committee recommendation in the next scheduled Spotted Seatrout FMP update. At their October 2024 meeting, the MFC Southern Advisory Committee voted to recommend the 2014 Finfish Advisory Committee recommendation (hereafter the Southern AC recommendation). Throughout the Spotted Seatrout FMP update process, this issue was raised by one stakeholder in public comment.

Adopting the Southern AC recommendation would likely reduce the amount of gear in the water somewhat and increase boater safety. However, it is unclear how much the Southern AC recommendation would reduce gear in the water because it is not clear how many participants in the fishery currently fish with only one license holder on the boat. It is also not possible to know how many of this unknown number of commercial fishers would change their behavior if the Southern AC recommendation were adopted. While fisher safety is a very real concern, it is similarly unclear how much safer the Southern AC recommendation would make the Spotted Seatrout fishery for the same reasons: it is unknown how many commercial fishers already fish with two people onboard and it is unknown how behavior would change.

It is very likely the Southern AC recommendation would increase harvest though the amount of that increase cannot be quantified. Anecdotal reports from commercial stakeholders indicate few commercial trips reach their limit of Spotted Seatrout primarily because commercial fishers approaching their limit are unlikely to continue fishing for Spotted Seatrout (personal communication). Adopting the Southern AC recommendation would double the number of Sotted Seatrout that could be harvested prior to approaching the trip limit. It is highly likely this would increase harvest even though it is not possible to quantify exactly how much. There are other fisheries where multiple trip limits are allowed with multiple license holders onboard (e.g., Striped Bass), but these are predominantly quota managed species where the quota already caps allowable harvest. Additionally, there are anecdotal reports of commercial fishers participating in the Striped Bass fishery obtaining licenses for family members as a way of increasing allowable harvest per trip (NCDMF, personal communication). While the effects of any individual trip are limited by the Striped Bass quota, there is no quota in the Spotted Seatrout fishery, therefore, such behavior in the Spotted Seatrout fishery would increase harvest would. As overfishing is occurring in the Spotted Seatrout fishery, management that has a chance of increasing harvest, even if that increase cannot be quantified, should not be considered. As such, the Division does not recommend adopting the 2014 Finfish Advisory Committee and 2024 Southern Advisory Committee recommendations in Amendment 1.

Option 2: Commercial Vessel Limit Options

- *a) Status Quo – Maintain current management of one 75 fish trip limit per vessel per day.*
- *b) Allow two commercial license holders fishing on one boat with one set of gear to harvest two commercial limits of Spotted Seatrout.*

MANAGEMENT OPTIONS

Table 3.2 Supplemental management options for the Spotted Seatrout fishery. Options would likely provide benefits to the stock but are not able to be quantified.

Topic	Option	Description
Recreational Boat limits and captain/crew allowance	1.a	Status quo – no boat limit, continue captain/crew allowance
	1.b	Eliminate captain/crew allowance on for-hire trips with no broader vessel limit.
	1.c	Implement 8 fish vessel limit with captain/crew allowance on for-hire trips counted as part of vessel limit.
Commercial vessel limits	2.a	Status quo – no change to commercial trip limits
	2.b	Allow two commercial license holders fishing on one boat with one set of gear to harvest two commercial limits of Spotted Seatrout.

RECOMMENDATION

Division Recommendation:

Option 1.b Eliminate the captain/crew allowance on for-hire trips with no broader vessel limit.

Option 2.a Status quo – Maintain current management of one 75 fish trip limit per vessel per day.

Appendix 4: COLD STUN MANAGEMENT

ISSUE

Implement additional management measures to protect Spotted Seatrout spawning stock biomass after periodic cold stun events.

ORIGINATION

The North Carolina Division of Marine Fisheries (DMF).

BACKGROUND

Spotted seatrout (*Cynoscion nebulosus)* and other finfish that over-winter in estuarine environments in North Carolina are susceptible to periodic cold stun events. Cold stun events occur when water temperatures drop below a fish's metabolic minimum, impairing their physiological functions and rendering them lethargic or immobile. These events are associated with rapid weather changes that disrupt the thermal balance of coastal waters. In North Carolina, cold stuns can be triggered by snow and ice melt following a winter storm or by sudden and-or prolonged periods of cooler temperatures from cold fronts. Cold stun events can be localized to individual tributaries, or they can be widespread across multiple estuaries. Mass mortality events can occur in these periods of sub-optimal water temperatures because the impaired function of the fish makes them unable to move to warmer waters. Cold stuns are not always lethal, but if water temperatures drop too low or remain low for too long and fish are unable to move to find thermal refuge, they are unlikely to survive. Fish in a stunned state are also easy targets for scavengers, predators, and can be susceptible to harvest with methods like dip nets.

Cold Tolerance

To better understand environmental conditions that lead to Spotted Seatrout cold stuns, several studies have investigated the temperatures at which Spotted Seatrout become stunned and experience mortality. In North Carolina, laboratory experiments suggest the temperatures in which Spotted Seatrout become stunned, or experience a complete loss of equilibrium, range from 2 to 4°C (Ellis et al. 2017). However, Spotted Seatrout begin showing signs of stress at temperatures as high as 7°C. An adult Spotted Seatrout's critical thermal minimum, or the lowest temperature Spotted Seatrout can be exposed to for a short time and still survive, was found to be approximately between 2-3°C. When adult Spotted Seatrout were acclimated and exposed over time to low water temperatures, a water temperature of 3°C was found to be 100% lethal after less than 2 days (Ellis et al. 2017). At 5°C, 93% were still alive after 5 days, but only 15% survived after 10 days. There was high survival (83%) after 10 days at 7°C. Based on this research, we have learned that Spotted Seatrout's survival of cold stun events is not only related to water temperature, but also the length of time they are exposed to these stressful conditions. Similar studies from South Carolina and Texas conducted on Spotted Seatrout saw comparable temperatures leading to Spotted Seatrout loss of equilibrium and mortality (Anweiler et al. 2014; McDonald et al. 2010), although lower temperatures were required to induce mortality in adults (~2°C) than juvenile (~3°C) Spotted Seatrout, indicating the possibility of size-dependent mortality (McDonald et al. 2010).

For Spotted Seatrout, cold water temperatures disrupt cellular processes, making it difficult to maintain osmotic balance of ion concentrations within their body (Hurst 2007). If temperatures drop below a threshold for long enough, and the fish is unable to leave the area, the imbalance will impact their central nervous system and result in loss of equilibrium, causing the "stunned" response where fish float on top of the water or lay along the bottom.

Population Impacts of Cold Stuns

Spotted seatrout mature quickly, with most able to reproduce by age one. Spotted seatrout are also highly fecund, meaning they can produce many offspring within a spawning season and over an individual's lifetime. Females spawn multiple times throughout a season and can produce 3-20 million eggs per year (Murphy et al., 2010; Nieland et al., 2002; Roumillat & Brouwer, 2004). Though Spotted Seatrout have a high capacity to replenish spawning stock biomass (SSB), they are also especially susceptible to cold stuns due to their limited tolerance for abrupt temperature shifts, particularly when these shifts occur outside of their preferred thermal range (Ellis, 2014). North Carolina Spotted Seatrout are more so susceptible to being impacted by cold stuns because they are near the northern extent of their geographical range.

Cold stun mortality has been shown to have population-level effects on Spotted Seatrout in North Carolina (NCDMF 2012; Ellis 2014; Ellis et al. 2018) by reducing stock size and annual cohort strength (Hurst 2007). Overall, the rate of mortality due to fishing activity or natural causes like cold stuns vary seasonally and annually. Using tag return data, Spotted Seatrout natural mortality has been estimated to be higher than fishing mortality during winters in which cold stuns occurred (Ellis et al. 2018; Loeffler et al. 2018; Bauer and Flowers 2019). The division does not have a method to quantify the severity of a cold stun on Spotted Seatrout SSB in real-time, or as the cold temperatures are occurring. However, eliminating or reducing harvest after a cold stun event protects the remaining SSB by ensuring surviving adults have a chance to spawn.

Compared to other commercially and recreationally important fish species in North Carolina, Spotted Seatrout are more likely to experience population-level impacts from cold stun events. Spotted seatrout are a subtropical fish species, with North Carolina being one of the northernmost points of their range. Consequently, Spotted Seatrout are not as well adapted as other species to withstand winters with below average temperatures and winter storms that occur every few years. In addition, Spotted Seatrout in North Carolina overwinter in shallow estuarine creeks and bays which makes them more susceptible to being stunned or dying compared to other species that overwinter offshore, like weakfish, adult Red Drum, and mature southern flounder (Ellis 2014; Ellis et al. 2017b; McGrath and Hilton 2017; Bacheler et al. 2009; Krause et al. 2020). By overwintering in shallow creeks and bays, Spotted Seatrout have an increased risk of exposure to rapid declines in water temperature, usually due to runoff following snow or ice melt from a winter storm. Spotted seatrout can also become trapped in estuarine creeks due to rapid water temperature drops making escape difficult and mortality likely.

North Carolina Cold Stun Response

In 2015, the NCDMF started a comprehensive, statewide water quality monitoring program (Program 909) and deployed an array of continuous water temperature loggers. A total of 80 loggers at 55 stations measure the water temperature every 15 minutes. Station locations are distributed throughout coastal North Carolina with specific locations that staff determined were either representative of the riverine and estuarine systems they were in and-or locations of historic cold stuns (Figure 4.1). At depths greater than 2 meters, two loggers were placed to monitor temperatures at the surface and bottom to help managers identify water column stratification and turnover events.

Combining known Spotted Seatrout temperature tolerances and available water temperature data allows for more quantitative information that can be used in determining the necessity of a potential fishery closure. Quantitative temperature triggers that incorporate estimated probabilities of mortality could inform Spotted Seatrout fishery closure decisions.

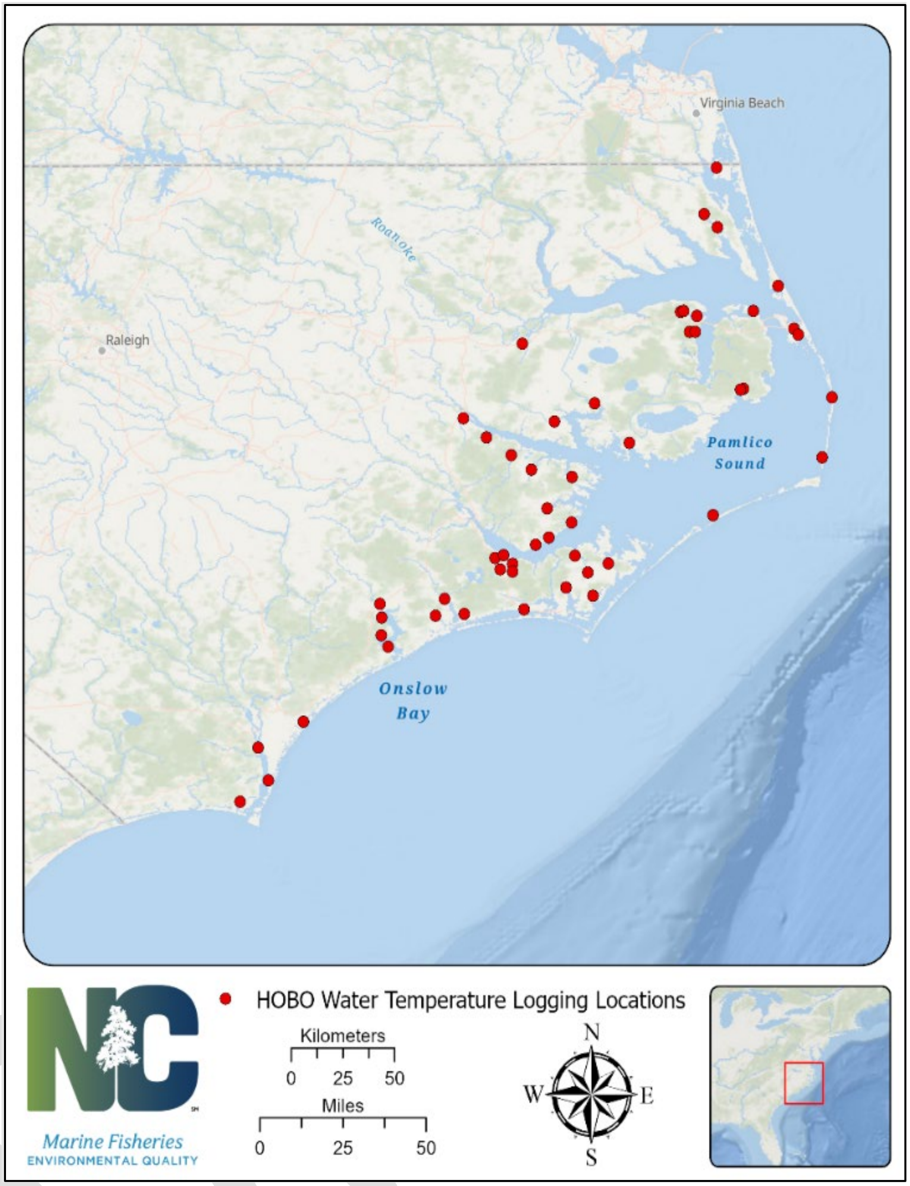


Figure 4.1. Locations of NCDMF water temperature loggers in coastal North Carolina.

Mortality due to cold stuns is recognized in the 2012 Spotted Seatrout Fishery Management Plan (FMP) as a factor impacting the abundance of Spotted Seatrout in North Carolina (NCDMF 2012). At their February 2012 business meeting, the Marine Fisheries Commission (MFC) directed the division to remain status quo regarding Spotted Seatrout management, with the assumption that in the event of a “catastrophic” cold stun the director would use proclamation authority to enact a temporary closure (NCDMF 2012). The objective of a Spotted Seatrout fishery closure after a cold stun event is to allow surviving fish an opportunity to spawn during their spring spawning season, potentially increasing recruitment the following year.

Spotted seatrout have a long history of cold stuns and winter mortality in North Carolina. Spotted seatrout cold stuns have been recorded in North Carolina as far back as over

300 years, and have occurred as recently as the winters of 2000, 2002, 2004, 2009, 2010, 2013, 2014, 2017, and 2022.

AUTHORITY

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
15A NCAC 03H .0103 PROCLAMATIONS, GENERAL
15A NCAC 03M .0512 COMPLIANCE WITH FISHERY MANAGEMENT PLANS
15A NCAC 03M .0522 SPOTTED SEATROUT

DISCUSSION

Several management strategies can be used to further protect Spotted Seatrout SSB after periodic cold stun events. These strategies may include temporary slot limits, fishery closures, spatial (area) closures, or some combination of these options. Management strategies also include the need for the use of adaptive management. Given the inherent difficulty in quantifying the severity of cold stun events as they occur, subsequent management strategies also lack precise quantification methods to determine effectiveness. The proposed management strategies are therefore grounded in a pragmatic, common-sense approach to protect SSB.

Seasonal Closures

The spawning season for Spotted Seatrout varies by location (Brown-Peterson et al., 2002; Nieland et al., 2002; Roumillat & Brouwer, 2004) and can occur with one or two peaks in spawning activity. In North Carolina, Spotted Seatrout have a protracted spawning season, usually lasting from April to October (Burns, 1996). Larger and older females are more developed at the beginning of the spawning season, will spawn sooner than smaller fish, and will spawn for a more protracted season. Smaller fish, that are virgin spawners at the beginning of the season, might enter the spawning stock and spawn later in the year through October.

Following a significant cold stun event, the Spotted Seatrout fishery has historically been closed until June 15th. North Carolina Spotted Seatrout have been observed to have a peak in spawning activity in May and June (Burns, 1996), with some individuals spawning later into the fall months. The option to maintain the status quo would continue to close the fishery until June 15th after a significant cold stun event. However, extending the standard closure to June 30th may ensure that more of the spawning peak is protected and would likely allow most of the larger, older fish to spawn at least once before the chance of significant harvest. Another option would be to extend the standard closure until October 15th, ensuring most surviving fish have the opportunity to spawn during the entire spawning season, but this would result in less fishing opportunities for anglers and likely have a diminishing return for the stock over protection during the peak spawn.

Size Limits

Size and slot limits are a common management strategy to limit harvest of specific size and-or age classes of fish in a stock. By setting a minimum size limit based on length at maturity, management can ensure a portion of the females in the stock have a chance to spawn at least once before harvest. The upper bound of a slot limit likewise helps protect larger females which have a greater reproductive capacity, meaning they can produce more eggs. Estimates of Spotted Seatrout fecundity range from 3 to 20 million eggs per year depending on age, length, and water temperature (Lowerre-Barbieri et al., 2009; Nieland et al., 2002; Roumillat & Brouwer, 2004). Spotted seatrout are batch spawners, meaning they can spawn multiple times in one season. The number of eggs produced within each batch also depends on age and length (Figure 4.2). Spotted seatrout fecundity estimates specific to North Carolina and Virginia are not available at this time.

Theoretically, the ability of the Spotted Seatrout stock to recover faster after significant cold stun event, would be enhanced if larger females are protected. For example, if a slot limit with a trophy fish allowance is adopted for sustainable harvest (Appendix 3, this amendment), the slot limit could be temporarily narrowed and-or the trophy fish allowance could be temporarily removed. Reducing or narrowing the slot limit following a closure, whether by increasing the lower bound or decreasing the upper bound, would ensure more mature fish are available to spawn. Because larger females are more fecund, it may be more important to focus on their protection after a cold stun event. This could be achieved by removing any prospective trophy fish allowance and-or by decreasing the upper bound of the slot limit in response to a severe cold stun event. This temporary slot limit could be put into place until after the peak spawning season (July) or until after most of the spawning season (October).

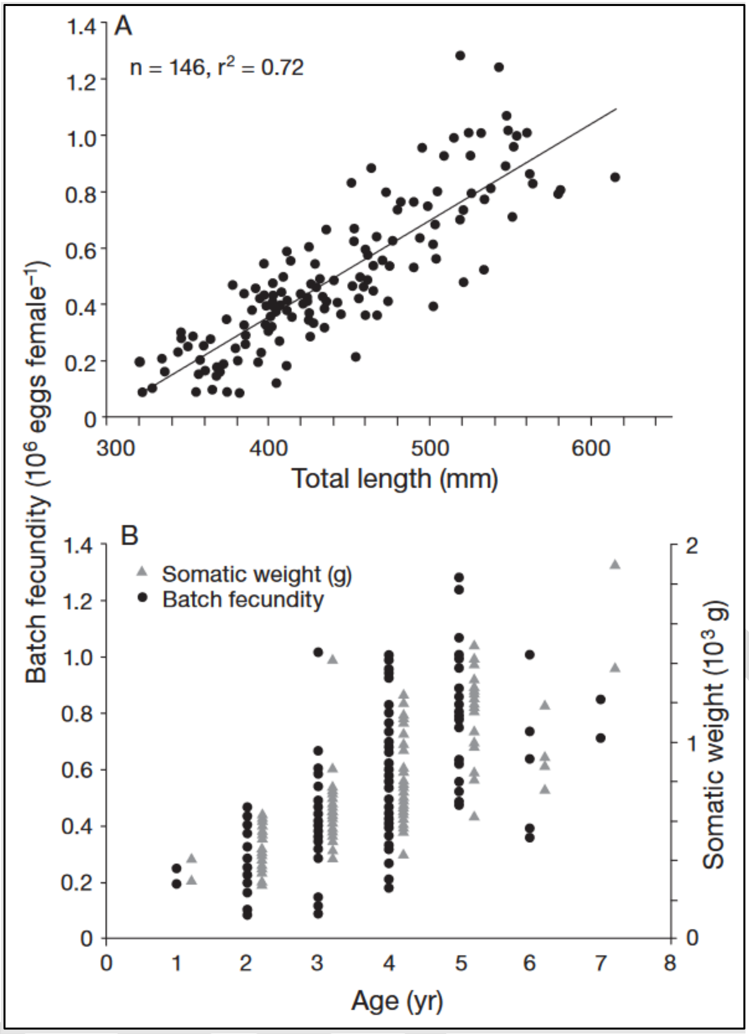


Figure 4.2. Taken from Lowerre-Barbieri et al. (Lowerre-Barbieri et al., 2009). Batch fecundity as it relates to size at age or Spotted Seatrout. (A) Batch fecundity to total length, with the predicted linear relationship, and (B) individual batch fecundities and somatic weights plotted by age.

Bag and Trip Limits

The current Spotted Seatrout daily recreational bag limit is 4 fish, and the daily commercial trip limit is 75 fish. In response to a severe cold stun, temporarily lowering these limits when harvest reopens could potentially reduce overall harvest. This approach aims to increase the Spotted Seatrout spawning stock biomass available through the end of the spawning season. The effectiveness of temporarily reducing bag and trip limits depends on the specific management measures adopted in Amendment 1. For example, if management to extend the cold stun closure through the majority of Spotted Seatrout spawning season is adopted in this Amendment (Appendix 4: Options 1.b or 1.c), temporarily reducing bag and trip limits would likely be less effective in rebuilding the stock as the majority of spawning would occur prior to harvest reopening and a portion of harvest reduced by temporary reductions would likely be recouped prior to the next spawning season. Most recreational and commercial fishers do not harvest their daily bag or trip limit (see Appendix 2) so a modest temporary reduction of bag and trip limits likely would not impact overall harvest. To achieve a reduction in harvest, the temporary reduction in bag and trip limits may need to be more substantial.

Temporary adjustments to bag and trip limits may not be the most effective strategy when applied solely as part of the standard cold stun closure. Instead, they are likely to be more impactful when integrated into an adaptive management framework used in the event of an especially severe cold stun. The adaptive management framework would allow for a more tailored response to address specific conditions that may arise in the event of a severe cold stun.

Area Closures

Historically, cold stun events have varied in their spatial impacts and have ranged from a few isolated creeks in one river system to multiple riverine and estuarine systems. Cold stun events can also occur over large areas of the state, causing more significant losses in all major systems.

Previous cold stun closures have closed the Spotted Seatrout fishery statewide. Tagging and genetics data suggest that Spotted Seatrout exhibit high site fidelity to their natal estuary with periods of greater movement during the spawning season (Ellis, 2014; O'Donnell et al., 2014; Ward et al., 2007). This, coupled with limited movement in the winter months, supports the idea that effects of a cold stun may vary regionally. Using available information about Spotted Seatrout temperature tolerances, mortality probabilities to sub-optimal temperature exposure, and available continuous water temperature monitoring, the division could potentially identify areas of concern when freezing temperatures are predicted to occur. However, the division does not have the ability to quantify or predict the severity of a cold stun event so selecting specific areas for closures would be difficult and may minimize the overall desired impact of maximizing spawning potential following a significant cold stun event.

A statewide closure encompasses all estuarine and riverine systems where Spotted Seatrout overwinter, protecting all Spotted Seatrout in North Carolina from fishing pressure. This ensures areas without documented kills or continuous water temperature monitoring are still protected and that remaining Spotted Seatrout will have the opportunity to spawn before being subject to harvest. However, this strategy will cause fishing opportunities to be lost in areas that may not be affected by cold stun conditions. However, a tradeoff would be that a statewide closure protects fish that may migrate into open areas during more active movement periods during the onset of the spawning period. A statewide closure will also aide Marine Patrol in enforcement of the closure and not burden fisherman with changing boundaries. Further, Spotted Seatrout are assessed and managed as a single stock in North Carolina. Simply closing a small area or region where a cold stun is observed will shift effort to surviving portions of the stock and potentially amplify the negative effects of a cold stun event.

Adaptive Management

The current adaptive management framework for cold stun events allows the Director to close the Spotted Seatrout fishery through June 15th following a significant cold stun event. Since the adoption of the original FMP in 2012 the Spotted Seatrout fishery has been closed twice due to cold stun events (2014 and 2018). The adaptive management framework for cold stun event closures can be refined to further aid in stock recovery following a cold stun event. Adaptive management may be used to temporarily adjust management measures such as size or slot limits, season closures, trip limits, bag limits, and gear requirements if it is determined that additional protections for the stock are needed after a significant cold stun event. Management needed will take into consideration factors such as the size and scope of the cold stun event, the rate of air and water temperature change, and the length of exposure to extreme temperatures. Below is an example of a revised adaptive management framework for cold stun events for consideration.

1) If a significant cold stun event occurs the Director will close the Spotted Seatrout fishery statewide through the date adopted in this amendment.
2) Temporary measures that may be implemented through adaptive management to aid in stock recovery after the standard closure period following a cold stun event include:
    a. recreational bag limit
    b. commercial trip limit
    c. size limit changes
    d. seasonal closure
    e. gill net yardage restrictions
    f. Use of adaptive management to further aid in stock recovery once the fishery reopens following a cold stun event is contingent on approval by the Marine Fisheries Commission.

MANAGEMENT OPTIONS

Table 4.1. Cold stun management options for the Spotted Seatrout fishery. Options would likely provide benefits to the stock but are not able to be quantified.

Topic	Option	Description
Season closure	1.a	Status quo – fishery closed until June 15th following a cold stun
	1.b	Extend fishery closure until June 30th following a cold stun
	1.c	Extend fishery closure until October 15th following a cold stun
Size limits	2.a	Status quo – no size limit change following a cold stun
	2.b	Temporary adjustment of size and or slot limits following a cold stun
Bag and trip limits	3.a	Status quo – no bag/trip limit changes
	3.b	Temporary adjustment of bag and trip limits following a cold stun
Adaptive management	4	

RECOMMENDATIONS

DMF Initial Recommendation:

Option 1.b Extend fishery closure until June 30th following a cold stun

Option 4 Adaptive management

Appendix 5: SPOTTED SEATROUT MANAGEMENT AND STOCK STATUS IN OTHER STATES

Table 5.1 Spotted Seatrout recreational regulations on the Atlantic coast and Gulf of Mexico coast by state as of March 2023. In Florida, Spotted Seatrout are managed separately across five Management Regions (Northeast, Central East, South, Big Bend, and Western Panhandle).

State	Size Limit	Daily Bag Limit	Season	Supplemental Management
VA	14”-24” one >24”	5 fish	Open year round	
SC	14”	10 fish	Open year round	Hook/line & gig only
GA	14”	15 fish	Open year round	
FL				No captain/crew allowance, no trebles w/ live/natural bait
Northeast	15”-19” one >19”	5 fish	Open year round	
Central East	15”-19” one >19”	2 fish	Closed Nov 1-Dec 31	
South	15”-19” one >19”	3 fish	Open year round	
Big Bend	15”-19” one >19”	5 fish	Open year round	
W. Panhandle	15”-19” one >19”	3 fish	Closed Feb	
AL	15”-22” one >22”	6 fish	Open year round	
MS	15”	15 fish	Open year round	
LA	12”-20” two >20”	15 fish	Open year round	No captain/crew allowance
TX	15”-20” one >30”	3 fish	Open year round	

Table 5.2 Spotted Seatrout commercial regulations on the Atlantic coast and Gulf of Mexico coast by state as of March 2023. In Florida, Spotted Seatrout are managed separately across five Management Regions (Northeast, Central East, South, Big Bend, and Western Panhandle).

State	Size Limit	Commercial Trip Limit/Quota	Season	Supplemental Management
VA	14”	51,104 lb annual quota	Sep 1-Aug 31 of following year	A daily incidental catch limit of 50 pounds per licensee aboard a vessel with a max limit of 100 pounds per vessel takes effect once the annual quota is caught.
SC	NA	NA	NA	Closed to commercial harvest
GA	14”	15 fish	Open year round	
FL				
Northeast	15”-24”	50 fish	Open Jun 1-Nov 30	Hook/line or cast net only
Central East	15”-24”	50 fish	Open May 1-Sep 30	Hook/line or cast net only
South	15”-24”	50 fish	Open Jun 1 – Oct 31	Hook/line or cast net only
Big Bend	15”-24”	50 fish	Open Jun 1 – Oct 31	Hook/line or cast net only
W. Panhandle	15”-24”	50 fish	Open Jun 1 – Oct 31	Hook/line or cast net only
AL	NA	NA	NA	Closed to commercial harvest
MS	15”	50,000 lb annual quota	Open year round until quota is met	
LA	14”	15	Jan 2-Dec 31 or until quota is met	No harvest on weekends, hook/line only
TX	NA	NA	NA	Closed to commercial harvest

Table 5.3 The stock status of Spotted Seatrout on the Atlantic coast and Gulf of Mexico coast by state as of March 2023. Not all states manage their Spotted Seatrout stock using stock assessments, therefore a stock status is not available for all states. In FL Spotted Seatrout stocks are assessed separately across five Management Regions (Northeast, Central East, South, Big Bend, and Western Panhandle).

State	Stock Assessment – Year	Stock Status
VA	Yes - 2020	Overfishing occurring, not overfished
SC	No	Unknown
GA	No	Unknown
FL	Yes - 2017	
Northeast		Overfishing occurring, overfished status unclear
Central East		Overfishing occurring, overfished status unclear
South		Not overfishing, not overfished
Big Bend		Overfishing occurring, overfished status unclear
W. Panhandle		Overfishing occurring, overfished status unclear
AL	Yes - 2017	At 20% SPR: overfishing occurring, not overfished At 30% SPR: overfishing occurring, stock overfished
MS	Yes – 2019	Overfishing status unclear, stock overfished
LA	Yes - 2021	Overfishing occurring, stock overfished
TX	No	Stock status unknown but independent sampling indicates depleted stock

Appendix 6: RESEARCH RECOMMENDATIONS

1. Develop a juvenile abundance index to gain a better understanding of a stock recruitment relationship.
2. Research the feasibility of including measures of temperature or salinity into the stock recruitment relationship.
3. Determine batch fecundity estimates for North Carolina Spotted Seatrout.
4. Size specific fecundity estimates for North Carolina Spotted Seatrout.
5. Investigation of the relationship of temperature with both adult and juvenile mortality.
6. Incorporate cold stun event information into the modeling of the population.
7. Estimate or develop a model to predict the impact of cold stun events on local and statewide Spotted Seatrout abundance.
8. Integrate tagging data into stock assessment model so both tagging data and other data sources can work together to give a better picture of the population.
9. Obtain samples (length, age, weight, quantification) of the cold stun events as they occur.
10. Define overwintering habitat requirements of Spotted Seatrout.
11. Determine factors that are most likely to influence the severity of cold stun events in North Carolina and separate into low and high salinity areas.
12. Investigate the distribution of Spotted Seatrout in nursery and non-nursery areas.
13. Further research on the possible influences of salinity on release mortality of Spotted Seatrout.
14. Survey of fishing effort in creeks with conflict complaints.
15. Determine targeted species in nursery areas and creeks with conflict complaints.
16. Microchemistry, genetic, or tagging studies are needed to verify migration patterns, mixing rates, or origins of Spotted Seatrout between North Carolina and Virginia.
17. Tagging studies to verify estimates of natural and fishing mortality.
18. Tagging studies to determine if there are localized populations within the state of North Carolina (e.g., a southern and northern stock).
19. A longer time series and additional sources of fishery-independent information.

20. Increased observer coverage in a variety of commercial fisheries over a wider area.

21. Expand nursery sampling to include SAV bed sampling in high and low salinity areas during the months of July through September.

22. Evaluate the role of shell hash and shell bottom in Spotted Seatrout recruitment and survival, particularly where SAV is absent.

23. Evaluate the role of SAV in the spawning success of Spotted Seatrout.

24. Develop estimates of commercial discards for runaround nets.

25. Conduct a detailed analysis of the existing Program 915 data to determine the extent to which late fall and spring provide insights into overwinter changes in abundance; this analysis could also provide insights into the magnitude of cold-stun events, which could explain differences in the effects observed in tagging and telemetry studies versus survey and fishery monitoring.

26. Improve estimates of recreational discard mortality.

Appendix 7: SPOTTED SEATROUT FISHERY MANAGEMENT PLAN ADVISORY COMMITTEE WORKSHOP SUMMARY

ISSUE

Summarize input received from stakeholders from Spotted Seatrout Fishery Management Plan Advisory Committee Workshop.

ORIGINATION

The North Carolina Division of Marine Fisheries (DMF).

BACKGROUND

The Spotted Seatrout Fishery Management Plan (FMP) Advisory Committee (AC) met for a three-day workshop April 22, 23, and 24 at the N.C. Cooperative Extension – Craven County Center in New Bern. The purpose of the workshop was for the AC to assist DMF staff in evaluating management issues and options included in draft Amendment 1 to the Spotted Seatrout FMP and informing the public on the issues contained in draft Amendment 1, solicit comments from peers and bring comments back to the AC, and evaluate the impacts of management options on the resource and user groups. It is important to note the purpose of the AC Workshop was to receive input from committee members based on their various experiences, expertise, and sector relationships, not to build a consensus among committee members or to recommended specific management strategies.

Division staff presented overviews of the stock assessment, life history, and fishery characterization portions of draft Amendment 1, including the Small Mesh Gill Net Information Paper and the Cold Stun Management, Sustainable Harvest, and Supplemental Management issue papers. Each presentation was followed by an opportunity for the AC to ask clarifying questions and discuss the content and management options included in each paper or section of draft Amendment 1. The AC did not have any suggestions regarding the content or clarity of the informational sections of draft Amendment 1. A summary of the management options and ideas discussed for information and issue papers in draft Amendment 1 are included below. Discussion points are organized by information and issue paper and topic. These points represent the discussion that occurred and the management options or combinations of options the AC suggested the division explore. Division staff explored these options and incorporated them directly into the relevant information and issue paper as appropriate.

DISCUSSION

Small-Mesh Gill-Net Fishery

The AC suggested looking at the data further to see if there is a mesh size(s) that might work with a slot limit in the gill-net fishery. The AC also suggested adding a research recommendation to look at discard mortality from runaround gill nets and other commercial gears.

Sustainable Harvest

Generally, the AC asked the division to prioritize access to the fishery when considering management measures and preferred raising the minimum size limit to reducing the bag/trip limit and season closures. The AC asked the division to consider a 15” or 16” to 20” slot limit, with or without a trophy fish allowance. There was discussion about implementing a commercial harvest cap either at 350,000 or 600,000 lb, similar to how the commercial Red Drum fishery is managed. If a season closure is considered by the division, the AC wanted it to be as short as possible and to consider the number of trips affected by a season closure. The AC gave some ideas for possible winter and spawning season closure options and urged for any closure to be less than 90 days. The AC suggested the division consider several combination options that included raising the minimum size limit, with and without a slot, paired with either a season closure or reducing the bag limit. The AC advised there is a need to build adaptive management into the FMP related to sustainable harvest.

Supplemental Management

The AC did not like the idea of a vessel limit for Spotted Seatrout. AC members relayed there was some support among charter captains to remove the captain and crew limit for Spotted Seatrout but not for species with lower bag limits (e.g., Red Drum, southern flounder).

The AC discussed the possibility of a commercial hook-and-line fishery. Discussion largely centered on the need to limit participation (e.g., exclude recreational fishermen with commercial licenses, commercial fishermen with no history of harvesting Spotted Seatrout) and the need for commercial license reforms prior to allowing a fishery. There was discussion concerning whether the fishery should be allowed with or without gill nets as an allowable gear. They also noted that further outreach and feedback is needed from the public prior to allowing a commercial hook-and-line fishery.

The AC discussed gear requirements in the Spotted Seatrout recreational fishery. Discussion included requiring circle hooks when using natural bait, prohibiting the use of treble hooks when using natural bait, and prohibiting treble hooks on artificial lures. The AC advised that increased outreach regarding ethical angling practices will be needed before any gear changes are required.

The AC brought up the issue of live release fishing tournaments and their potential impact on Spotted Seatrout, particularly the perceived increase in the number of tournaments. There was discussion concerning recent research suggesting the mortality of Spotted Seatrout from live release tournaments is roughly three times higher than recreational release mortality. The AC advised that more information needs to be collected from fishing tournaments.

Cold Stun Management Issue Paper

The AC was receptive to extending the standard cold stun closure period through June 30 (inclusive). The AC did not like the idea of instituting size limit restrictions as part of the standard cold stun management response. Instead, the AC preferred to use adaptive management to implement additional temporary management measures (e.g., size limit, bag limit, trip limit, closed season), with a defined end date, based on the severity of a cold stun. There was a general preference for reducing the bag/trip limit instead of extending the season closure beyond the standard cold stun closure period.

Appendix 8: SUMMARY OF MANAGEMENT RECCOMMENDATIONS AND COMMENT

Table 8.1 Summary of management recommendations from NC DMF, the Northern, Southern, and Finfish Advisory Committees (AC).

	DMF	Northern AC	Southern AC	Finfish AC
Appendix 2: Sustainable Harvest				
Recreational	Option 5.h: 3-fish bag limit 14”-20” slot limit with allowance for one fish >26” January-February harvest closure *39.5% harvest reduction*	No quorum	Option 5.h: 3-fish bag limit 14”-20” slot limit with allowance for one fish > 26” January-February harvest closure *39.5% harvest reduction*	16”-20” slot limit with allowance for one fish > 24” Maintain 4-fish bag limit *33% harvest reduction*
Commercial	Option 2.c: Saturday-Monday harvest closure October-December January-February closure *40.2% harvest reduction*	No quorum	January-February closure Option 1.a: Maintain 75-fish trip limit *21.6% harvest reduction*	Saturday-Monday closure October-December Saturday-Sunday harvest closure January-September *30.3% harvest reduction*
Stop Net	Option 4.b: Formalize management in FMP	No quorum	Option 4.a: Maintain status quo	Option 4.a: Maintain status quo
Adaptive Management	Adopt Adaptive Management Framework	No quorum	Adopt Adaptive Management Framework	
Appendix 3: Supplemental Management				
	Option 1.b: Eliminate captain/crew limit on for-hire trips	No quorum	Allow two trip limits on one boat with one set of gear and two license holders Option 1.b: Eliminate captain/crew limit on for-hire trips	Option 1.b: Eliminate captain/crew limit on for-hire trips
Appendix 4: Cold Stun Management				
	Option 1.b: Extend fishery closure until June 30th following a cold stun Adopt Cold Stun Adaptive Management Framework	No quorum	Option 1.b: Extend fishery closure until June 30th following a cold stun	Adopt Cold Stun Adaptive Management Framework

Online Spotted Seatrout Public Questionnaire

The online Spotted Seatrout Public Questionnaire opened on September 27, 2024 and closed October 16, 2024. In total, the questionnaire had 201 participants, 153 of which left comments in addition to their responses.

Of the open response comments received, 47 were generally negative toward commercial fishing with many of these comments explicitly advocating for an outright ban or additional limitations (e.g., slot limit) on inshore gill nets. Additionally, most comments advocating against gill nets also advocated for a ban on inshore trawling. It is important to note that many of these comments either overstated the contribution of commercial harvest to total spotted seatrout harvest (e.g., “netting is the problem”) or incorrectly blamed inshore trawling.

Twenty-four responders mentioned slot limits with several of these supporting a slot limit with no trophy allowance and one supporting a 25” trophy allowance. Of the suggested slot limits, there was nearly equal support between a 14-20” and a 16-20” slot limit.

Sixteen comments addressed season closures; however, the scope of these comments ranged from not supporting any season closure to supporting extending the winter closure into spring to supporting a spawning season closure. Two responders expressed support for an early spring to June or July season closure as opposed to a wintertime closure.

Eleven responders emphasized the need for stronger enforcement of existing regulations, noting that violations like over-limit trips go unchecked.

Additional responders commented on the importance of equitable management between sectors, the desire for no additional management, or were generally negative toward the entire amendment. Three comments discussed discard rates, suggesting the discard estimates are too high in the recreational fishery.

Two responders mentioned and suggested the elimination of tournaments, citing that too many are being held and that the practice of high grading puts too much pressure on larger fish.

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DECISION DOCUMENT

Eastern Oyster Fishery Management Plan Amendment 5

This document was developed to help the MFC track previous activity and prepare for upcoming actions for Eastern Oyster FMP Amendment 5.
November 2024

Summary

At their November 2024 business meeting, the Marine Fisheries Commission will review and provide input on the draft of Amendment 5 to the Eastern Oyster Fishery Management Plan (FMP). They will then vote on sending draft Amendment 5 out for review by the Marine Fisheries Commission Advisory Committees and the public.

Background

The Eastern Oyster FMP is undergoing its five-year review with focus on wild mechanical harvest, recreational harvest, and formalizing cultch planting as an integrated fishery management strategy. Since there is no stock assessment for status determination of either species, the goal is to manage the resource to maintain both species populations to provide long-term harvest and continue to offer protection and ecological benefits to North Carolina estuaries. Only wild harvest issues and management strategies are considered in Amendment 5 as current shellfish aquaculture methods have limited impacts on wild oyster stocks, and managing the private culture industry has grown beyond the scope of the FMP process.

Recreational shellfish harvest does not require a license in NC, resulting in the inability of the division to adequately collect recreational landings data. This data gap has been cited as a major need in all past FMPs and needs addressed to account for all removals from the populations. Additionally, shellfish harvest is subject to changing area closures due to human health and safety concerns. Without licensing or permitting requirements, the division is unable to ensure that every recreational harvester is informed of shellfish sanitation concerns. The FMP contains an issue paper outlining the broad need to capture recreational harvest sector information and have an effective means to provide health and safety information to all recreational shellfish harvesters.

Management strategies are divided regionally by Pamlico Sound (generally subtidal, mechanical harvest) and South of Core Sound (hand harvest, mixed subtidal and intertidal) populations. These strategies apply to both natural reefs and cultch reefs. Natural reefs formed with no human intervention and cultch reefs were built by DMF. Both types of reefs are colonized by wild oysters. Oyster reefs are highly susceptible to the effects of harvest, particularly mechanical, due to oysters being both a fishery resource as well as their own habitat needed to perpetuate their population.

Pamlico Sound is the only area where mechanical gears are allowed for oyster harvest. Mechanical harvest is managed through a sampling program which was designed to stop mechanical harvest in a management area when the percent legal oyster falls below 26% to reduce habitat impacts. The season duration for mechanical harvest for oysters in each management area can be highly variable and is affected by the amount of the oyster resource available and fishery effort. The current trigger monitoring approach, despite a large sampling effort from the division, does not provide fishery independent data suitable to create indices for a future stock assessment. Additionally, the current approach results in the division having to quickly issue proclamations to close management areas to mechanical harvest, with short public notice. The draft FMP proposes a tiered approach to potential management aimed to balance both the habitat and fishery value of Pamlico Sound oysters. The proposed strategy would provide some certainty in season length for mechanical harvesters and utilize the divisions extensive cultch planting program as a management tool.

South of Core Sound, only hand harvest occurs and accounts for most of the commercial oyster landings. The FMP contains an information paper outlining the decline in participation and landings in hand harvest after a management shift implemented in Amendment 4 reduced holders of a Shellfish License statewide to 2 bushels per day and no more than 4 bushels per vessel in Internal Coastal Fishing Waters. The division is investigating the use of a pilot oyster sentinel site monitoring program to collect fishery independent data for intertidal oyster reefs to potentially inform a future stock assessment and management decisions for the southern region.

Amendment Timing

(gray indicates a step is complete)

You are here

September 2023	Division holds public scoping period
November 2023	MFC approves goal and objectives of FMP
December 2023 – June 2024	Division drafts FMP
July 2024	Division held workshop to review and further develop the draft FMP with the Oyster/Clam FMP Advisory Committee
August – November 2024	Division updates draft plan
November 2024	**MFC Reviews draft and votes on sending draft FMP for public and AC review**
January 2025	MFC Regional and Standing Advisory Committees meet to review draft FMP and receive public comment
February 2025	MFC selects preferred management options
March – April 2025	DEQ Secretary and Legislative review of draft FMP
May 2025	MFC votes on final adoption of FMP
TBD	DMF and MFC implement management strategies

Goal and Objectives

The goal of the N.C. Eastern Oyster FMP is to manage the oyster resource in such a way as to maintain oyster populations that provide long-term harvest and continue to offer protection and ecological benefits to North Carolina's estuaries. To achieve this goal, it is recommended that the following objectives be met:

- Use the best available biological, environmental, habitat, fishery, social, and economic data to effectively monitor and manage the oyster fishery and its environmental role.
- Support and implement the restoration and protection of oyster populations as both a fishery resource and an important estuarine habitat through the actions of the Cultch Planting and Oyster Sanctuary programs.
- Coordinate with DEQ and stakeholders to implement actions that protect habitat and environmental quality consistent with the Coastal Habitat Protection Plan (CHPP) recommendations.
- Manage oyster harvesting gear use to minimize damage to habitat.
- Promote stewardship of the resource through public outreach to increase public awareness regarding the ecological value of oysters and encourage stakeholder involvement in fishery management and habitat enhancement activities.

Summary of Preliminary Management Recommendations

A summary of the DMF’s preliminary recommendations can be found below. ***Please note: these are the Division’s initial recommendations and are subject to change.***

Recreational Harvest

Support the NCDMF to further explore potential options and develop a solution to quantify recreational shellfish participation and landings, and to establish a mechanism to provide all recreational shellfish harvesters with Shellfish Sanitation and Recreational Water Quality health and safety information outside of the FMP process.

Mechanical Harvest

To continue to maintain harvestable oyster populations and to better balance the value of oysters as both a fishery resource and essential habitat, the Division recommends the following:

- Adopt the proposed Pamlico and Neuse River DORAs which are bound by existing navigational aids.
- Adopt the proposed Cultch Supported Harvest strategy as described in the Issue Paper.
- Adopt the proposed Rotational Cultch Site strategy as described in the Issue Paper.

- Adopt the proposed adaptive management framework.

Management Options

Recreational Harvest

Implementing a licensing or permitting requirement for recreational shellfish harvesters would give the Division the opportunity to inform participants of where to find information on harvest closure boundaries, where to sign up to receive polluted area proclamations or to access temporary closure maps, and where to find information on safe handling practices, particularly as it relates to Vibrio bacteria.

To pursue any of these solutions, significant time and effort will be needed to assess internal program and resource capabilities and limitations. Any legislative changes require a specific process and are ultimately out of NCDMF or MFC control. Given these constraints, NCDMF recommends exploring potential options and solutions outside of the FMP process.

Mechanical Harvest

The oyster resource in Pamlico Sound is unique in that the commodity is responsible for building the substrate of valuable subtidal habitat which supports rich biodiversity and provides vital ecosystem services. To continue to maintain harvestable oyster populations in Pamlico Sound, and to better balance the value of oysters as both a fishery resource and essential habitat, a three-tiered approach is proposed for the Pamlico Sound oyster mechanical harvest management:
Deep-Water Oyster Recovery Areas, Cultch Supported Harvest, and Rotational Cultch Sites.

Tier/Strategy 1:

The remnant deep water natural oyster reefs in the Pamlico River and Neuse River have suffered mass mortality from water quality impacts. These reefs have likely not supported much fishery effort since 2018 and have had very few live or legal oysters sampled during division monitoring efforts. Additionally, no cultch planting effort is occurring in these areas. Proposed Deep-Water Oyster Recovery Areas (DORAs) would not open to the mechanical harvest of oyster, to allow these reefs to accumulate shell material to gain the height necessary to be resilient to storm events. Reefs deeper than 5m have been identified to be most vulnerable to poor water quality events. Two proposed DORAs (Pamlico and Neuse River) have been constructed by creating boundaries using existing navigational aids for ease of compliance and enforceability.

Tier/Strategy 2:

The Cultch Supported Harvest strategy seeks to link mechanical oyster harvest management in Pamlico Sound to the Divisions extensive cultch planting effort. The primary changes from previous management in the proposed strategy is that season lengths will be predetermined and based on division pre-season sampling of the oyster resource in these areas, and the 10-bushel per day bays and 15-bushel per day deep areas will be considered differently for each management area. This will eliminate the unpredictability experienced by harvesters of how long mechanical harvest will occur in given season and consider the differences in oyster mortality experienced in varying depths of Pamlico sound. Season lengths will be predetermined based on pre-season sampling of oyster condition. Results of sampling data will be used to set season length as shown in the Issue Paper. During the harvest season, in-season sampling will occur to determine if the initial season length should be extended. Harvesters will be encouraged to report productive sites, aiding in more accurate in-season assessments. The new approach aims to reduce unpredictability by setting season lengths based on oyster resource conditions and ensuring that harvesting does not overly damage oyster habitats. The goal is to balance sustainable oyster harvests with the preservation of habitat provided by cultch planting

Tier/Strategy 3:

The Cultch Planting Program has implemented a reef building strategy in Pamlico Sound to create large ~10-acre cultch planting sites in areas open to mechanical harvest, with the goal of having at least 16 sites planted by 2026. Within each management area there would be four cultch sites integrated into a rotational opening plan. These Rotational Cultch Sites would not be subject to the season lengths set for Cultch Supported Harvest. Instead, a subset of these large cultch sites would be open in each management area and their open/closure status would rotate between seasons. This strategy focuses on the fishery value of these reefs and gives harvesters relatively open access to these targeted cultch plantings. Formalizing a Rotational strategy would also help to add statutory anchor points for the Cultch Planting Program within the requirements of G.S. 113-182.1. This could be useful in pursuing additional and consistent funding for the Program moving forward.

Adaptive Management:

The fixed mechanical season lengths for Cultch Supported Harvest were developed using fishery monitoring data for the five oyster mechanical harvest seasons between November 2018 and May 2023. Any large changes in effort could result in these fixed season lengths becoming either inadequate or too restrictive. The average number of participants with landings in the mechanical oyster fishery between 2018 and 2023 was 93. If the three-year running average of participants is less than 70 or greater than 116 (calculated during annual FMP Update), examination of oyster sampling data and potential adjustment to fixed season lengths for Cultch Supported Harvest is triggered.

Next Steps

At their November business meeting, the Marine Fisheries Commission will review draft Amendment 5 to the Eastern Oyster FMP, including the full list of management options. This is an opportunity for the Commission to provide input on the management strategies and options that are included in the draft FMP for public and MFC Advisory Committee review.

Following their review and input, the Commission will vote to send draft Amendment 5 out for public and MFC Advisory Committee review. If approved, the draft is expected to go out to the appropriate MFC Advisory Committees in January 2025 with a public comment period held around that same time. The outcome of that comment period and MFC AC review would then be presented to the Commission during their February business meeting.

DRAFT SUBJEC

NORTH CAROLINA OYSTER FISHERY MANAGEMENT PLAN AMENDMENT 5

NC Division of Marine Fisheries 3441 Arendell St. P.O. Box 769 Morehead City, NC 28557

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

ACKNOWLEDGMENTS

Amendment 5 to the North Carolina (NC) Oyster Fishery Management Plan (FMP) was developed by the NC Department of Environmental Quality (NCDEQ), Division of Marine Fisheries (NCDMF) under the auspices of the NC Marine Fisheries Commission (NCMFC) with the advice of the Shellfish Advisory Committee (AC). Deserving special recognition are the members of the Shellfish/Crustacean AC and the NCDMF Plan Development Team (PDT) who contributed their time and knowledge to this effort.

Shellfish Advisory Committee

Oyster/Clam Plan Development Team

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EXECUTIVE SUMMARY

*** This section is completed prior to final approval***

INTRODUCTION

This is Amendment 5 to the Oyster 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 4) was approved by the N.C. Marine Fisheries Commission (NCMFC) in 2018. 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 Eastern Oyster fishery is vested in the State of North Carolina. The NCMFC adopts rules and policies and implements management measures for the Eastern Oyster fishery in Coastal Fishing Waters in accordance with 113-182.1. Until Amendment 5 is approved for management, Eastern Oysters are managed under Amendment 4 of the Oyster FMP (NCDMF 2018).

For more information about previous and current management, see the original Eastern Oyster FMP (NCDMF 2001) and the previous amendments, all of which are available on the North Carolina Division of Marine Fisheries Fishery Management website.

Fishery Management Plan History

Original FMP Adoption:	2001
Amendments:	Amendment 1 (2003) Amendment 2 (2008) Amendment 3 (2013) Amendment 4 (2017)
Revisions:	None
Supplements:	Supplement A (2010)
Information Updates:	None
Schedule Changes:	None
Next Comprehensive Review:	Five years after adoption of Amendment 5

Past versions or revisions of the Oyster FMP (NCDMF 2003, 2008, 2013, 2017) are available on the NCDMF website at: https://www.deq.nc.gov/about/Divisions/marine-fisheries/managing-fisheries/fishery-management-plans

Management Unit

The management unit of this FMP includes the Eastern Oyster *(Crassostrea virginica)* and its fisheries in all coastal fishing waters of North Carolina.

Goal and Objectives

The goal of the N.C. Eastern Oyster FMP is to manage the oyster resource in such a way as to maintain oyster populations that provide long-term harvest and continue to offer protection and ecological benefits to North Carolina's estuaries. To achieve this goal, it is recommended that the following objectives be met:

- Use the best available biological, environmental, habitat, fishery, social, and economic data to effectively monitor and manage the oyster fishery and its environmental role.
- Support and implement the restoration and protection of oyster populations as both a fishery resource and an important estuarine habitat through the actions of the Cultch Planting and Oyster Sanctuary programs.
- Coordinate with DEQ and stakeholders to implement actions that protect habitat and environmental quality consistent with the Coastal Habitat Protection Plan (CHPP) recommendations.
- Manage oyster harvesting gear use to minimize damage to habitat.
- Promote stewardship of the resource through public outreach to increase public awareness regarding the ecological value of oysters and encourage stakeholder involvement in fishery management and habitat enhancement activities.

DESCRIPTION OF THE STOCK

Biological Profile

DISTRIBUTION

The Eastern Oyster (*Crassostrea virginica*) is an immobile filter feeding bivalve mollusk occurring naturally along the western Atlantic Ocean from the Gulf of St. Lawrence to the Gulf of Mexico (Figure 1; Bahr and Lanier 1981; Carlton and Mann 1996; Jenkins et al. 1997; MacKenzie et al. 1997). Recent research suggests several related oyster species are distributed throughout the Caribbean and coastal South America; however, the Eastern Oyster’s southern range extends only to the northern Yucatan Peninsula Caribbean (Gaffney 2005; Amaral and Simone 2014).

Initial molecular analysis indicates North Carolina's stock is part of the Atlantic coast stock, which extends from Maine to Key Biscayne, Florida (ASMFC 1988). Additional genetic analyses suggest a population division occurs in the Mid-Atlantic region, subdividing the Atlantic coast stock into northern and southern groups (Wakefield and Gaffney 1996; Hoover and Gaffney 2005; Varney and Gaffney 2008). North Carolina represents a transition zone within the Atlantic stock of Eastern Oyster, with a shift between northern and southern types occurring approximately at the southern boundary of the Pamlico Sound (Sackett 2002).

Figure 1. Distribution of Crassostrea virginica (red line) as adapted from Bahr and Lanier (1981). Current research suggests the range of the Eastern Oyster does not extend south of the Caribbean Sea (adapted from Amaral and Simone 2014).

Eastern Oysters inhabit varied water temperatures that may range between 0 to 32°C annually (Butler 1954). While their optimum salinity range varies between 14 and 28 ppt, oysters can tolerate extreme salinities (as low as 5 ppt and as high as 40 ppt) depending on temperature (Galtsoff 1964; Wallace 1966; Shumway 1996; Loosanoff 1965; Rybovich 2014). The distribution and survival of Eastern Oysters is further influenced by abiotic factors such as oxygenation, flow, and tide (Stanley and Sellers 1986; Roegner and Mann 1995; Kennedy et al. 1996; Lenihan 1999), as well as biotic factors such as disease, bioeroders, and predation (Barnes et al. 2010; Johnson and Smee 2012; Pollack et al. 2012; Dunn et al. 2014). More information on the impacts of introduced pathogens and native bioeroders may be found in the Biological Stressors section.

North Carolina's oyster stocks are composed of both subtidal populations (below the mean low tide water level, up to eight meters deep) and intertidal populations (between the mean high and low tide levels; MacKenzie et al. 1997). Throughout the Croatan, Roanoke, and Pamlico sounds, oyster resources are almost exclusively subtidal. This region is primarily influenced by wind driven tides, with intertidal oysters found occasionally near the inlets. Scattered subtidal populations may be found in larger systems farther south (Newport, White Oak, and New River systems). Conversely, intertidal populations are predominantly observed south of Cape Lookout and throughout estuaries extending to the state's southern border. The horse or crested oyster, (*Ostrea equestris*), may be confused with small Eastern Oysters, and can be locally abundant in both intertidal and subtidal habitats in southeastern North Carolina (Markwith et al. 2009).

MORPHOLOGY

Eastern Oyster bodies (meats) have a small foot, a relatively small adductor muscle, fillibranch gills with interlamellar junctions, and lack a siphon (Galtsoff 1964). The interior of the Eastern Oyster shell contains a purple-pigmented adductor muscle scar that does differentiate Eastern Oysters from other similar species within its range (Figure 2). The left valve is generally more cupped than the right that is normally found on top and there is no gap between the shells when the valves are completely closed (Figure 2; Yonge 1960; Galtsoff 1964). Shell morphology can vary greatly depending on substrate and habitat conditions. For instance, oysters grown in subtidal and lower salinity environments tend to have thick, rounded shells with visible radial ridges (Stanley and Sellers 1986). In the presence of predators, oysters may allocate more energy to shell growth, resulting in thicker and heavier shells (Johnson and Smee 2012; Lord and Whitlatch 2012). Shell thickness has also been found to correlate with latitude and water temperature along the Atlantic coast, with warmer southern locations having oysters with thicker shells than colder northern locations (Lord and Whitlatch 2014).

Figure 2. Left and right valves of a subtidal Eastern Oyster from Stump Sound North Carolina, illustrating the purple pigmented adductor muscle scar in the interior of the cupped left valve, and radial ridges on the exterior of the right valve.

REPRODUCTION AND RECRUITMENT

Oysters are typically hermaphroditic, as they first develop and spawn as males in the first few years and may ultimately develop as females as individuals get larger and older (Galtsoff 1964; Kennedy 1983). Oysters may change sexes once each year when the gonad is undifferentiated (Thompson et al. 1996). Research suggests natural oyster populations maintain balanced sex ratios (Kennedy 1983). However, certain environmental conditions, such as limited food availability and extreme salinity gradients, have been attributed to skewing sex ratios to high abundances of males (Bahr and Hillman 1967; Davis and Hillman 1971; Powell et al. 2013). The sex of nearby oysters may also influence individual oyster sex determination (Smith 1949; Menzel 1951). Age or size selective mortality (i.e., from disease or harvest pressure) can alter oyster population demographics and result in a local shift from male to female majority (Harding et al. 2012).

The formation of eggs and sperm is initially stimulated by increasing water temperatures during the spring (Galtsoff 1964; Kennedy et al. 1996). In North Carolina, oyster broadcast spawning peaks twice, once in June at 20°C, with a second spawning event in August at 25°C (Chestnut 1954). Salinities greater than 10 ppt are also typically required for mass spawning (Breuer 1962). Gonads may be developed in oysters at two to three months old, but most of these sub-adult oysters will not be sexually mature (Galtsoff 1964; Kennedy 1983). Fecundity estimates range from 2 million eggs for a 4 cm (1.5 in) oyster to 45 million for an oyster 7 cm (2.8 in) in length (Kennedy et al. 1996). These estimates range widely as oysters can spawn several times per season and gonads may expand into other tissues (Kennedy et al. 1996). However, it’s accepted that larger oysters allocate greater energy towards egg production, and therefore have increased fecundity (Kennedy et al. 1996). For instance, oysters collected from North Carolina’s no-take sanctuaries have demonstrated that fecundity increases exponentially with size, reaching the highest levels in May (Mroch et al. 2012; see Appendix 4 for further information on NC’s Oyster Sanctuaries).

Under normal conditions, male oysters spawn first in response to various physical stimuli and environmental conditions. Female oysters are stimulated to spawn specifically by the presence of oyster sperm. Fertilization must take place shortly thereafter in the surrounding waters, or the unfertilized eggs lose their viability. Fertilized eggs develop into a free-swimming larva, which can migrate vertically in the water column in response to temperature and salinity changes (Hopkins 1931; Galtsoff 1964). Oyster larvae have also been documented to travel up to 30 miles, with dispersion strongly dependent on prevailing winds (Bahr and Lanier 1981; Andrews 1983). Patterns of larval distribution in North Carolina estuaries remain relatively unstudied; however, predictive models of Pamlico Sound larval dispersal from oyster sanctuaries have been developed (Haase et al. 2012).

An oyster larva may visit several sites before it cements itself to the substrate (Kennedy et al. 1996). Several environmental factors, including light, salinity, temperature, acoustic signature, and current velocity may influence the setting of larvae (Hidu and Haskins

1971; Lillis et al. 2013). Oyster larvae also respond positively to a protein on the surface of oyster shells as well as other recently set spat (Kennedy et al. 1996). Larval oysters tend to set in the intertidal zone where salinities are above 20 ppt whereas in subtidal areas they set when salinities are below 20 ppt (Mackin 1946; Loosanoff 1952; Menzel 1955). Generally, spatfall is higher in intertidal areas and in areas boasting salinities in the upper range of tolerance (Bahr and Lanier 1981).

Chestnut (1954) reported recruitment peaks generally occurring in June, the latter part of August and possibly another peak in October. Ortega et al. (1990) found recruitment in western Pamlico Sound to be continuous, concentrated in one or two peaks depending on the year and location. Generally, peaks occurred in June (lesser) and September-October (greater). Munden (1975) reported that spat monitors located in Morehead City and Wilmington did not show a decline in availability of spat during the summer of 1972 until September.

GROWTH

Oyster growth is highest during the first six months after settling and gradually declines throughout the life of the oyster (Galtsoff 1964). Seasonally, adult oysters grow most rapidly during spring and fall in North Carolina. Shell growth was found to cease when water temperatures reach 28°C and slowed when temperatures decreased to 5°C (Chestnut 1954). Ortega et al. (1990) examined data from 1979-1989 and found that spat from all western Pamlico Sound sites attained lengths of 10-40 mm during the first year and reached marketable size (76 mm) by the end of three years. Varying growth rates have been observed between and within different regions of North Carolina and under different environmental conditions (Godwin 1981; Kennedy and Breisch 1981; Roegner and Mann 1995; Puckett and Eggleston 2012).

Stock Status

There is insufficient data to conduct a traditional stock assessment for the Eastern Oyster in North Carolina; therefore, population size and rate that oysters are removed from the population cannot be determined. Currently, the only long-term data representative of the stock are commercial landings and associated effort. For information on the methodology used in previous stock assessment attempts, see Amendment 4 of the Oyster FMP.

While the Eastern Oyster is managed by 18 other states along the Atlantic Coast and Gulf of Mexico, it is worth noting that only Louisiana, Maryland, and Virginia have complete stock assessments (Delaware conducts a population survey to set quotas; New Jersey does an annual assessment of Delaware Bay). Louisiana's most recent stock assessment in 2023 utilized 1,700 dredge samples and 1,000 diver quadrat samples collected during summer months. Their results suggested a 118% year-over-year increase in the stock of oysters, with most of the stock occurring in the west. Maryland conducts a stock assessment within the northern region of Chesapeake Bay and its tributaries (north of Smith Island, following the state-boundary); while Virginia's stock assessment of eastern oysters includes the southern portion of the Chesapeake and its tributaries, including the James River.

Virginia Oyster Stock Assessment and Replenishment collects data during the fall using tongs to extract samples of one square-meter (VOSARA). Their most recent evaluation found the oyster stock in the southern Chesapeake was at its best condition in a generation, extending the fishery season for the first time since 1987. In addition to a stock assessment, Virginia employs a rotational harvest management system for the Eastern Oyster. Maryland's stock assessment, which involves a stage-structured model integrated with various fishery-independent data, recently reported increases to their adult and spat populations but regional overfishing occurring within the fishery (MDDNR 2021). For more information on how other states manage their Eastern Oyster fisheries, see Appendix 5.

Researchers at North Carolina State University and The Nature Conservancy have partnered with NCDMF to design statistically robust fishery-independent population survey methodologies for oysters in North Carolina to inform a potential future stock assessment. While methods have been developed, NCDMF does not currently have the staff or equipment resources to implement the recommended sampling programs.

STOCK UNIT

For the purposes of this fishery management plan, the unit stock is considered all Eastern Oysters occurring within North Carolina coastal waters.

DESCRIPTION OF THE FISHERIES

Additional in-depth analyses and discussion of North Carolina's commercial oyster fishery can be found in earlier versions of the Oyster FMP, Revisions, Amendment 1, Amendment 2, Supplement 2A, Amendment 3, and Amendment 4 (NCDMF 2001, 2003, 2008, 2010, 2014, 2017); all FMP documents are available on the DMF Fishery Management Plans website and commercial landings can be found in the License and Statistics Annual Report (NCDMF 2022) produced by the DMF which can be found on the DMF Fisheries Statistics page (https://www.deq.nc.gov/about/divisions/marine-fisheries/science-and-statistics/fisheries-statistics).

Commercial Fishery

HISTORICAL OVERVIEW

The Eastern Oyster fishery was the first regulated fishery in North Carolina, with laws limiting gear to hand methods only and prohibiting oysters from being sold out of state until 1872 (Thorsen 1982). Prior to 1880, New Bern and Wilmington were the state's major oyster markets, while Beaufort and Washington were also sites for significant oyster trade. Despite dredging methods being blamed for overharvesting in other states, North Carolina adopted a law in 1887 allowing for oyster dredging in public bottom waters deeper than 8 ft throughout Pamlico and Roanoke sounds (Thorsen 1982). However, a loophole resulted in an influx of out-of-state fishers flocking to North Carolina in 1889. Consequently, increased exploitation of oyster stocks with dredges and mechanical tongs led to a conflict between resident and out-of-state oystermen known as the "Oyster Wars".

In response to the conflict, a law prohibiting oyster harvest by non-residents was passed and enforced in 1891. Attempts to return to hand-harvest-only management from 1892 to 1895 and limited dredging in 1896 resulted in huge declines in oyster production and closing of many oyster canneries. In 1897 the dredging law was amended, allowing limited dredging, a longer dredging season, and more law enforcement, resulting in 677,239 bushels landed and reopening of the canneries. Landings reached their highest level in 1902 at 806,363 bushels (Table 1).

However, oyster landings saw a drastic decline soon after this peak, reaching 171,090 bushels in 1918. Around this time, the state recognized the value of recycling shell for rebuilding oyster beds. From 1915 to 1920, the state began funding the Cultch Planting Program, resulting in 10,000-12,000 bushels of shell being planted each year for the aimed benefit of the fishery. After initial success and apparent rebound in harvest, additional state funding allowed the program to scale up and plant around 100,000 bushels of seed oysters and substrate in the early 1920s. Harvest statistics show a rebound in landings from 1923 to around 1931. For a more comprehensive history of the Cultch Program, see Appendix 1.

All oyster landings prior to 1931 were accomplished using hand methods and sail-powered oyster dredge boats. The 1940s saw restrictions on powerboats lifted, likely due to heightened demand and the price of oysters during World War II. The distinction between power and sailboat dredging disappeared altogether by 1955. Throughout the remainder of the 20th century, oyster landings fluctuated between 650,000 to less than 50,000 bushels per year. Apart from 1987, the overall trend of oyster landings in North Carolina was that of gradual decline through 2000.

There appear to be several factors contributing to the continued landings decline. For instance, taking oysters for personal consumption was allowed year-round until 1966, which may have been exacerbated by the fact that hand gear for oyster harvest has been largely unregulated in shallow subtidal (hand tongs) and intertidal areas (hand rakes and by hand). Furthermore, a lack of adequate enforcement seemed to allow the harvest and sale of undersize oysters; it was not until 1981 that the three-inch size limit was applied throughout the state (Chestnut 1951; Thorsen 1982).

For a more thorough history of the oyster fishery including changes in regulations for commercial gear, length of seasons, and openings and closures of bays, refer to Amendment 4 of the Oyster FMP (NCDMF 2017).

MECHANICAL HARVEST METHODS

Harvest of oysters by mechanical methods is accomplished almost exclusively with oyster dredges in North Carolina (Figure 3). The dredge itself is a metal frame with a chain mesh acting as a net, collecting oysters or other shellfish, while a boat tows it along the bottom. Other mechanical gear used for harvesting oysters include patent tongs and power rakes. NCDMF commercial fishery statistics indicate prior to 1960, most oyster landings were taken by dredge when compared to all hand methods (Figure 4). Chestnut (1955) reported that 90% of oysters landed in North Carolina prior to 1960 came from Pamlico Sound, suggesting that harvest in Pamlico Sound was largely dependent on dredging.

The mechanical oyster fishery is limited to Pamlico Sound with a maximum season beginning on the third Monday in November and running through March 31. Mechanical harvest gear is restricted to the deeper portions (more than 6 ft) of the Sound, including deeper areas of rivers and bays (see Appendix 2, Figures 2.8 and 2.9). There are currently four oyster management areas for mechanical harvest in Pamlico Sound: Northern Dare, Northern Hyde, Pamlico River, and Neuse River (see Appendix 2, Figures 2.8 and 2.9). Throughout these areas, mechanical harvest is limited to 15 bushels per fishing operation in the open sound and the Neuse and Pamlico rivers. Conversely, some larger bays and tributaries are also open to mechanical harvest for a maximum of six weeks with a limit of 10 bushels per fishing operation. These areas and limitations are based on recommendations and criteria established in the original Oyster FMP (NCDMF 2001) and are designated in N.C. Marine Fisheries Commission Rule 15A NCAC 03R .0108.

In-season openings and closures of these areas are determined by management triggers. These triggers are based on the percentage of legal sized oysters (≥3 in) in a management region. Biweekly monitoring by NCDMF gathers samples in bays and deep waters of Pamlico Sound across four management areas. Failure to meet the 26% legal-size threshold for two consecutive trigger sampling trips results in closure of an area. The specifics of the trigger sampling protocol are outlined in further detail in Supplement A to the Oyster FMP (NCDMF 2010). The trigger sampling as it applies to the season length is further discussed in Appendix 2 (the Mechanical Oyster Harvest Management Issue Paper).

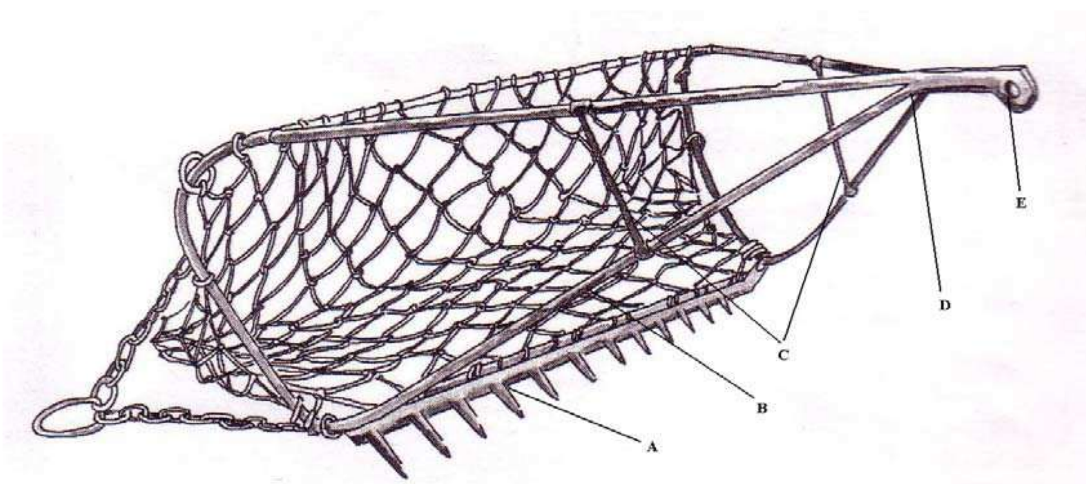

Figure 3. Sketched illustration of a dredge used in North Carolina's mechanical oyster fishery (from Shefi 2007, adapted from Heddeen 1986).

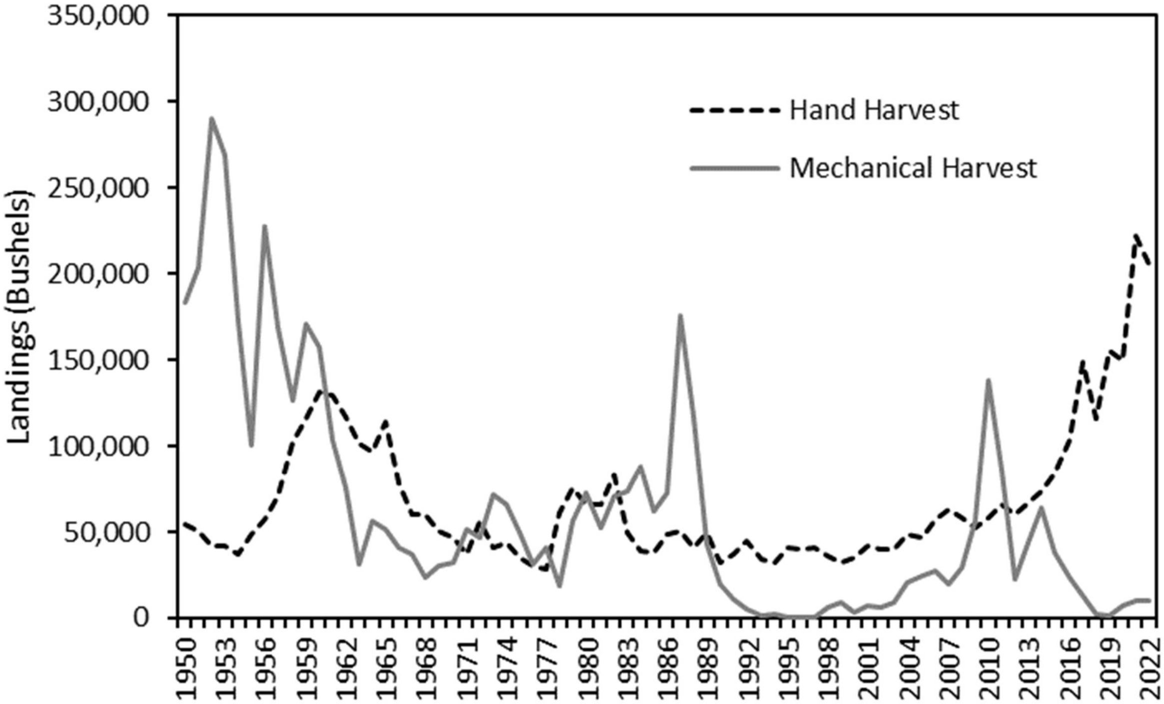

Figure 4. Commercial oyster landings by gear, 1950-2022. Landings for both gear types include both from public and private bottom. The recent increase in hand harvest is attributed to increasing participation in private aquaculture in North Carolina. (Sources: Chestnut and Davis 1975; National Marine Fisheries Service unpublished data; NCDMF Trip Ticket Program).

In areas open to mechanical harvest (see Appendix 2, Figures 2.8 and 2.9), oysters may be impacted by hurricanes, low dissolved oxygen events, or extreme temperatures. These impacts may only allow harvest for a few weeks before the management trigger is reached. Furthermore, poor water quality from storm events has disproportionately affected the deep-water oyster reefs in the Neuse River and Pamlico River areas of western Pamlico Sound. These reefs have suffered large die offs compared to oyster reefs in the shallow bays or the eastern portion of Pamlico Sound, closer to Oregon Inlet. These reefs have been in poor condition since 2017 and have likely not supported any significant mechanical harvest.

Research has shown oyster reefs need higher vertical relief (height) in these deep areas to be resilient to negative water quality impacts from storm events (Lenihan and Peterson 1998; Lenihan 1999). However, mechanical harvest reduces the ability of natural oyster reefs in deep water to gain and maintain height as dredging actively removes valuable shell bottom habitat (see Threats and Alterations for further information). As a result of these influences affecting oyster condition within the fishery and current trigger sampling protocol, the actual mechanical harvest season for oysters is highly variable. This variability in season length and area openings is often viewed negatively by commercial harvesters.

In-season openings and closures of these areas are determined by management triggers. These triggers are based on the percentage of legal sized oysters (≥3 in) in a management region. The specifics of the trigger sampling protocol are outlined in further detail in Supplement A to the Oyster FMP (NCDMF 2010). The trigger sampling as it applies to the season length is further discussed in Appendix 2 (the Mechanical Oyster Harvest Management Issue Paper).

Table 1. North Carolina oyster landings in pounds of meat and bushels, 1880-2022. (Source: Chestnut and Davis 1975; National Marine Fisheries Service unpublished data; NCDMF Trip Ticket Program).

Year	Pounds	Bu. (x1,000)	Year	Pounds	Bu. (x1,000)	Year	Pounds	Bu. (x1,000)
1880	938,400	134	1959	1,311,000	287	1992	293,956	50
1887	1,175,650	168	1960	1,216,200	289	1993	223,136	35
1888	1,129,960	161	1961	1,209,100	233	1994	183,704	35
1889	5,528,942	790	1962	961,400	192	1995	220,661	42
1890	4,456,075	637	1963	694,000	133	1996	210,931	40
1897	4,740,675	677	1964	727,700	153	1997	218,970	41
1902	5,645,928	807	1965	863,700	166	1998	224,214	42
1908	4,159,320	594	1966	626,200	119	1999	216,831	41
1910	1,834,058	262	1967	514,900	98	2000	203,427	38
1918	1,197,630	171	1968	402,600	84	2001	258,086	49
1923	3,089,146	441	1969	370,300	80	2002	243,775	46
1927	2,397,750	343	1970	382,500	79	2003	261,043	49
1928	2,286,610	327	1971	423,400	88	2004	367,961	70
1929	2,828,420	404	1972	470,112	103	2005	378,014	71
1930	2,205,674	537	1973	548,351	112	2006	447,889	85
1931	1,500,571	353	1974	558,821	109	2007	441,415	83
1932	1,201,356	275	1975	424,831	84	2008	466,176	88
1934	1,160,700	271	1976	333,315	61	2009	573,630	108
1936	2,480,500	651	1977	365,714	69	2010	1,040,407	197
1937	1,940,900	457	1978	449,544	84	2011	800,543	151
1938	1,426,900	334	1979	665,439	132	2012	440,063	83
1939	1,055,600	313	1980	723,099	139	2013	586,625	111
1940	690,400	204	1981	550,502	119	2014	727,775	138
1945	1,707,100	586	1982	611,998	155	2015	648,444	123
1950	1,322,100	238	1983	724,509	123	2016	668,423	126
1951	1,531,900	253	1984	724,557	128	2017	852,848	161
1952	1,620,900	331	1985	545,439	100	2018	625,278	118
1953	1,525,300	310	1986	745,548	120	2019	832,708	157
1954	998,400	210	1987	1,425,584	226	2020	829,106	157
1955	731,000	150	1988	913,100	157	2021	1,227,347	232
1956	1,318,000	285	1989	529,858	92	2022	1,142,911	216
1957	1,086,500	239	1990	328,850	52			
1958	1,041,500	228	1991	319,040	48			

Recent Changes to Mechanical Harvest Methods

The most recent changes in mechanical harvest gear management included closing off 30,000 acres to mechanical gear by closing the upper portions of the Pamlico Sound bays and part of Roanoke Sound. The closures were accomplished under a framework established in the original Oyster FMP (NCDMF 2001). Another change was reduction of the mechanical harvest limit to match the hand harvest limit set in the remaining areas of Pamlico Sound as outlined in Amendment 2 (NCDMF 2008). Supplement A to the Oyster FMP established a trigger-monitoring system for determining the closure of mechanical harvest areas and changed the management strategy for mechanical harvest limits to allow up to 20 bushels to be harvested per commercial fishing operation per day (NCDMF 2010). The bays around Pamlico Sound are opened for a six-week season normally from mid-November through December with a 10-bushel-per-commercial-fishing-operation-per-day harvest limit as adopted in the original Oyster FMP (NCDMF 2001).

From 2009 to 2012, many inexperienced oyster dredgers came into the fishery and several new restrictions were required to maintain traditionally accepted harvest and culling techniques. The 2 PM time limit on dredging resulted in harvesters culling their entire catch after 2 PM rather than on-site, often depositing cultch where it could no longer function as oyster habitat. North Carolina Marine Fisheries Commission Rule 15A NCAC 03K .0202 requires that oysters be culled on site. It is unlawful to possess more than five bushels of unculled catch onboard a vessel. Only material on the culling tray is exempt from culling restrictions. It is unlawful to possess unculled catch or culled cultch material while underway and not engaged in mechanical harvesting.

Additionally, some harvesters did not have vessels or dredges rigged for circular dredging patterns which work best with towing points over the side of the vessel or for short tows. As a result, restrictions were put in place to encourage circular dredging patterns and shorter tows to encourage culling between pickups. These restrictions include: 1) It is unlawful for the catch container (bag, cage) attached to a dredge to extend more than 2ft in any direction from the tooth bar; and 2) it is unlawful to tow a dredge unless the point where the tow line or cable is in the water is on the port or starboard side of the vessel forward of the transom.

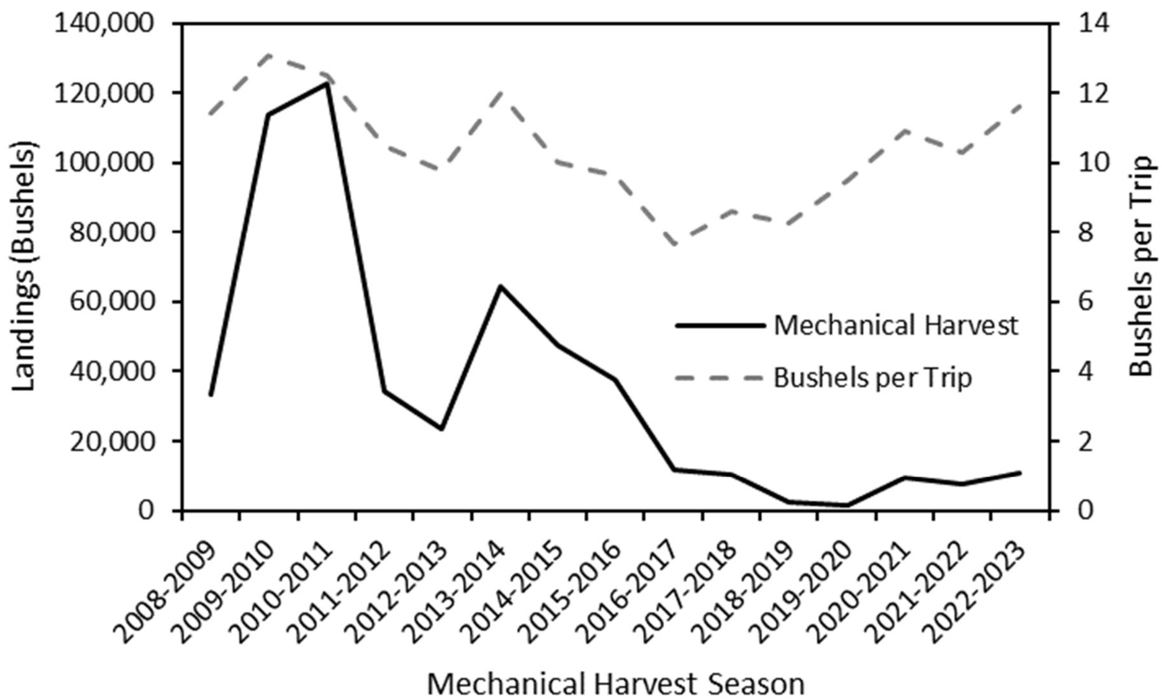

Figure 5. Mechanical harvest oyster landings on public bottom by season 2008-09 through 2022-23. A monitoring system for determining the closure of mechanical harvest areas began in the 2010-11 season (Source: NCDMF Trip Ticket Program)

Recent Trends and Impacts to Mechanical Harvest

In the past two decades the mechanical oyster fishery has experienced two relative peaks—the 2009 and 2014 seasons (Figure 5).

During the early 2009-2010 mechanical harvest oyster season, the Great Island Narrows area between Great Island and mainland Hyde County experienced intensive oyster harvest. NCDMF staff observed approximately 50 oyster dredge boats intensively working in this small area with some returning with new crews to fish the 15-bushel limit twice in one day. Further investigation indicated substantial shell damage was occurring on the remaining oysters and the area was closed after six weeks of harvest. Deeper waters of western Pamlico Sound and areas of Middle Ground also contributed to increased landings in the 2009-2010 and 2010-2011 seasons.

The closure of oyster harvest areas in the Gulf of Mexico following the Deepwater Horizon oil spill generated greater market demand and resulted in North Carolina's mechanical harvest season opening earlier on November 1st in 2010. Supplement A to the N.C. Oyster FMP Amendment 2 (adopted November 3, 2010) provided for a variable mechanical harvest limit of up to 20 bushels per day from November 18-24 and March 16-31 and likely increased landings. The Neuse River area was closed to dredging from January 7 to February 14, 2011, because samples failed to meet the minimum 26% legal size criterion set in Supplement A (NCDMF 2010). Effort in the Neuse River area appeared to be much lower after the re-opening.

In August 2011, Hurricane Irene had major impacts on mechanical harvest areas. Sedimentation or strong currents likely buried or displaced oyster resources on the Middle Ground following the storm. Many of the deeper water oyster resources located near Brant Island Shoal also suffered significant damage caused by detritus covering and killing oyster beds. Oysters in the Neuse and Pamlico rivers did not show any of the typical growth patterns in the following months, which likely had a pronounced effect on the mechanical harvest season in 2011-2012. The mechanical harvest area in western Pamlico Sound was closed on January 2, 2012. Sampling of oyster sizes has made it clear that oyster growth during the harvest season is essential to sustain acceptable harvest levels.

Prior to the 2012-2013 mechanical harvest season, NCDMF oyster sampling indicated an apparent, severe low dissolved oxygen event occurred in the Neuse River that caused virtually 100 percent mortality of the oyster resources at 18 ft or greater depths. A few oyster rocks in shallower waters between Maw Point Shoal and Light House Shoal were spared as well as some NCDMF oyster habitat enhancement projects in other shallow areas. The Pamlico River area also had not recovered from the effects of Hurricane Irene at this time. The Neuse River area was available for mechanical harvest until the adjacent bays closed on December 21 although there was no harvest activity in the river during the time it was open. The Pamlico River area closed to mechanical harvest on February 1, 2013 based on failure to meet the 26% trigger although effort was much reduced since early January. The 2012-2013 mechanical harvest oyster landings declined further to 23,566 bushels (Figure 5).

There was little evidence of recovery of the Neuse River oyster resources prior to the 2013-2014 season but the Pamlico River area appeared to be recovering and growth indicators were good during the season. The Dare County area in northern Pamlico Sound also supported some significant mechanical harvest activity throughout the season, and when oyster harvests began to decline in the western sound in early February, 20 to 25 boats moved to Dare County to finish the season. The remaining productive areas in the Neuse River closed on February 28, 2014 and most of the harvesters left the Pamlico River area by mid-February. Mechanical harvest in Dare County continued until the season ended on March 31, 2014. The overall result was a significant increase in mechanical harvest oyster landings with 64,274 bushels for the season.

After the peak in 2013-2014, mechanical oyster harvest declined steadily, reaching lows reminiscent of the mid-1990s. Hurricane Florence in 2018 severely damaged coastal infrastructure, vessels, and habitat. These impacts, along with the world-wide COVID pandemic, are likely responsible for low harvest between 2018 and 2020. Since then, mechanical harvest landings have rebounded slightly to 11,061 bushels in the 2022-2023 season (Figure 5).

Overall, participation in the mechanical oyster fishery has declined rapidly since 2010 according to trip ticket data. There was a high of 503 participants in 2010, wherein 74.8% of landings (bushels) were brought in by the top quartile (25%) of participants (Figure 6). Between 2012 and 2016, participation declined and fluctuated around 200 fishers. During the same period, the top quartile of participants contributed 62-70% of total landings (Figure 6). However, in the last five years (2018-2023) there were 60 or fewer participants in the mechanical oyster fishery, and the top quartile of participants contributed 48-61% of bushels landed (Figure 6).

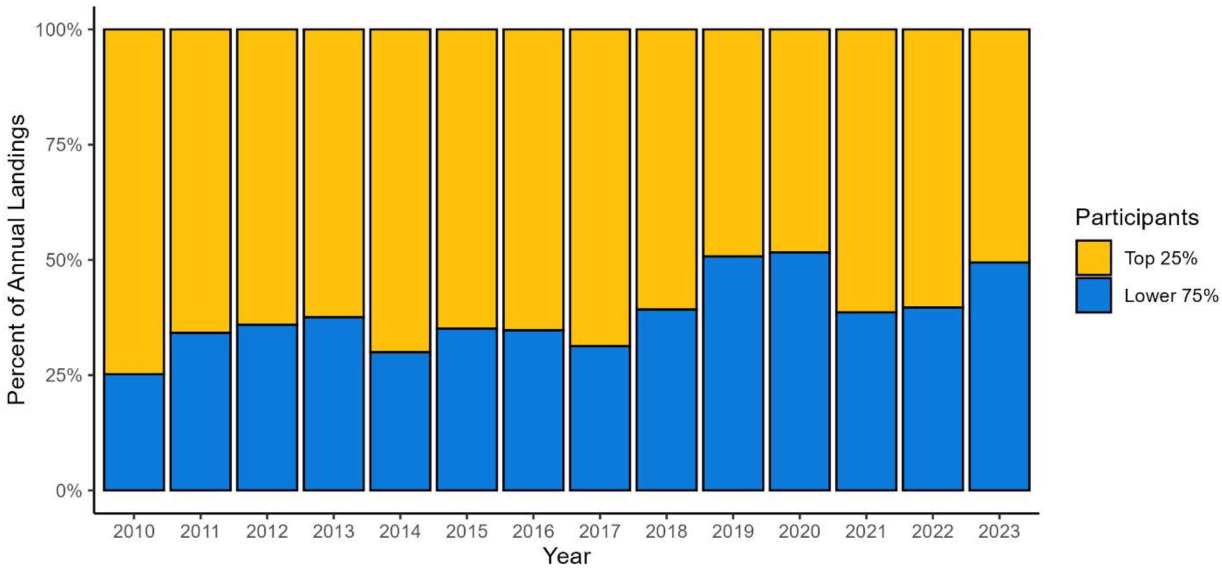

Figure 6. Relative contribution to annual landings from public bottom by the top quartile of participants in North Carolina's mechanical oyster fishery, 2010-2023 (Source: NCDMF Trip Ticket Program).

HAND-HARVEST METHODS

In North Carolina, hand harvest methods include hand tongs, hand rakes, and by hand (Figure 7). Hand tongs are generally used in shallow subtidal areas. Hand rakes and actual picking up by hand are normally used in intertidal areas. Some specialized uses of rakes and modified tongs occur in subtidal areas. Hand-harvest methods are allowed in all areas found suitable for shellfish harvest by the Shellfish Sanitation and Recreational Water Quality Section of the NCDMF.

The hand-harvest season for commercial and recreational harvest begins on October 15 each year with commercial harvest limited to Monday through Friday each week. The season typically continues until closed by rule on March 31 although some locations may close early due to perceived excessive harvest or pollution concerns. Brunswick County is the only area frequently closed early due to excessive harvest, and typically is closed by proclamation on March 15 annually.

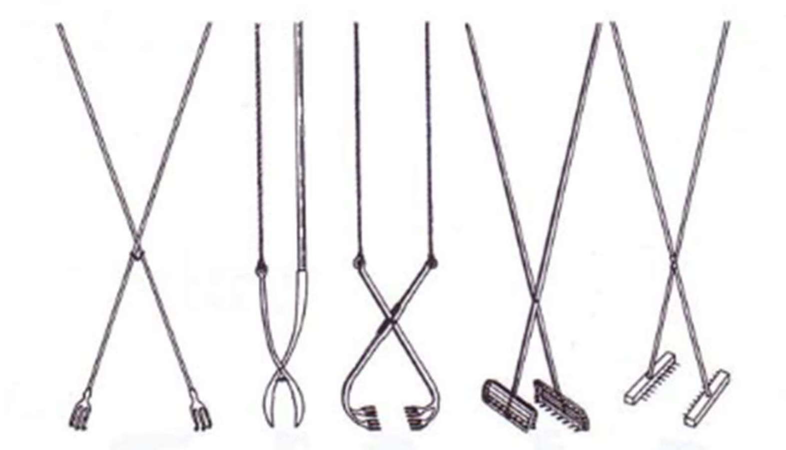

Figure 7. An illustration of several different designs for hand tongs and rakes that may be used for harvesting oysters (from Shafi 2007, reproduced from von Brandt 1964).

Since the 1990s, hand harvest has accounted for most of the commercial landings each season and has been the dominant harvest gear for oysters in North Carolina (Figure 4). This trend may be the result of hand harvest landings being less variable than mechanical harvest landings. For instance, southern intertidal oyster resources did not suffer the same long-term mortality from Dermo that affected subtidal oyster beds in the northern part of the state (for more information, see Biological Stressors).

These higher and more consistent landings come primarily from intertidal oyster reefs between Core Sound and the North Carolina-South Carolina state line. Hand harvest from the southern region represents a significant amount of the overall oyster landings even though the area only accounts for five percent of the total shellfish harvest area open in the state. The southern portion of the coast from Core Sound south to the North Carolina-South Carolina border (Coastal Fishing Waters in Brunswick, New Hanover, Pender, Onslow, and portions of Carteret counties) currently operates under a harvest limit of five bushels per person per day, not to exceed 10 bushels per vessel per day for Standard and Retired Commercial Fishing License holders.

Oyster harvest areas north of Core Sound also operated under the 5 bushels per person per vessel (not to exceed 10 bushels per vessel) per day limit until the 2009-2010 season. At that time, Amendment 2 to the N.C. Oyster FMP changed the limit in that area to 10 bushels per fishing operation in typical hand-harvest waterbodies including bays, small rivers and shallow sounds designated by proclamation. A 15-bushel limit is specified for Pamlico Sound, Neuse and Pamlico rivers, and Croatan Sound, but oysters in these areas are seldom harvested by hand methods. The practical application of the 10-bushels-per-fishing-operation limit results in hand harvesters working alone with the opportunity to take 10 bushels each day. The rationale for the change was to encourage hand harvesting by making mechanical and hand-harvest limits the same in areas where they overlap. The increased limit was justified because hand-harvest oyster resources in the northern area are widely dispersed and much more difficult to locate than in the southern area making excessive harvest less likely.

Hand-harvest oyster landings from areas north of Core Sound accounted for less than 2% of total hand-harvest landings prior to 2005 (Figure 8). In 2005, the percentage began to climb, reaching a peak near 11% in 2009. The highest percentages occurred in 2015 and 2017, with landings north of Core Sound reaching almost 20% of the total hand-harvest landings. Since 2019, the percentage has remained under 5%.

Hand-harvest oyster landings generally increased from 1994 to 2017 (Figure 9). This is likely due to increased effort as reflected by the number of trips mirroring the trend in landings (Figure 9). Hand harvest landings peaked in 2017 at 61,574 bushels, and despite some decline, have remained steady around 41,000 bushels since 2017.

In response to the concern of increasing participation and declining bushels landed per trip in the hand harvest oyster fishery, the Marine Fisheries Commission limited Shellfish License holders to two bushels of oysters per person per day and no more than four bushels per vessel statewide as part of Amendment 4 in October 2017. After Amendment 4 implementation, participation and landings in the hand harvest fishery declined.

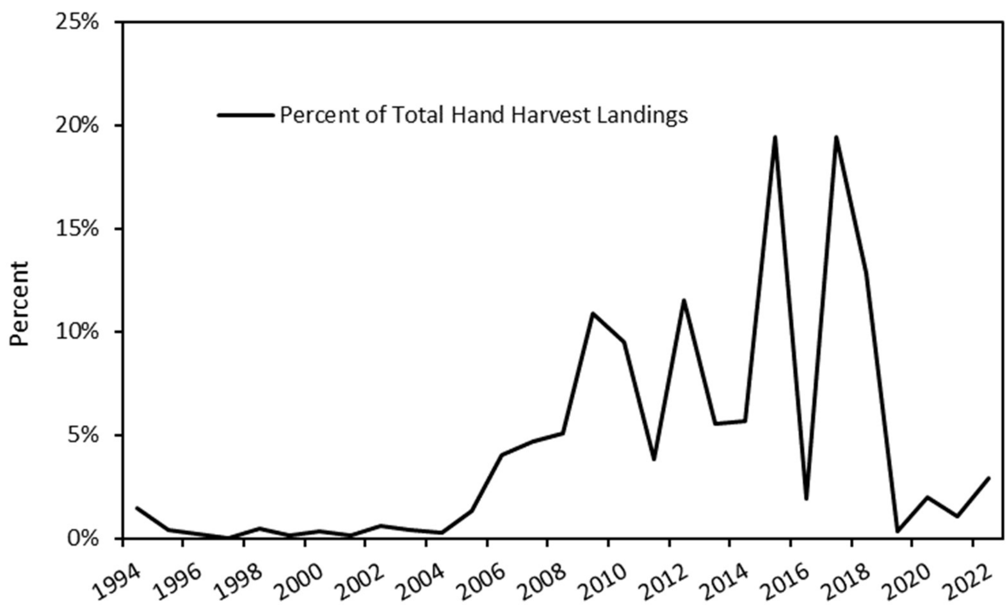

Figure 85. Public bottom commercial hand harvest oyster landings north of Core Sound as a percentage of total public bottom hand harvest oyster landings, 1994-2022 (Source: NCDMF Trip Ticket Program).

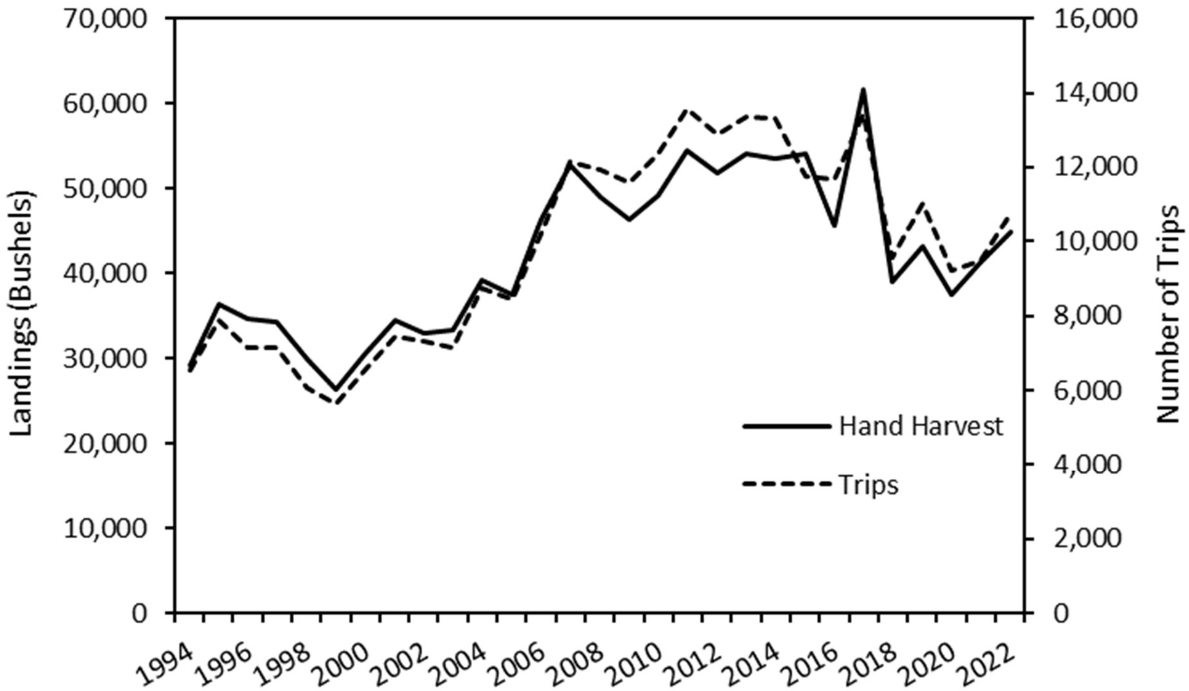

Figure 9. Commercial oyster hand harvest landings and number of dedicated trips in public bottom waters of North Carolina, 1994-2022. (Source: NCDMF Trip Ticket Program).

Recreational Fishery

Oysters are commonly harvested recreationally in North Carolina from October to March by hand, rake, and hand tongs. The limit allowed for personal consumption is one bushel of oysters per person, not to exceed two bushels per vessel with a minimum shell length of 3-inches. The NCDMF has limited data on recreational oyster fishing, including the number of participants and the extent of their economic activity. Efforts to accurately quantify the impact of recreational fishing on shellfish (mollusks and crustaceans) have been met with limited success in North Carolina. The NCDMF collects data on recreational fishing in conjunction with the Marine Recreational Information Program (MRIP). However, MRIP collects information on finfish only. The Marine Recreational Fishery Statistics Survey (MRFSS) reported that in the state, more than one million recreational fishing trips targeted shellfish in 1991; however, estimates of shellfish harvest were not reported.

Based on recommendations by the original Oyster and Hard Clam FMPs, House Bill 1427 was introduced before the general assembly in 2004 to establish a recreational shellfish license on a three-year trial basis (NCDMF 2001). However, House Bill 1427 was not passed. Similarly, in the same year House Bill 831 sought to create a saltwater fishing license requiring individuals recreationally fishing for finfish and shellfish to obtain a license, but did not pass. The state legislature revisited the issue in 2005 and replaced the saltwater fishing license with the Coastal Recreational Fishing License (CRFL). When CRFL was implemented in 2007, it was only required when harvesting finfish and did not include shellfish.

To overcome this data gap, NCDMF implemented an optional shellfish survey during November 2010 to collect monthly data on the harvest of crabs, oysters, clams, and scallops from the CRFL license pool. The survey sample is made up of approximately 1,300 randomly selected CRFL holders that held a valid license for at least one day during the survey period and answered “yes” to the harvest of at least one of the following species: crabs, oysters, clams, or scallops. The survey aims to obtain information on the number of trips taken during the survey period, average length of the trip, average party size, number of species kept and discarded, gear used, location information (water access), waterbody, and county of harvest. While data from this survey could be of potential use for estimating recreational catch and effort of shellfish, there are limitations regarding the representative population of recreational shellfish harvesters. For instance, the supplementary CRFL survey does not include individuals who fish exclusively for shellfish as they would not need to purchase a CRFL.

Furthermore, some recreational fishers may purchase a commercial Shellfish license over a CRFL because the license is easy to obtain (available to any NC resident), is relatively inexpensive ($50), and allows fishers to harvest more shellfish than the recreational limits allow. Additionally, the Recreational Commercial Gear License (RCGL) allows recreational fisherman to use limited amounts of commercial gear to harvest seafood for personal consumption. In both cases for commercial license holders and RCGL holders, shellfish that are kept for personal consumption and not sold to a seafood dealer will not be captured in landings data recorded by the North Carolina Trip Ticket Program (NCTTP).

With the limited data collected from the optional CRFL survey, some pieces of information about recreational effort have been captured. For instance, recreational oyster harvest was reported from 92 waterbodies throughout coastal North Carolina, with Topsail Sound, Pamlico Sound, Bogue Sound, and Masonboro Sound all boasting more than 100 reported trips. The same survey revealed 70% of reported oyster harvesting effort originated from private residence, private boat ramp, or shore. Given only 28% of reported effort originated at public access locations, intercept-oriented surveys are less than ideal. Recreational oyster harvesting effort and catch were both concentrated between October and March, accounting for over 84% of reported trips. Conversely, some individuals reported recreational harvest of oysters during the summer months despite state-imposed restrictions on harvest during this time. This suggests unfamiliarity with state regulations.

Given North Carolina’s shellfish fisheries are exclusively under state jurisdiction, a lack of recreational shellfish harvest data makes it extremely difficult to address potential management issues such as harvest limits, size limits, and gear restrictions for this fishery. There are currently no data on demographics, perceptions, or expenditures of recreational oyster harvesters in the state. Consequently, there is no data available to conduct an economic impact assessment of recreational oyster harvesting. Due to the widespread accessibility of intertidal oysters along North Carolina’s coast, the potential impact of recreational harvest on stock status could be significant. Furthermore, collecting recreational data would fill data gaps that may be necessary for completion of a comprehensive stock assessment. For additional background regarding this issue, please refer to Appendix 1.

PRIVATE CULTURE

In North Carolina, a shellfish lease or franchise are mechanisms through which individuals or entities can gain exclusive rights to grow and harvest shellfish, from designated areas of public trust waters. Today some shellfish leases are held by commercial fishers to supplement their income from public harvest areas. Other shellfish leases are held by individuals and corporations looking to augment other sources of income; to be engaged in a sustainable business opportunity; or to maintain an attachment to cultural maritime heritage. The NCDMF does not differentiate between clam, oyster, bay scallop, and mussel leases, thereby allowing shellfish growers to grow out multiple species simultaneously or as their efforts and individual management strategy allows. Oysters commercially landed from shellfish leases or franchises (designated as private bottom landings) are considered by the NCDMF as farm raised.

Landings from farmed raised oysters have shown a consistent upward trend since around 2014, surpassing wild harvest landings since 2017 (Figure 10). This shift marked a notable change in the primary methods and scale of production, with farm-raised oysters becoming a dominant component of overall oyster landings in the state. This growth was facilitated by advancements in aquaculture technology, increased investment in oyster farming infrastructure, and favorable market conditions for farmed oysters. Additionally, initiatives supporting aquaculture and the expansion of shellfish leasing programs further contributed to the industry's expansion during this period.

Since 1994, North Carolina has seen a significant increase in private shellfish aquaculture participation. Additionally, changes to common practices among private oyster cultures and the termination of the relay program have reduced reliance on wild shellfish among private leases. As such, addressing issues specific to aquaculture has expanded beyond the intended scope of the Fishery Management Plan. Therefore, Amendment 5 of the Oyster FMP will only focus on managing wild oyster populations. For additional details on private culture of shellfish, including the application process, statutes, rules, proclamations, contact, and other helpful resources, please visit the Shellfish Lease and Franchise program website (https://www.deq.nc.gov/about/divisions/marine-fisheries/licenses-permits-and-leases/shellfish-lease-and-franchise#ShellfishLeaseApplications-4100).

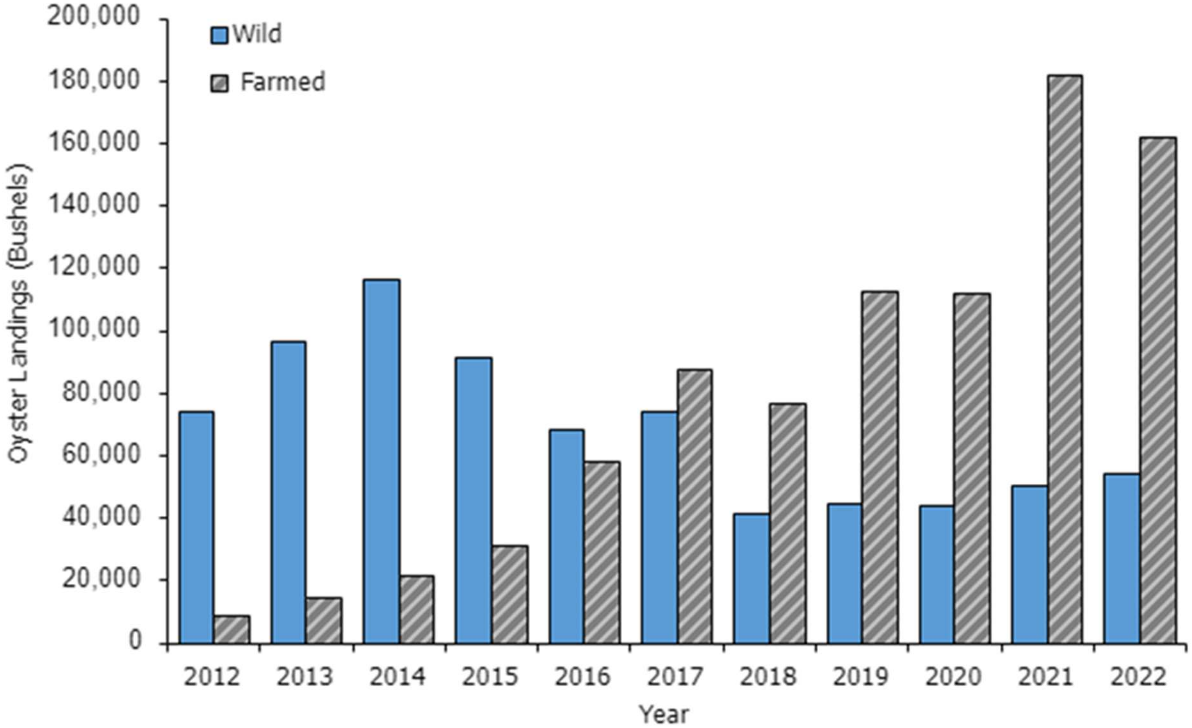

Figure 10. Annual commercial landings of wild harvest and farm-raised (aquaculture) oysters in North Carolina. Wild harvest includes oysters landed by either mechanical (dredge) or hand (i.e., tong, rakes) methods on public bottom.

Summary of Economic Impact

In 2022, oysters were the third most commercially important species in the state (NCDMF 2022). As a species landed primarily during the winter months, oysters provide income to commercial fishers at a time when other species are not present in harvestable amounts. The expenditures and income within the commercial fishing industry as well as those by consumers of seafood create additional indirect economic benefits throughout the state. Each dollar earned and spent generates additional impact by stimulating other industries, fostering jobs, income, and business sales. NCDMF estimates the extent of these impacts using a commercial fishing economic impact model which uses information from socioeconomic surveys of commercial fishers and seafood dealers in North Carolina, economic multipliers found in *Fisheries Economics of the United States, 2020,* and IMPLAN economic impact modeling software. In 2022, the commercial oyster fishery in North Carolina supported an estimated 636 full-time and part time jobs, $3.5 million in income, and $7.7 million in sales impacts (Table 2).

Table 2. A summary of the economic impact of the commercial oyster fishery on public bottom over the last ten years in North Carolina, 2013-2022. (Source: NCDMF Fisheries Economics Program)

			Estimated Economic Impacts			
Year	**Trips[1]**	**Bushels landed[1]**	**Ex-vessel value (in thousands)[1]**	**Jobs[2,3]**	**Income impacts (in thousands)[3]**	**Sales impacts (in thousands)[3]**
2022	11,620	54,342	$2,574	636	$3,526	$7,666
2021	10,328	50,416	$2,516	612	$3,459	$8,474
2020	9,831	44,080	$2,211	611	$3,400	$7,336
2019	11,190	44,567	$2,261	635	$3,651	$8,384
2018	9,880	41,611	$2,105	671	$3,282	$7,190
2017	14,985	73,809	$3,776	923	$5,587	$12,417
2016	14,295	68,573	$3,618	957	$5,315	$11,577
2015	15,748	91,689	$4,222	1,008	$6,061	$13,587
2014	18,951	116,330	$5,058	1,158	$7,562	$17,375
2013	17,013	96,258	$3,817	1,031	$5,533	$12,502

[1]As reported by the North Carolina Division of Marine Fisheries (NCDMF) Trip Ticket Program.
[2]Represents both full-time and part-time jobs.
[3]Economic impacts calculated using the NCDMF commercial fishing economic impact model.

RECENT ECONOMIC TRENDS

The inflation-adjusted value of North Carolina oyster increased in the early 2010s, reaching a peak of about $6.7 million in 2010. Since then, the value of the oyster fishery has trended downwards (Figure 11). The nominal ex-vessel price per bushel for oysters exhibited an overall steady increase from 1994 to 2022. When corrected for inflation the price per bushel for oysters has increased by $10 over the last thirty years.

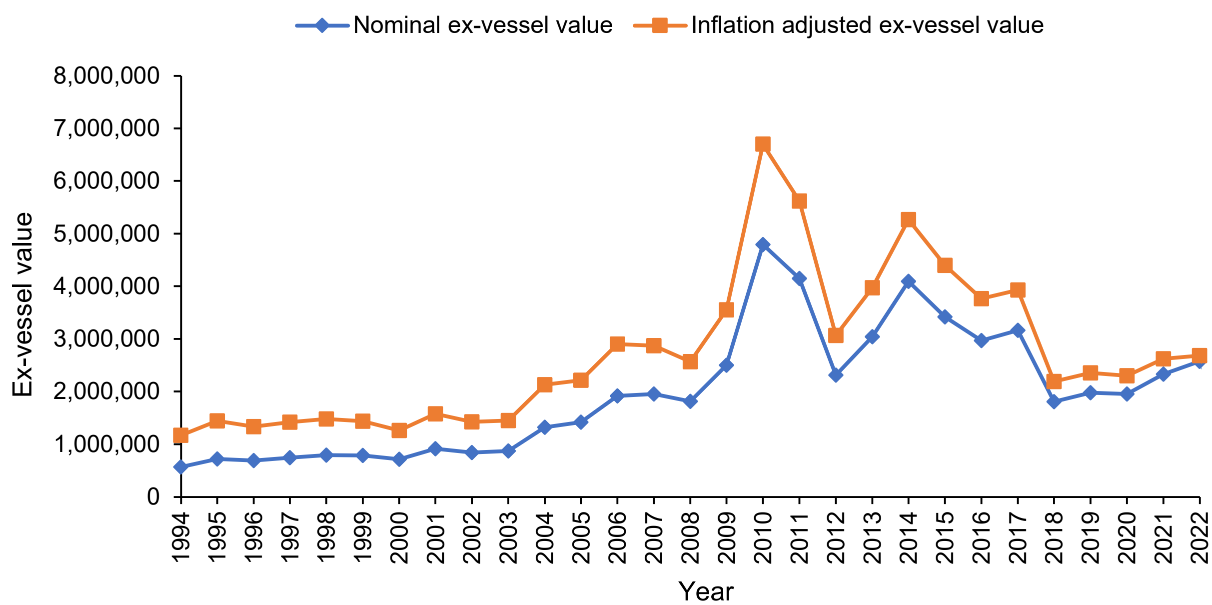

Figure 11. Annual ex-vessel value within North Carolina's oyster fisheries, 1994-2022. Inflation adjusted values are in 2023 dollars (Source: NCDMF Trip Ticket Program).

In the 2000s the proportion of landings by mechanical harvest was consistent before reaching a peak in 2010 when it made up 74% of landings (Figure 12). Since then, mechanical harvest has steadily decreased, comprising a small percentage of total landings. This decrease in mechanical landings is likely a result of fewer water bodies being open to mechanical harvest as well as greater participation in the private lease aquaculture program. While many water bodies have accounted for a steady portion of the overall harvest value, the oyster fishery in Pamlico Sound has decreased in market share from 34% in 2004 down to 16% in 2022. Conversely, Topsail Sound, Masonboro Sound, and Newport River have increased in their market shares in the same time span.

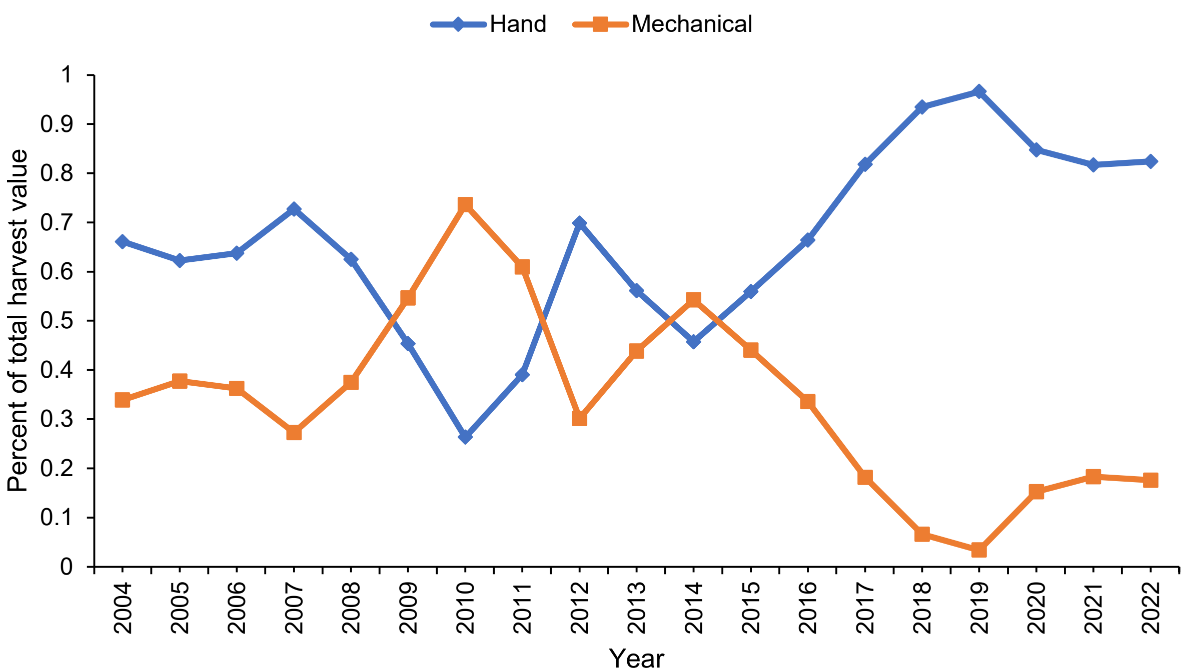

Figure 62. Annual percent of total landings value by gear types used in North Carolina's hand and mechanical oyster fisheries, 2004-2022 (Source: NCDMF Trip Ticket Program).

The NCDMF tracks commercial catches of all fishers in the state when the catch is sold to a commercial seafood dealer. Data suggests the oyster fishery expanded from 2004 to 2010, when it peaked at 1,148 participants. However, between 2010 and 2018 there was a significant decrease in participation, but the number of participants has been relatively consistent since 2018. The number of commercial hand harvest and mechanical harvest trips landing oysters exhibited decreasing trends since 2017 with a large decrease in trips in the last year of the data set. Mechanical harvest has seen a considerable downward trend since 2014 and has stayed consistently low since 2018.

As is the case in all commercial fisheries in the state, oyster fishers may only sell their catch to licensed seafood dealers. From 2004 to 2022, number of seafood dealers who deal in oysters fluctuated between 120 and 170, with a decreasing trend in the last few years. Many seafood dealers are likely oyster fishers who also hold a dealer license, who can vertically integrate their commercial fishing business by both catching and selling a seafood product to wholesalers or consumers.

SOCIAL IMPORTANCE OF THE FISHERY

The NCDMF Fisheries Economics Program has conducted a series of in-depth interview-style surveys with commercial fishers along the coast since 1999. This information is used for fishery management plans, tracking the status of the industry, and informing management of fisher perceptions on potential management strategies. The most recent surveys were collected in 2017. For an in-depth look into responses, see Amendment 4 of the Oyster FMP (NCDMF 2017). A summary of survey responses from 168 commercial fishers active in the oyster fishery across 58 different communities along North Carolina’s coast is provided in this Amendment.

The greatest number of commercial oyster fishers lived in Sneads Ferry, followed by Newport, Beaufort, and Wilmington. Active participants in the oyster fishery were characterized as white males, with an average age of 50 and 28 years of commercial fishing experience. On average, commercial fishing accounted for 68% of the personal income for these fishers, and 46% reported commercial fishing was their sole source of personal income. Most (77%) commercial fishers that targeted oysters fished year-round. Respondents indicated commercial fishing held extremely high historical importance and economic importance within their communities.

The most important issue to these fishers was low prices for seafood which is also related to competition from imported seafood. Another key issue for oyster fishers was development of the coast. Several areas of coastal North Carolina have undergone intense development in recent decades. Water quality impairments are often associated with coastal development, which greatly impact opening/closure of shellfish areas. Additionally, coastal development is associated with losing working waterfronts, another top five concern of respondents. Conversely, the bottom ranked issues according to 168 commercial oyster harvesters were keeping up with rule changes/proclamations, overfishing, bag limits, size limits and quotas.

ECOSYSTEM PROTECTION AND IMPACT

This section primarily focuses on the role of oysters as habitat, though it also addresses the impacts of the fishery on habitat and other ecosystem services of oyster reefs. The benefits and impacts discussed below refer to “shell bottom” and “oyster reefs” interchangeably, and includes both intertidal and subtidal habitats, consisting of fringing or patch oyster reefs, surface aggregations of living shellfish, and/or shell accumulations. This section includes overviews of the Coastal Habitat Protection Plan (CHPP) and NCDMF’s Habitat & Enhancement Shellfish Rehabilitation Programs, both of which aim to protect and enhance oyster reef habitat throughout the state.

Coastal Habitat Protection Plan

In the 1990s, addressing habitat and water quality degradation was recognized by resource managers, fishers, the public, and the legislature as a critical component for improving and sustaining fish stocks, as well as the coastal ecosystem. When the Fisheries Reform Act (FRA) of 1997 (G.S. 143B-279.8) was passed, it required developing Coastal Habitat Protection Plans (CHPPs). The legislative goal of the CHPP is "…the long-term enhancement of coastal fisheries associated with coastal habitats." The FRA specifies the CHPP will identify threats and recommend management actions to protect and restore coastal habitats critical to NC's coastal fishery resources. The plans are updated every five years and must be adopted by the NC Coastal Resources Commission (CRC), the NC Environmental Management Commission (EMC), and NCMFC to ensure consistency among commissions as well as their supporting DEQ agencies. The 2021 CHPP Amendment is the most recent update to the CHPP, building upon the 2016 CHPP source document.

The NCMFC's CHPP includes four overarching goals for the protection of coastal habitat: 1) improve effectiveness of existing rules and programs protecting coastal fish habitats; 2) identify and delineate strategic coastal habitats; 3) enhance habitat and protect it from physical impacts; and 4) enhance and protect water quality. The CHPP is an interagency plan with its goals and actions carried out by several state agencies. For instance, while NCDMF has the capacity to recommend management decisions towards meeting the goals described above pertaining to coastal habitat, the Division of Water Quality enforces policies concerning water quality issues described in the CHPP. Overall, achieving the goals set by the CHPP to protect North Carolina's coastal resources involves managers and policy makers from several state agencies making recommendations and enforcing regulations.

The CHPP identifies bottom disturbing fishing gear, including oyster dredges, as having the potential to be highly destructive towards oyster reefs. As such, the NCMFC has recommended the following actions: Protect habitat from adverse fishing gear effects and protect and restore important fish habitat functions from damage associated with activities such as dredging (NCDEQ 2016). This recommendation is cited as a specific objective within this Amendment of the Eastern Oyster FMP, and is explored further in Appendix 2, the Mechanical Oyster Harvest Issue Paper. Furthermore, the complexity of managing the oyster resource as both a fishery and essential estuarine habitat is reason for establishing an ongoing and sustained interconnectedness between the Oyster FMP and the CHPP.

ESSENTIAL HABITAT

In estuarine ecosystems worldwide, oyster reefs play a vital role in creating habitat for diverse communities in estuarine habitats. As prolific filter feeders, dense oyster assemblages can affect phytoplankton dynamics and water quality, which in turn aids submerged aquatic vegetation (SAV) and reduces excessive nutrient loading that could otherwise lead to hypoxic conditions (Thayer et al. 1978; Newell 1988; Everett et al. 1995; Newell and Koch 2004; Carroll et al. 2008; Wall et al. 2008). Such an impact on water quality also provides direct and indirect benefit to humans in the form of ecosystem services. For instance, oyster reefs serve as habitat for a variety of economically important species while also stabilizing sediment along coastlines. With successive generations building upon shells left by their predecessors, oyster reefs add spatial complexity to the benthos, creating colonization space, refuge, and foraging substrate for many species (Arve 1960; Bahr and Lanier 1981; Zimmerman et al. 1989; Lenihan and Peterson 1998). As water quality and healthy, diverse oyster reefs benefit coastal communities, NCDMF recognizes the economic importance of oyster reef habitat. Combining the ecosystem services provided by oysters, the estimated value of North Carolina's oyster reefs is $2,200 to $40,200 per acre annually (Grabowski et al. 2012).

Studies have shown shell bottom supports a greater abundance and/or diversity of finfish and crustaceans than unstructured soft bottom (Grabowski and Peterson 2007; Nevins et al. 2013). The structural complexity and emergent structure of these reefs offer various benefits to inhabitants, including refuge and foraging opportunities (Coen et al. 1999; Grabowski et al. 2005; Lenihan et al. 2001; Peterson et al. 2003). The reef structures themselves impact the flow of currents, thereby offering enhanced deposition of food for benthic fauna (Grabowski 2002; Kelaher 2003). Additionally, tertiary production of nektonic organisms is found to be more than double on oyster reefs than from *Spartina* marshes, soft bottom, and SAV, indicating the importance of this habitat for higher order consumers (English et al. 2009).

In North Carolina, over 70 species of fish and crustaceans have been documented using natural and restored oyster reefs (Table 3; ASMFC 2007; Coen et al. 1999; Grabowski et al. 2005; Lenihan et al. 2001; Peterson et al. 2003). The list includes 12 Atlantic State Marine Fisheries Commission-managed and seven South Atlantic Fishery Management Council-managed species, highlighting the importance of this habitat for recreational and commercial fisheries. Many of the state's economically important fishery species are estuarine dependent at some point in their life cycles as oyster reefs serve as nursery habitat for numerous marine and estuarine species during key phases of their life cycles (Ross and Epperly 1985; Pierson and Eggleston 2014). Estuarine fish can be grouped into three categories: estuary-dependent species, permanent resident species, and seasonal migrant species (Street et al. 2005; Deaton et al. 2010). The most abundant on oyster reefs are estuary-dependent species, which inhabit the estuary as larvae. This group includes species that spawn offshore as well as species that spawn in the estuary.

Oyster reefs also host large abundances of small forage fishes and crustaceans, such as pinfish, gobies, grass shrimp, and mud crabs, which are important prey for larger recreationally and commercially important fishes (Minello 1999; Posey et al. 1999; Plunket and La Peyre 2005; ASMFC 2007). The structural complexity of oyster reefs provides safe refuge from disturbance events, thereby offering stability to both shell-bottom and soft-bottom habitats. A diversity of invertebrates and microalgae that have key food web roles inhabit these microenvironments. Soft bottoms offer refuge for clams and polychaete worms while larger, mobile invertebrates such as horseshoe crabs, whelks, tulip snails, moon snails, shrimp and hermit crabs live on the surface of soft bottoms. Most soft bottom species listed above also inhabit shell bottoms; however, shell bottom supports additional benthic macroinvertebrates, including mud crabs, pea crabs, barnacles, soft-shelled clams, mussels, anemones, hydroids, bryozoans, flatworms, and sponges (Street et al. 2005; Deaton et al. 2010). Fiddler crabs use intertidal flats and submerged flats, and shallow bottoms support blue crab and other crustaceans and shellfish.

An in-depth discussion of fish species' usage of oyster reef habitats is available in Amendment 4 to the Oyster FMP (NCDMF 2017) and Chapter 3 of the 2016 CHPP (NCDEQ 2016).

WATER QUALITY

Oyster habitat offers a variety of direct and indirect ecosystem services related to water quality. The filtering activities of oysters and other suspension feeding bivalves remove particulate matter, phytoplankton, and microbes from the water column (Prins et al. 1997; Coen et al. 1999; Wetz et al. 2002; Cressman et al. 2003; Nelson et al. 2004; Porter et al. 2004; Grizzle et al. 2006; Coen et al. 2007; Wall et al. 2008). Adult oysters have been reported to filter as high as 10 L per hour per gram of dry tissue weight (Jordan 1987). Because non-degraded oyster reefs contain high densities of filter-feeding bivalves, they can modify water quality in shallow waters by their intense filtration. Even small-scale additions of oysters to tidal creeks can reduce total suspended solids (TSS) and chlorophyll-a concentrations downstream of transplanted reefs (Nelson et al. 2004).

Oyster reefs also provide a key ecosystem service by removing nutrients, especially nitrogen, from the water column (Piehler and Smyth 2011; Kellogg et al. 2013). Nitrogen (N) and phosphorous (P) in biodeposits can become buried or removed via bacterially mediated nitrification-denitrification (Newell et al. 2002; Porter et al. 2004; Newell et al. 2005). In North Carolina, Smyth et al. (2013) found that rates of denitrification by oyster reefs were like that of SAV and marsh, and highest in the summer and fall when oyster filtration is greatest. The dollar benefit of the nitrogen removal service provided by oyster reefs was estimated to be $2,969 per acre per year (2011 dollars; $4,135 per acre per year in 2023 dollars).

Habitat and Enhancement Programs

In 2007, a National Oceanic and Atmospheric Administration biological review team found that current east coast oyster harvest is 2 percent of peak historical volume and suggested oyster restoration and enhancement efforts are "necessary to sustain populations" (EOBRT 2007). In North Carolina, the Neuse River Estuary has experienced widespread loss of oyster habitat, as oyster beds have been "displaced downstream roughly 10-15 miles" since the late 1940s (Jones and Sholar 1981; Steel 1991). Natural expansion of healthy oyster reefs is not expected in this area because adjacent bottom lacks attachment substrate, and any shell that is sloughed from an existing reef might be subject to deep water hypoxia and sediment burial, where reef establishment is unlikely (Lenihan 1999; Lenihan and Peterson 1998).

Table 3. List of all observed and known estuarine species which have been surveyed on oyster reefs or are known to use oyster reefs as habitat in North Carolina.

Common name	Scientific name	Common name	Scientific name
Anchovy, Bay	*Anchoa mitchilli*	Mullet, Striped *†‡	*Mugil spp.*
Bass, Striped *†‡	*Morone saxatilis*	Needlefish, Houndfish	*Tylosurus crocodilus*
Blenny, Feather	*Hypsoblennius hentz*	Perch, Sand	*Diplectrum formosum*
Blenny, Striped	*Chasmodes bosquianus*	Perch, Silver	*Bairdiella chrysoura*
Bluefish **	*Pomatomus saltatrix*	Pigfish	*Orthopristis chrysoptera*
Bumper, Atlantic	*Chloroscombrus chrysurus*	Pinfish	*Lagodon rhomboides*
Butterfish	*Peprilus triacanthus*	Pinfish, Spottail	*Diplodus holbrooki*
Clam, Hard	*Mercenaria mercenaria*	Pompano	*Trachinotus carolinus*
Cobia **	*Rachycentron canadum*	Sea Bass, Black **	*Centropristis striata*
Crab, Blue *†‡	*Callinectes sapidus*	Sea Bass, Rock	*Centropristis philadelphica*
Crab, Florida Stone	*Menippe mercenaria*	Searobins, Prionotus	*Prionotus spp.*
Crabs, Spider	*Majidae spp.*	Seatrout, Spotted *‡	*Cynoscion nebulosus*
Croaker, Atlantic **	*Micropogonias undulatus*	Shad, Threadfin	*Dorosoma petenense*
Dogfish, Smooth	*Mustelus canis*	Shark, Atlantic Sharpnose	*Rhizoprionodon terraenovae*
Dogfish, Spiny **	*Squalus acanthias*	Shark, Blacktip	*Carcharhinus limbatus*
Drum, Black **	*Pogonias cromis*	Shark, Finetooth	*Carcharhinus isodon*
Drum, Red *	*Sciaenops ocellatus*	Sheepshead *	*Archosargus probatocephalus*
Eel, American **†	*Anguilla rostrata*	Shrimp, Palaemonidae *	*Palaemonetes spp.*
Eel, Conger	*Conger oceanicus*	Shrimp, Penaeidae *	*Farfantepenaeus spp. Litopenaeus spp.*
Filefish, Planehead	*Stephanolepis hispidus*	Silverside, Atlantic	*Menidia menidia*
Filefish, Pygmy	*Monacanthus setifer*	Silverside, Inland	*Menidia beryllina*
Flounder, Gulf	*Paralichthys albigutta*	Silverside, Rough	*Membras martinica*
Flounder, Southern *†‡	*Paralichthys lethostigma*	Skate, Clearnose	*Raja eglanteria*
Flounder, Summer **‡	*Paralichthys dentatus*	Skilletfish	*Gobiesox strumosus*
Goby, Naked	*Gobiosoma bosc*	Snapper, Grey	*Lutjanus griseus*
Grouper, Gag	*Mycteroperca microlepis*	Spadefish, Atlantic	*Chaetodipterus faber*
Harvestfish	*Peprilus alepidotus*	Spot **	*Leiostomus xanthurus*
Herring, Atlantic Thread	*Opisthonema oglinum*	Stingray, Bullnose	*Myliobatis freminvillei*
Herring, Blueback*†	*Alosa aestivalis*	Stingray, Cownose	*Rhinoptera bonasus*
Jack, Bar	*Caranx ruber*	Stingray, Southern	*Dasyatis americana*
Jack, Crevalle	*Caranx hippos*	Tarpon	*Megalops atlanticus*
Killifish	*Fundulus spp.*	Tautog **	*Tautoga onitis*
Lizardfish, Inshore	*Synodus foetens*	Toadfish, Oyster	*Opsanus tau*
Lookdown	*Selene vomer*	Triggerfish, Grey	*Balistes capriscus*
Mackerel, Spanish**	*Scomberomorus maculatus*	Weakfish **	*Cynoscion regalis*
Menhaden, Atlantic **	*Brevoortia tyrannus*		

*NCDMF state managed species
** ASMFC federally managed species
† Most recent stock assessment suggests population is overfished as of 2025
‡ Most recent stock assessment suggests overfishing is occurring as of 2025

To improve and preserve the diverse ecosystem functions provided by oyster reef habitat, restoration is essential in North Carolina. In recognition of this need, NCDMF's Habitat and Enhancement section coordinates ongoing habitat enhancement activities to improve statewide oyster populations and subsequently enhance the ecosystem services they provide. These efforts began with the Cultch Planting program in 1915 with the goal to rebuild oyster beds on public bottom by planting shells for substrate, thereby creating state-subsidized harvest areas for the fishery. Since the 1980s, over 2,000 cultch sites have been planted throughout North Carolina's coastline, with each area ranging in size from 0.5 to 10 acres. Estimates by DMF biologists indicate that each acre of cultch material can support and yield 368 bushels of oysters.

Additionally, NCDMF's Habitat & Enhancement Section oversees the construction of no-take reserves with the goal of creating and maintaining a self-sustaining network of subtidal oyster reefs. Protected oyster sanctuaries have the potential to supply approximately 65 times more larvae per square meter than non-protected reefs (Puckett and Eggleston 2012; Peters et al. 2017). This heightened reproductive output potential further benefits naturally occurring reefs and cultch sites as wind patterns distribute oyster larvae to historical oyster fishing areas for grow-out and future harvest (Haase et al. 2012; Puckett et al. 2014). A 20-acre protected oyster reef could provide an annual commercial fish value of $33,370 and have a larval oyster supply functionally equivalent to 1,300 acres of non-protected oyster reef (adapted from Grabowski et al. 2012; Peters 2014; Peters et al. 2017). Oyster Sanctuaries also provide recreational hook-and-line fishing and diving opportunities for the public. Sanctuary and cultch sites are planned with the aim to improve larval connectivity within the network of restoration sites. To date there are 17 sanctuaries, and a total of 789 acres of protected habitat placed in effect by proclamation.

Secondary to improving oyster populations, these enhancement programs also provide valuable reef habitat for many estuarine species (Table 3). Both cultch sites and sanctuaries offer oysters and other species refuge from hypoxia events via the construction of high relief habitat using alternative substrates. Additionally, artificial reefs may serve as nursery habitat to commercially valuable finfish. The estimated commercial fish value supported by a hectare of oyster reef is $4,123 annually (Grabowski et al. 2012). Peterson et al. (2003) conducted a meta-analysis that indicated every 10 m^2 of newly constructed oyster reef in the southeast United States is expected to yield an additional 2.6 kg of fish production per year for the lifetime of the reef.

For a more comprehensive history of NCDMF's oyster habitat enhancement efforts and detailed methodologies employed by the cultch and sanctuary programs (site selection, monitoring, and analysis), please refer to Appendix 4.

Threats and Alterations

Oysters are unique in their status as an ecosystem engineer in that they not only have a disproportionate impact on their surrounding environment, but they are also a global commodity. Population declines of oysters have been observed, especially on sub-tidal reefs along the US East Coast (Rothschild et al. 1994; Hargis and Haven 1988; NCDMF 2001). In 2007, a National Oceanic and Atmospheric Administration biological review team found that current east coast oyster harvest is two percent of peak historical volume (EOBRT 2007). Oyster harvest in North Carolina has shown a similar trend of decline (Street et al. 2005; Deaton et al. 2010).

The primary threats to oyster habitat in North Carolina are physical disturbance (i.e., harvesting) and water quality degradation (i.e., bacterial contamination and eutrophication). Other potential threats such as sedimentation, and in-water development have the potential to impact oyster habitat, and those threats are discussed in Amendment 4 to the Oyster FMP (2017) and in the CHPP (2016), but they are omitted here to provide a focus on the most widespread and long-term threats to oyster habitat across North Carolina. Notably, of these threats, only hand-harvest and bottom-disturbing gear are directly within the control of the NCMFC. However, the NCMFC can encourage progress on other issues through collaboration with the EMC and CRC through its role in developing the CHPP.

PHYSICAL DISTURBANCE FROM HARVEST METHODS

Of the factors affecting the condition and distribution of oyster habitat, oyster harvest has had the greatest impact. Chestnut (1955) and Winslow (1889) reported finding formerly productive areas in Pamlico Sound where intensive oyster harvesting made further harvest and recovery of the oyster rocks impossible. Heavily fished oyster reefs lose vertical profile and are more likely to be affected by sedimentation and anoxia which can suffocate live oysters and inhibit recruitment (Kennedy and Breisch 1981; Lenihan and Peterson 1998; Lenihan et al. 1999). Anecdotal accounts also indicate significant negative impacts occurred to oyster rocks prior to closure of areas to mechanical harvest of clams, and current fisheries regulations prohibit the use of mechanical gear in SAV beds and live oyster beds because of the destructive capacity of the gear. Further discussion of the impacts of mechanical harvest is included in [Appendix 2].

Intensive hand harvest methods can also be destructive to oyster rocks. The harvest of clams or oysters by tonging or raking on intertidal oyster beds causes damage to not only living oysters but also the cohesive shell structure of the reef (Lenihan and Peterson 1998). This destruction has been an issue where oysters and hard clams co-exist, primarily around the inlets in the northern part of the state and on intertidal oyster beds in the south (DMF Oyster FMP 2001). Studies by Noble (1996) and Lenihan et al. 1999) quantified the effects of oyster and clam harvest on oyster rocks, finding that the density of live adult oysters was significantly reduced where clam harvesting occurred, but that oyster harvesting had little effect on clam populations. Further discussion of the impacts of hand harvest is included in Appendix 3.

BIOLOGICAL STRESSORS

Introduced Species

Nuisance and non-native aquatic species have been accidentally or intentionally introduced to North Carolina waters through river systems, created waterways like the

Intracoastal Waterway (IWW), discharged ballast water, out-of-state vessels, and the sale of live fish and shellfish for bait or aquaculture. Oysters were impacted by the introduction of the Dermo parasite and the pathogen *Haplosporidium nelson* (MSX) via introduced Pacific oysters in 1988 (*Crassostrea gigas*; NCDMF 2001). However, infection rates of MSX within oysters have drastically declined since 1989 and further sampling for MSX was discontinued in 1996 (for more information, please see Amendment 4). Intentional introductions of non-native species are covered under state laws and rules of several commissions. Permits are required for introducing, transferring, holding, and selling as bait any imported marine and estuarine species. Applicants must provide certification to ensure the organisms being moved are disease free and no additional macroscopic or microscopic organisms are present. The Fisheries Director may hold public meetings concerning these applications to help determine whether to issue the permit.

There is much debate and uncertainty regarding the introduction of non-native oysters for the purpose of rebuilding complex reef habitat, enhancing water filtration, and preserving the fishery (Andrews 1980; NCDMF 2001; Richards and Ticco 2002). Concerns of introduction include long-term survival of introduced species, competition with native oysters, unknown reef-building attributes, cross-fertilization reducing larval viability, and unintentional introduction of non-native pests (NCDMF 2008). Testing of the Pacific oyster and the Suminoe oyster (*Crassostrea ariakensis*) was carried out by researchers in North Carolina to assess their potential (NCDMF 2008). Pacific oysters were found to be too thin to resist predation by native oyster drills and boring worms and Suminoe oysters were found to be susceptible to a parasitic protist in high salinities (DeBrosse and Allen 1996; Richards and Ticco 2002). In 2009, the US Army Corps of Engineers issued a Record of Decision to disallow introduction of the Suminoe oyster and instead encouraged enhanced restoration and aquaculture using native oysters.

Dermo Disease

The oyster parasite (*Perkinsus marinus)*, also known as Dermo disease, is a protist that causes tissue degradation resulting in reduced growth, poor condition, diminished reproductive capacity, and ultimately mortality resulting from tissue lysis and occlusion of hemolymph vessels in infected oysters (Ray and Chandler 1955; Haskin et al. 1966; Ford and Figueras 1988; Ford and Tripp 1996). Oysters become more susceptible to parasitism and disease during extended periods of high salinity and temperature (VIMS 2002; La Peyre et al. 2006; NCDMF 2008), dissolved oxygen, sediment loading, and anthropogenic pollution (Barber 1987; Kennedy et al. 1996; Lenihan et al. 1999).

Research on experimental subtidal oyster reefs in the Neuse River estuary found oysters located at the base of reefs had the highest Dermo prevalence, infection intensity, and mortality, while oysters located at the crest of reefs were much less susceptible to parasitism and Dermo-related mortality (Lenihan et al. 1999). Dermo infection was responsible for large-scale oyster mortalities in North Carolina during the late 1980s to mid-1990s (NCDMF 2008).

In 1989, NCDMF began diagnosing Dermo infections and by 1991, a formal annual monitoring program was in place. Samples with moderate and high categories of infection intensity are expected to have mortality rates that considerably affect harvest if optimum conditions for parasitic growth and dispersal continue to persist. North Carolina appears to have some overwintering infections during mild years, although few samples are taken during winter months. Infection levels were high in the early 90s and mortality of a smaller size class of oysters was observed. Infection intensity dropped between the mid-1990s to the mid-2000s.

Staff observed in southern estuaries during late summer that moderate and high dermo infection levels did not reduce oyster populations. It is suspected that small, high salinity estuaries may inhibit mortality by flushing out parasites at a higher rate or by exceeding the salinity tolerance of the Dermo parasite, allowing for a higher survival rate compared to Pamlico Sound. The link between low dissolved oxygen, increased availability of iron, and increased parasite activity may also be a factor in the different mortality rates as the smaller, high salinity estuaries are less prone to low dissolved oxygen events than Pamlico Sound (Leffler et al. 1998). Dermo infection intensity levels since 2005 have remained low (NCDMF unpublished data).

Other Harmful microbes

In addition to Dermo, there are various environmental pathogens that can impact shellfish and those that consume shellfish. Pathogens of most notable concern are *Vibrio* and Neurotoxic Shellfish Poisoning (NSP), and *Haplosporidium nelson* (MSX). In North Carolina oysters, infection rates of MSX have drastically declined since 1989 and are currently not considered a major concern (for more information, please see Amendment 4 (NCDMF 2017).

Vibrio spp. are salt-loving bacteria that inhabit coastal waters throughout the world and can be ubiquitous in open shellfish growing areas. *Vibrio* can be found in North Carolina's coastal waters year-round but are more abundant during the warmer summer months (Pfeffer et al. 2003; Blackwell and Oliver, 2008). While they are not usually associated with pollution that typically triggers shellfish closures, filter-feeders can accumulate high concentrations of *Vibrio*. These bacteria can pose a public health risk as they may cause gastrointestinal illness from the consumption of raw or undercooked shellfish. People with underlying health conditions such as liver disease, diabetes, cancer, or weakened immune systems are at a higher risk of infection and can potentially experience life-threatening illness from *Vibrio*. For this reason, it is not advised to consume raw shellfish in the warm-water months. Humans can also contract *Vibrio* infections through open wounds on the skin and contact with brackish or saltwater.

Neurotoxic Shellfish Poisoning is a disease caused by consumption of molluscan shellfish contaminated with brevetoxins primarily produced by the dinoflagellate, *Karenia brevis*. Blooms of *K. brevis*, called Florida red tide, occur frequently along the Gulf of Mexico (Watkins et al. 2008). Green gill disease in shellfish comes from the single-celled alga called *Haslea ostrearia.* This is a blue-green diatom found in the coastal waters of North Carolina.

For more detailed information on these environmental pathogens, see Amendment 2 of the Hard Clam FMP (NCDMF 2017). The NCDMF has a contingency plan in place as required by the FDA, including a monitoring program and management plan. The purpose is to ensure quick response to any harmful algal species within State waters that may threaten the health and safety of shellfish consumers. The plan also details the system to provide early warning of any potential issues, actions to be taken to protect public health and steps to reopen areas to harvest (Shellfish Sanitation and Recreational Water Quality Section Marine Biotoxin Contingency Plan 2022).

Boring Sponge

The boring sponge (*Cliona spp.*) is a bioeroder of calcified skeletons such as corals and oyster reefs. These sponges can chemically etch out canal systems within oyster reefs, as well as incrust and smother them which can cause mortality by weakening the shell. Once the oyster reef has been compromised, there is a loss of substrate, reduction in vertical relief and loss of structural integrity. Boring sponges are linked to salinity gradients with some species found in high salinity waters while other species are found in low to mid-range salinities but typically are not found in waters with less than 10 ppt salinity. Intertidal oysters have some refuge from boring sponge.

Lindquist et al. (2012) examined the distribution and abundance of oyster reef bioerosion by *Cliona* in North Carolina. The study examined levels of boring sponge infestations across salinity gradients in multiple oyster habitats from New River through the southern portions of Pamlico Sound, finding that higher salinity areas, with a mean salinity of 20 ppt or greater, were infested by the high salinity tolerant boring sponge *Cliona celata*. As salinities increased, infestations increased and subtidal reefs disappeared (Lindquist et al. 2012), and freshets that occurred in White Oak River and New River prior to initial surveys demonstrated resilience of boring sponges to low salinity events. Sample sites in both areas had no active infestations but gemmules were observed, and sampling seven to eight months later found moderate to high levels of active sponge infestation. Bioeroding polychaete *Polydora* worms were also more abundant in lower salinity areas and less abundant in higher salinities (Lindquist et al. 2012).

WATER QUALITY THREATS

Marine bivalves, including oysters, have been shown to accumulate chemical contaminants, such as hydrocarbons and heavy metals, in high concentrations. Reductions in growth and increased mortality have been observed in soft-shelled clams (*Mya arenaria*) following oil spill pollution events (Appeldoorn 1981). Impaired larval development, increased respiration, reduction in shell thickness, inhibition of shell growth, and general emaciation of tissues have been attributed to adult bivalve exposure to heavy metal contamination (Roesijadi 1996). High concentrations of organic contaminates also result in impairment of physiological mechanisms, histopathological disorders, and loss of reproductive potential in bivalves (Capuzzo 1996). As shellfish can easily accumulate chemical pollutants in their tissues, consumption of impaired shellfish creates a health risk. Subsequently, shellfish closures occur due to chemical contamination, commonly associated with industry, marinas, and runoff.

Delivery of inorganic pollutants, organic contaminants, and harmful microbes to waterways occurs via both point and non-point sources. Accumulation of harmful agents in the water column subjects oyster populations to the adverse effects listed above. Point sources have identifiable origins and include National Pollution Discharge Elimination System (NPDES) wastewater discharges. Although wastewater discharges are treated, mechanical failure allows contaminated sewage to reach shellfish growing waters triggering an area to be closed to harvest.

Non-point sources of microbial contamination include runoff from animal agriculture operations and urban development. Animal agriculture produces waste with fecal bacteria, runoff from pastures, concentrated animal feeding operations (CAFOs), and land where CAFO waste has been applied as manure, all of which can be transported to surface waters and subsequently lead to shellfish restrictions (Burkholder et al. 2007; Wolfson and Harrigan 2010; Hribar 2010). Impervious surfaces (e.g., roads, roofs, parking lots) facilitate runoff and microbe transportation, facilitating significant water quality degradation in neighboring watersheds (Holland et al. 2004). For instance, in New Hanover County, an analysis of the impact of urban development showed that just 10-20% impervious cover in an area impairs water quality (Mallin et al. 2000). In North Carolina, CAFOs primarily house swine and poultry with a majority located in the coastal plain portions of the Cape Fear and Neuse basins; however, both occur in all basins across the coastal plain (NCDWR 2023a).

Low Oxygen

Point and non-point sources (developed and agricultural lands) are also sources of increased nutrient loads, which fuel phytoplankton growth and increase the strength and frequency of algal blooms. The eventual bacterial decomposition of these blooms results in depletion of dissolved oxygen to levels that can be dangerous to shellfish, particularly in warm, deep waters. Increased eutrophication leads to decreased oxygen levels (hypoxia and anoxia), which North Carolina’s estuaries are already prone to because of salinity stratification and high summertime water temperatures (Buzzelli et al. 2002). Low-oxygen events degrade the usability of subtidal oyster reef habitats for fish (Eby and Crowder 2002) and cause high rates of oyster mortality in the deeper (4-6 m) estuarine waters (Lenihan and Peterson 1998; Powers et al. 2009; Johnson et al. 2009). State action to limit nutrient loading from urban and agricultural lands is critical for reducing hypoxia impacts to estuarine habitat and resources, including oysters and the reefs they create (DWR 2023b).

Shellfish Sanitation

North Carolina is part of the National Shellfish Sanitation Program (NSSP). The NSSP is administered by the U.S. Food and Drug Administration. The NSSP is based on public health principles and controls and is designed to prevent human illness associated with the consumption of shellfish. Sanitary controls are established over all phases of the growing, harvesting, shucking, packing and distribution of fresh and fresh-frozen shellfish. Shellfish Sanitation and Marine Patrol are the primary Sections of NCDMF responsible for North Carolina's compliance with the NSSP.

The Shellfish Sanitation Section classifies shellfish growing areas and recommends closures and re-openings to the Director that are implemented by proclamation. The entire North Carolina coast is divided into a series of management units referred to as Growing Areas. Each Growing Area is individually managed to determine which portions of the area are suitable for shellfish harvest, and which need to be closed to harvest. Data collected and used in classifying Growing Areas include actual and potential pollution sources, rainfall and runoff impacts, physical hydrodynamic patterns, and bacteriological water quality.

Shellfish growing waters can be classified as "Approved", "Conditionally Approved", "Restricted", or "Prohibited". Approved areas are consistently open to harvest, while Prohibited areas are off limits for shellfish harvest. Conditionally Approved areas can be open to harvest under certain conditions, such as dry weather when stormwater runoff is not having an impact on surrounding water quality, and Restricted waters can be used for harvest at certain times as long as the shellfish are subjected to further cleansing before they are made available for consumption. For a map of both temporary and permanent closures, please visit the Interactive Shellfish Closure Map on NCDMF's Shellfish Sanitation website. Additional information can be found under Current Polluted Area Proclamations.

Climate Change

Along the southeastern coastline, models suggest the intensity of hurricanes is likely to increase with warming temperatures, which will result in increased heavy precipitation from hurricanes (Kunkel et al. 2020). Additionally, it is likely the frequency of severe thunderstorms and annual total precipitation in NC will increase. The expected increase in heavy precipitation events will lead to increased runoff, which will result in an increase in chemical and microbial pollutants transferred to oyster habitats. Recent research has provided evidence that negative impacts from increased precipitation and pollutant delivery to estuaries have already begun in North Carolina (Paerl et al. 2019; Kunkel et al. 2020).

For instance, Paerl et al. (2020) investigated the impact of tropical cyclones on nutrient delivery and algal bloom occurrences in the Neuse River Estuary and Pamlico Sound. They found high-discharge storm events, such as high-rainfall tropical cyclones, can double annual nutrient loadings to the estuary, leading to increased nutrients and dissolved organic carbon. Phytoplankton response to moderate storm events is immediate, while during high-rainfall events like Hurricanes Floyd (1999), Matthew (2016), and Florence (2018), phytoplankton growth is diverted downstream to Pamlico Sound, where it can persist for weeks. Additionally, increased organic matter and phytoplankton biomass from heavy rainfall events contribute to oxygen depletion, exacerbating hypoxic and anoxic conditions in the Neuse River and Pamlico Sound.

Additionally, warming water temperatures caused by climate change may benefit growth rates for pathogens that can negatively impact oyster resources. For instance, increased water temperatures have been linked to increasing abundance of *Vibrio* over the past 60 years and may increase in frequency and length as temperatures rise (Vezzulli et al. 2016). Rising water temperatures threaten to increase this risk, potentially through longer periods of the year.

To reduce the negative impacts of climate change on the oyster fishery, it will be important for state agencies to implement policies that encourage the use of agriculture, forestry, and urban stormwater best management practices (BMPs) to reduce the amount of runoff reaching North Carolina's estuaries. This need, among others, has been emphasized in the CHPP as recommended actions to improve water quality (NCDEQ 2016, 2021). While the MFC has little direct control over such actions to mitigate the impacts of increased runoff, it can continue to support them through its role in developing and approving the CHPP.

Protected Species

A "protected species" is defined as any organism whose population is protected by federal or state statute due to the risk of extinction. In North Carolina, these species are primarily protected by the following federal statues: the Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), and the Migratory Bird Treaty Act. The NMFS has designated oyster fisheries as Category III, with no known gear interactions with marine mammals. More information on the MMPA List of Fisheries and fisheries categorizations can be found on the National Oceanic and Atmospheric Administration (NOAA) MMPA website.

North Carolina estuaries are also home to multiple ESA-listed species including Atlantic Sturgeon (*Acipenser oxyrinchus*), Shortnose Sturgeon (*Acipenser brevirostrum*), and five species of sea turtle. These species are unlikely to be impacted by oyster harvest, as the timing of the season (i.e., October – March) and harvest methods employed largely exclude any potential for direct interactions. Due to the lack of recorded interactions and the unlikelihood of any interactions between these ESA-listed species and the oyster industry, there is little to no extant literature. As such, it can be assumed any potential impacts of oyster harvest on protected species populations would be indirect and at the ecosystem-level.

North Carolina is home to a diverse array of migratory bird species (Potter et al. 2006). Little evidence exists to suggest most species of birds are directly impacted by oyster harvest. However, as oysters are a primary prey species of the American Oystercatcher (*Haematopus palliatus;* Tuckwell and Nol 1997), oyster harvest may result in secondary interactions with the species. For example, overharvest of oyster reefs has been found, in some cases, to contribute to a decrease in overall reproductive success of nearby nesting Oystercatchers (Thibault et al. 2010).

FINAL AMENDMENT 5 MANAGEMENT STRATEGY

****Section will be completed when the MFC selects preferred management and prior to DEQ secretary and legislative committees review****

The purpose of this section is for readers to see exactly how we are managing this fishery and what constitutes a change in management. It should include an overview and statement of policies, as well as any adaptive management..

RESEARCH NEEDS

The research recommendations listed below are offered by the Division to improve future management strategies of the estuarine striped bass fishery. They are considered high priority as they will help to better understand the oyster fishery and meet the goal and objectives of the FMP. A more comprehensive list of research recommendations is provided in the Annual FMP Review and NCDMF Research Priorities documents.

- Improve the reliability of estimating recreational harvest.
- Develop regional juvenile and adult abundance indices or methods to monitor abundance of the oyster population (fisheries-independent).
- Establish and monitor sentinel sites for shell bottom habitat condition; develop shell bottom metrics to monitor.
- Develop a program to monitor oyster reef height, area, and condition.
- Explore water quality data sources (i.e., NOAA, U.S. Geological Survey, FerryMon, Shellfish Growing Areas and Recreational Water Quality programs, meteorology sources) and their use in analyses that incorporates environmental variables that can impact regional population dynamics.

MANAGEMENT FROM PREVIOUS PLANS

A daily limit of two bushels of oysters per person with a maximum of four bushels of oysters per vessel off public bottom for Shellfish License holders statewide.

A six-week opening timeframe for mechanical harvest in deep bays to begin on the Monday of the week prior to Thanksgiving week through the Friday after Thanksgiving. Reopen two weeks before Christmas for the remainder of the six-week season.

A 15-bushel hand/mechanical harvest limit in Pamlico Sound mechanical harvest areas outside the bays, 10-bushel hand/mechanical harvest limit in the bays and 10-bushel hand harvest limit in the Mechanical Methods Prohibited area along the Outer Banks of Pamlico Sound.

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APPENDICES

Appendix 1: Recreational Shellfish Harvest Issue Paper

ISSUE

The number of recreational shellfish harvesters in North Carolina is currently unknown which makes estimating the total recreational harvest of shellfish difficult. Additionally, commercial harvesters are provided with human health and safety information regarding shellfish harvest when acquiring their license; however, there is currently no mechanism for reaching and educating recreational harvesters.

ORIGINATION

The North Carolina Division of Marine Fisheries (NCDMF) Oyster/Clam Plan Development Team (PDT).

BACKGROUND

Despite the importance of the commercial shellfish fisheries (molluscan and crustacean) to the state, limited data exist on recreational shellfish harvest. Currently, the NCDMF has limited data on recreational shellfish harvesting, including the number of participants and the extent of their economic activity. Collection of recreational shellfish harvest data, in addition to existing commercial landings data available through the North Carolina Trip Ticket Program (NCTTP) would provide a better estimate of total fishing mortality, relative abundance, and improve our knowledge of variation in abundance caused by a combination of fishing effort and environmental changes. A more accurate account of landings allows mangers to examine the proportional harvest of recreational and commercial fisheries to make better decisions on management strategies for both harvest sectors. It is imperative to collect high quality recreational harvest data to address potential management issues such as harvest limits, size limits, and gear restrictions.

Efforts to accurately quantify the impact of recreational fishing on shellfish (mollusks and crustaceans) have had limited success in North Carolina. The NCDMF collects data on recreational fishing in conjunction with the federal government's Marine Recreational Information Program (MRIP). However, MRIP collects information on finfish only.

Participation in recreational shellfishing in North Carolina has not been assessed for over 30 years. In 1991, a phone survey was conducted by the Marine Recreational Fisheries Statistics Survey (MRFSS), precursor to the MRIP, and it indicated that 3% of households in coastal North Carolina participated in recreational shellfishing, compared to an average of approximately 7% for finfish at that time (D. Mumford, NCDMF, personal communication). In 1991, MRFSS reported that in the state more than one million recreational fishing trips targeted shellfish. However, data on actual shellfish harvest estimates were not reported. The current extent of coastal households in North Carolina which recreationally harvest shellfish is unknown at this time.

The Hard Clam Fisheries Management Plan FMP (NCDMF 2001a) and Oyster FMP (NCDMF 2001b) supported adoption of a mechanism to provide data on recreational shellfish harvest. As a result of the recommendation by the Oyster and Hard Clam FMPs in 2001, House Bill 1427 was introduced before the general assembly in 2003 to establish a recreational shellfish license. This license would have been for shellfish only and would have been instituted on a trial basis for three years. However, the bill was never passed. In 2004, House Bill 831 did pass a saltwater fishing license mandating those individuals recreationally fishing for both finfish and shellfish to obtain a license. However, the state legislature revisited the issue in 2005 and replaced the saltwater fishing license with the Coastal Recreational Fishing License (CRFL). The Marine Fisheries Commission in the Bay Scallop FMP, Hard Clam FMP, and Oyster FMP recommended developing a mechanism to obtain data on recreational harvest of shellfish (DMF 2007). The need for a mechanism to be able to accurately quantify recreational effort and harvest has been a consistent area of concern in all North Carolina shellfish and crustacean FMPs.

The CRFL, which was implemented January 1, 2007, is only required when targeting finfish. When the CRFL legislation was originally drafted in 2007, it included shellfish. However, that language was removed before it was finally legislated. To fill this data gap, a survey of shellfish harvesting participation was added to the CRFL in November 2010 to collect monthly data on the harvest of crabs, oysters, clams, and scallops from the CRFL pool. The survey sample is made up of approximately 650 randomly selected CRFL holders that hold a valid license for at least one day during the survey period and answer "yes" to the harvest of at least one of the following species: crabs, oysters, clams, or scallops. In September 2014, the sample size was doubled to approximately 1,300 CRFL holders to increase the number of responses and precision of estimates. The selected CRFL holders are sent a letter explaining the survey along with the survey itself. Those that have not responded by the end of the month are sent a second copy of the survey. This survey obtains information on the number of trips taken during the survey period, average length of the trip, average party size, number of species kept and discarded, gear used, location information (water access), waterbody, and county of harvest. The mail survey estimates are a useful representation of shellfish harvest by CRFL holders but are limited in that they do not cover the entire population of potential recreational shellfish harvesters and probably represent a minimum estimate of effort and harvest. Despite good response rates, few responses contain oyster and clam activity.

The Fisheries Reform Act of 1997 (FRA) created a Recreational Commercial Gear License (RCGL) to allow recreational fisherman to use limited amounts of commercial gear to harvest recreational limits of seafood for personal consumption; however, shellfish gear (including hand, rakes, and tongs) was not authorized under this license. Since these gears are not covered by RCGL, recreational shellfishers can use these gears to harvest recreational bag limits of oysters and clams without a license. Therefore, recreational harvest data are not captured by past RCGL surveys.

Some recreational fishers may purchase a commercial shellfish license rather than a CRFL because the license is easy to obtain (available to any NC resident), is relatively inexpensive ($50.00), and allows fishers to harvest more shellfish than allowed under recreational limits. The Trip Ticket Program only captures landings from fishers who sell their catch to certified seafood dealers. Identifying and surveying individuals who purchase a commercial shellfish license but do not have any record of landings within the North Carolina Trip Ticket Program could be used to determine if the license is indeed being used for recreational purposes. This is also true for fishers who buy a Standard Commercial Fishing License (SCFL) with a shellfish endorsement but do not have any reported landings of shellfish. Even though this approach limits the sampling universe to only recreational fishers who bought a commercial license, it would provide some information on recreational shellfish harvest occurring that is not constrained by recreational limits. The shellfish harvest survey provides the ability to characterize recreational shellfish harvest, but still has limitations for estimating the total recreational harvest of shellfish.

With the limited data collected from the optional CRFL survey, some pieces of information about recreational effort have been captured. For instance, recreational oyster harvest was reported from 92 waterbodies throughout coastal North Carolina, with Topsail, Pamlico, Bogue, and Masonboro sounds all boasting more than 100 reported trips. The same survey revealed 70% of recreational oyster harvest effort originated from private residences, private boat ramps, or from shore. Given only 28% of reported effort originated at public access locations, intercept-oriented surveys are less than ideal. Recreational oyster harvest effort and catch were concentrated between October and March, accounting for over 84% of reported trips. Conversely, some individuals reported recreational harvest of oysters during the summer months despite state-imposed restrictions on harvest during this time. This suggests unfamiliarity with state regulations such as season and area closures.

Another concern of not having a license requirement for recreational shellfish harvest is the inability to easily communicate health and safety concerns of this harvest to recreational participants. The Shellfish Sanitation and Recreational Water Quality Section (SSRWQ) within the Division is responsible for ensuring all shellfish (oysters, clams, mussels) harvested or processed within North Carolina are safe for human consumption. To ensure shellfish are being harvested from areas free of contaminants, SSRWQ conducts pollution source assessments around shellfish growing areas, direct water quality sampling, hydrographic studies at point source discharges of pollution, and studies of the impacts of stormwater runoff on water quality. SSRWQ also conducts inspections and certifications of shellfish dealer facilities, as well as providing training for commercial harvesters and dealers, to ensure that shellfish are handled, stored, processed, and transported in a manner that keeps them safe for consumption.

To help keep the public informed of safe harvest areas and safe harvesting and handling practices, SSRWQ produces several publicly available informational resources, including:

Prohibited Shellfish Harvest Boundaries – SSRWQ establishes permanent closure boundaries that prohibit the harvest of shellfish in areas where there may be consistent contamination exceeding the standards for safe human consumption. These permanently closed areas are described and established via proclamation.

Polluted Area Proclamations and Temporary Closure Maps – In addition to the permanently closed areas described above, studies have found that water quality in certain areas can be negatively impacted by stormwater runoff, and shellfish can become temporarily unsafe for harvest under certain conditions. SSRWQ has developed management plans describing rainfall thresholds that can generate negative impacts and require temporary closures of these impacted areas. Temporary closures are put in place via proclamation and shown visually on the Division website through a web map updated as closed areas change.

Articles and Fact Sheets on Safe Handling Practices – Temperature abuse or improper handling practices can render shellfish unsafe to eat. To provide the public with information on how to safely store and handle shellfish, SSRWQ has prepared articles, fact sheets, and pamphlets available through the Division website.

Information on *Vibrio* Bacteria – *Vibrio* bacteria are naturally occurring bacteria that can be found in North Carolina waters and can cause severe illness in certain susceptible populations if consumed or through exposure to open wounds. Notably, these bacteria can proliferate within harvested shellfish even after they've been removed from the water, if the shellfish are held in warm/hot temperatures for extended periods of time. Proper handling/cooling of harvested shellfish is a critical step towards avoiding illness. SSRWQ has made available pamphlets and articles describing risks associated with these types of bacteria, and best practices for shellfish handling.

Although commercial harvesters, dealers, and shellfish lease/franchise holders, are provided with all this information when acquiring their license, getting their dealer certification, or acquiring/renewing their lease, there is no mechanism for reaching and educating recreational harvesters unless they actively seek out information.

AUTHORITY

N.C. General Statute

113-134	Rules.
113-169.2	Shellfish license for NC residents without a SCFL,
113-174.2	Coastal Recreational Fishing License.
113-182	Regulation of fishing and fisheries.
113-182.1	Fishery Management Plans.
113-201	Legislative findings and declaration of policy; authority of Marine Fisheries Commission.
113-221.1	Proclamation; emergency review.
143B-289.52	Marine Fisheries Commission – powers and duties.

Session Law 2023-137

N.C. Marine Fisheries Commission Rule (15A NCAC)

03O.0101	PROCEDURES AND REQUIREMENTS TO OBTAIN LICENSES, ENDORSEMENTS AND COMMERCIAL FISHING VESSEL REGISTRATION
03O.0107	LISENCE REPLACEMENT AND FEES
03O.0501	PROCEDURES AND REQUIREMENTS TO OBTAIN PERMITS
03O.0502	PERMIT CONDITIONS; GENERAL
03O.0506	SPECIAL PERMIT REQUIRED FOR SPECIFIC MANAGEMENT PURPOSES

DISCUSSION

Given North Carolina's shellfish fisheries are exclusively under state jurisdiction, lack of recreational shellfish harvest data makes addressing potential management issues such as harvest limits, size limits, and gear restrictions difficult. There are no data on demographics, perceptions, or expenditures of recreational shellfish harvesters in the state. Consequently, there is no data available to conduct an economic impact assessment of recreational oyster harvesting. Due to widespread accessibility of intertidal oysters and clams along North Carolina's coast, the potential impact of recreational harvest could be significant.

Table 1.1. Recreational shellfish harvest license requirements for east coast states.

State	License Requirements
Maine	No state license, towns have local restrictions and permits
New Hampshire	State license
Massachusetts	No state license, towns have local restrictions and permits
Rhode Island	Required for non-residents
Connecticut	No state license, towns have local restrictions and permits
New York	No state license, towns have local restrictions and permits, also has residency requirements
New Jersey	State license
Delaware	State license
Maryland	None, must be state resident
Virginia	None
North Carolina	None
South Carolina	State license
Georgia	State license and free permit
Florida	State license

License requirements for recreational shellfish harvesting varies by state along the United States east coast (Table 6). Most states require some type of license while in Maine, Massachusetts, New York, and Connecticut individual towns and cities require a license to recreationally harvest shellfish. North Carolina and Virginia are the only states without some form of license, local permitting, or residency requirements.

There are multiple avenues the NCDMF and MFC could pursue to better assess population of recreational shellfish harvesters. One solution is to include shellfish as part of the CRFL. This can be accomplished by three different methods. The first is to require the existing CRFL to recreationally harvest both finfish and shellfish. The second would be to create a separate shellfish only CRFL. This license would only give a recreational angler access to the allowed shellfish species and would exclude finfish harvest. This would allow fishery access to recreational anglers who are only interested in harvesting shellfish, and the cost could be set at a lower price than a standard CRFL. The third option would be to require the existing CRFL and create an additional recreational shellfish endorsement. The endorsement would be applied to the CRFL and would indicate the angler is licensed to recreationally harvest both finfish and shellfish. One drawback to these three options is it would require legislation to change the CRFL.

Another solution is to develop a recreational shellfish permit. The MFC has the authority to implement a permit to help manage estuarine and coastal resources and can set a maximum fee of up to $100 (although most permits are free of charge). A permit could function similar to a license. Recreational anglers would be required to have the permit to participate in the recreational shellfish fishery. A nominal fee for the permit would discourage participants from only obtaining the permit because it was free, helping to constrain the sampling universe.

Creating a specific CRFL, as outlined above, or a recreational shellfish permit would provide NCDMF with a complete pool of recreational shellfish harvesters. That list could then be used as a survey frame to help estimate effort and harvest in the fishery. Having a list of the population of recreational shellfish harvesters is useful for distributing shellfish area closure proclamations and maps. If shellfish species are added to the existing CRFL, the activity survey conducted during CRFL sale would still be needed to identify fishers who are involved in recreational shellfishing. These fishers would then receive additional surveys to estimate effort and harvest in the recreational shellfish fishery.

Although creating a specific type of CRFL, adding shellfish under the existing CRFL, or developing a recreational shellfish permit would be the most efficient mechanisms to determine effort in the fishery, another way to obtain these data would be to capture this activity in MRIP. MRIP does capture some non-finfish activity, but those data are broad and not available to shellfish at the species level and MRIP agents rarely encounter those types of recreational fishing trips. Most recreational shellfishing effort is by coastal residents using private docks and access points as opposed to public access points. Because MRIP is a nation-wide program, any changes to methodology designed to intercept more recreational shellfishing activity would need to undergo extensive review process and if implemented could take away from intercepts in other target fisheries.

Personal consumption by participants holding commercial fishing licenses (either a SCFL with a shellfish endorsement or a Shellfish license without a SCFL) would not be covered under any type of recreational shellfish license or permit. In the fall of 2023, the North Carolina General Assembly passed Session Law 2023-137. Section 6 of this legislation requires anyone holding a commercial fishing license who is engaged in a commercial fishing operation to report all fish (including shellfish) harvested to NCDMF, regardless of if the fish are sold or kept for personal consumption. Currently, this legislation is effective December 1, 2025. NCDMF is working on draft rules to implement this law and to develop the reporting mechanism for these participants. Implementation of this law should fill this data gap.

Implementing a licensing or permitting requirement for recreational shellfish harvesters would give the Division the opportunity to inform participants of where to find information on harvest closure boundaries, where to sign up to receive polluted area proclamations or to access temporary closure maps, and where to find information on safe handling practices, particularly as it relates to Vibrio bacteria.

To pursue any of these solutions, significant time and effort will be needed to assess internal program and resource capabilities and limitations. Any legislative changes require a specific process and are ultimately out of NCDMF or MFC control. Given these constraints, NCDMF recommends exploring potential options and solutions outside of the FMP process.

Management Options

- Status Quo
  - Does not provide reliable estimates of recreational shellfish harvest or effort.
  - Does not provide a mechanism to ensure recreational shellfish harvesters are provided with SSRWQ health and safety information and links to harvest area closures.
- Support the NCDMF to further explore potential options and develop a solution to quantify recreational shellfish harvest participation and landings, and to establish a mechanism to provide all recreational shellfish harvesters with SSRWQ health and safety information outside of the FMP process.

Recommendations

DMF RECOMMENDATION: Support the NCDMF to further explore potential options and develop a solution to quantify recreational shellfish participation and landings, and to establish a mechanism to provide all recreational shellfish harvesters with SSRWQ health and safety information outside of the FMP process.

LITERATURE CITED

NCDMF. 2001a. North Carolina Hard Clam Fishery Management Plan. North Carolina Department of Environment and Natural Resources. North Carolina Division of Marine Fisheries, PO Box 769, Morehead City, NC.

NCDMF. 2001b. North Carolina Oyster Fishery Management Plan. North Carolina Department of Environment and Natural Resources. North Carolina Division of Marine Fisheries, PO Box 769, Morehead City, NC.

Appendix 2: Mechanical Oyster Harvest Management Issue Paper

ISSUE

Addressing management for the mechanical fishery for subtidal oyster stocks in Pamlico Sound North Carolina.

ORIGINATION

The Coastal Habitat Protection Plan as adopted by the North Carolina Marine Fisheries Commission, and the Division of Marine Fisheries.

BACKGROUND

The North Carolina Eastern Oyster Fishery Management Plan Amendment 5 is focused on management of wild oyster stocks, and this issue paper does not include farm raised or private cultured oysters.

North Carolina's wild oyster stocks are composed of both intertidal (exposed to air during portions of the tidal cycle) and subtidal (continuously submerged) populations. In North Carolina, oyster harvesting through mechanical means is primarily achieved using oyster dredges and is limited to subtidal oyster reefs in specific areas of Pamlico Sound. Although some hand harvest of subtidal oysters does occur, the primary harvest method for oysters in Pamlico Sound has been mechanical gear (Figure 2.1). While mechanical harvest gear like oyster dredges may offer an efficient means of harvesting oysters, their use requires careful management and consideration of their potential negative impacts on both oyster stocks and habitat. The North Carolina Marine Fisheries Commission's (NCMFC) Coastal Habitat Protection Plan (CHPP) identifies bottom disturbing fishing gear, including oyster dredges, as having the potential to be highly destructive towards oyster reefs. The NCMFC has set a goal to “Enhance and protect habitats from adverse physical impacts” and recommended the following actions: Protect habitat from adverse fishing gear effects and protect and restore important fish habitat functions from damage associated with activities such as dredging (NCDEQ 2016).

Currently, large scale abundance estimates and a traditional stock assessment for North Carolina Oysters is not possible. The Division is unable to assign a stock status or determine sustainable harvest limits for Pamlico Sound oysters. Oysters pose a unique management problem as they are simultaneously a stock that is harvested as a fishery resource, and the essential habitat for that same fishery resource. Oysters need suitable hard substrate (cultch) for juvenile oyster (spat) to settle on and grow. Shells of living or dead oysters provide the appropriate hard substrate for juvenile oysters to settle on, creating self-sustaining oyster reefs. If living oysters or dead shell material is removed from a reef through fishery effort at a rate faster than it can naturally replenish, both the oyster resource and habitat will eventually disappear. An approach to manage oyster fisheries which considers this balance of shell gain and loss (Shell Budget Model) has been developed and employed in the Gulf of Mexico (Soniat et al. 2022; Soniat 2016).

A key component for Pamlico Sound mechanical oyster harvest management is to balance the value of utilizing oysters as a fishery resource while maintaining their role as an essential habitat for themselves and a wide range of estuarine species. To minimize damage to oyster habitat from mechanical harvest, decreases in bushel limits and larger area or seasonal closures implemented via fishery monitoring have been established through time. Dredges are subject to weight and size restrictions and are required to be towed from the side of the vessel to mitigate habitat impacts by not removing excess cultch material and sub-legal oysters from their areas of origin. To limit excessive effort impacts, mechanical harvest is only allowed from sunrise to 2:00 PM Monday through Friday. To ensure excess reef material and undersized oysters are not removed from their respective reefs, culling of cultch material and undersized oysters must occur at the harvest location with a 5% culling tolerance. Additionally, extensive cultch planting efforts have occurred in mechanical harvest areas to mitigate harvest impacts to oyster reefs by adding cultch material.

The first oyster harvest limits for the mechanical fishery were introduced in 1947 at 75 bushels per vessel per day, remaining until 1984. From then until 1989, the daily limit was lowered to 50 bushels per vessel. In 1989, the daily limit for commercial operations was capped at 50 bushels per vessel, but with added flexibility for the director to set lower limits as needed. In 1990, the bushel limit was dropped to 20 then further reduced to 15 bushels due to declining populations attributed to Dermo disease. The 2001 Eastern Oyster FMP changed the criteria for where mechanical harvest would be allowed in the bays of Pamlico Sound (NCDMF 2001). The 2008 Amendment 2 to the Oyster FMP outlined a strategy for Pamlico Sound and its tributaries, setting a 15-bushel limit per commercial fishing operation in open waters of the sound, and limiting harvest in the bays to a six total possible week season with a daily limit of 10 bushels per vessel (NCDMF 2008). In 2010, Supplement A to Amendment 2 of the Oyster FMP established the trigger for closing areas to mechanical harvest when sampling indicates the number of legal-sized oysters in the area has declined below the threshold (NCDMF 2010). Additionally, this management strategy was re-adopted in Amendment 4 in 2016 (NCDMF 2016). Beginning in 2017, the six-week open period for bays was split into two potential open periods. The first begins on the Monday of the week prior to Thanksgiving and runs through the Friday after Thanksgiving. The second opening of the bays could begin two weeks before Christmas and remain open for the remaining four weeks. For more detailed information on the management history of the Pamlico Sound mechanical oyster fishery see the previous Oyster Management Plan, Amendments, and Supplement.

The current mechanical oyster fishery is limited to the subtidal open water regions of Pamlico Sound as well as specified subtidal regions of its surrounding bays. The mechanical harvest season has the potential to occur between the third Monday in November to 31 March in the subtidal, open water areas of Pamlico Sound; however, the actual season length is ultimately determined by a harvest monitoring program. In bays where harvest is allowed, the season is capped to a total of six possible weeks. If the area in which the bay is located is closed due to harvest monitoring the season may be shorter than six weeks. There is a 15 bushel-per-day limit in the deeper portion of Pamlico Sound and a 10 bushel-per-day limit in the bays.

Annual landings from mechanical harvest in North Carolina have declined significantly since a peak in 2010. The 2010-2011 landings peak reflects the highest participation and landings in the mechanical oyster fishery between 1994 and 2021. During the 2010-2011 oyster season, high market demand caused by the closure of harvest areas in the Gulf of Mexico from the Deepwater Horizon oil spill drew a large amount of effort and participation into the North Carolina mechanical harvest oyster fishery. Landings in this fishery are strongly tied to participation and effort, and declining trends in participation mirror landings trends (Figures 2.1 and 2.2). Prior to 2012, mechanical harvest of oysters only required a Shellfish Commercial License. This license is not capped to a total number of participants, unlike the Standard/Retired Commercial Fishing License (SCFL/RSCFL) and is potentially available at a relatively low cost to all residents of the state. The large and rapid increase in effort in the mechanical fishery observed leading up to the 2010-2011 harvest season was primarily driven by new entrants into the fishery obtaining Shellfish licenses. In response to this, a SCFL/RSCLF has been required to participate in this fishery since the 2011-2012 season.

Weather and water quality events have also directly influenced effort and landings in the mechanical oyster fishery. After major hurricanes, low dissolved oxygen events, or extreme temperature events, the oyster resource in the mechanical harvest areas may only sustain harvest for a few weeks before NCDMF closes areas to mechanical harvest. The actual length of time mechanical harvest for oysters can occur each year in North Carolina is determined by the monitoring program and is variable depending on the status of the oyster resource and fishery effort.

The current harvest monitoring program serves as a habitat protection framework to manage fishery effort in the Pamlico Sound mechanical oyster fishery and has been in place since 2010. The Sound is divided into four Management Areas based on geographic region: the Neuse River Area, Pamlico River Area, Northern Hyde Area, and Northern Dare Area (Figure 2.3). The Division samples oyster reefs in each management area once before the opening of the mechanical harvest season, and then biweekly once mechanical harvest is open. Sampling sites are chosen based on current (or previously known) presence of commercial harvesting in the area. Areas are selected where commercial harvest occurs with the goal of assessing localized depletion and addressing habitat protection concerns. A threshold of 26% legal-size live oysters (3 inches shell length or greater) in pooled samples for each sampling event and Management Area was established as the management trigger. In developing this management framework, the effect of the effort required to harvest a limit of legal oysters on reef habitat was considered. When an area oyster population reaches 26% or lower legal oysters, it was determined that impacts to reef habitat through the removal of shell material outweighed the fishery benefit from harvest. If the pooled samples collected across a management area for a sampling event show 26% or less legal oysters, the management trigger is tripped for that area. If two consecutive sampling events result in the management trigger being tripped, the entire management area is closed to mechanical harvest. An area may re-open if two additional consecutive sampling events show above 26% legal oysters.
There is no minimum threshold for percent legal in the initial opening of an area to mechanical harvest. A management area will open even if pre-season sampling shows the area is below the 26% legal threshold. Biweekly sampling begins the first week of the

mechanical harvest season, meaning areas that start below the 26% legal threshold can take three weeks to trip the management trigger twice before closing.

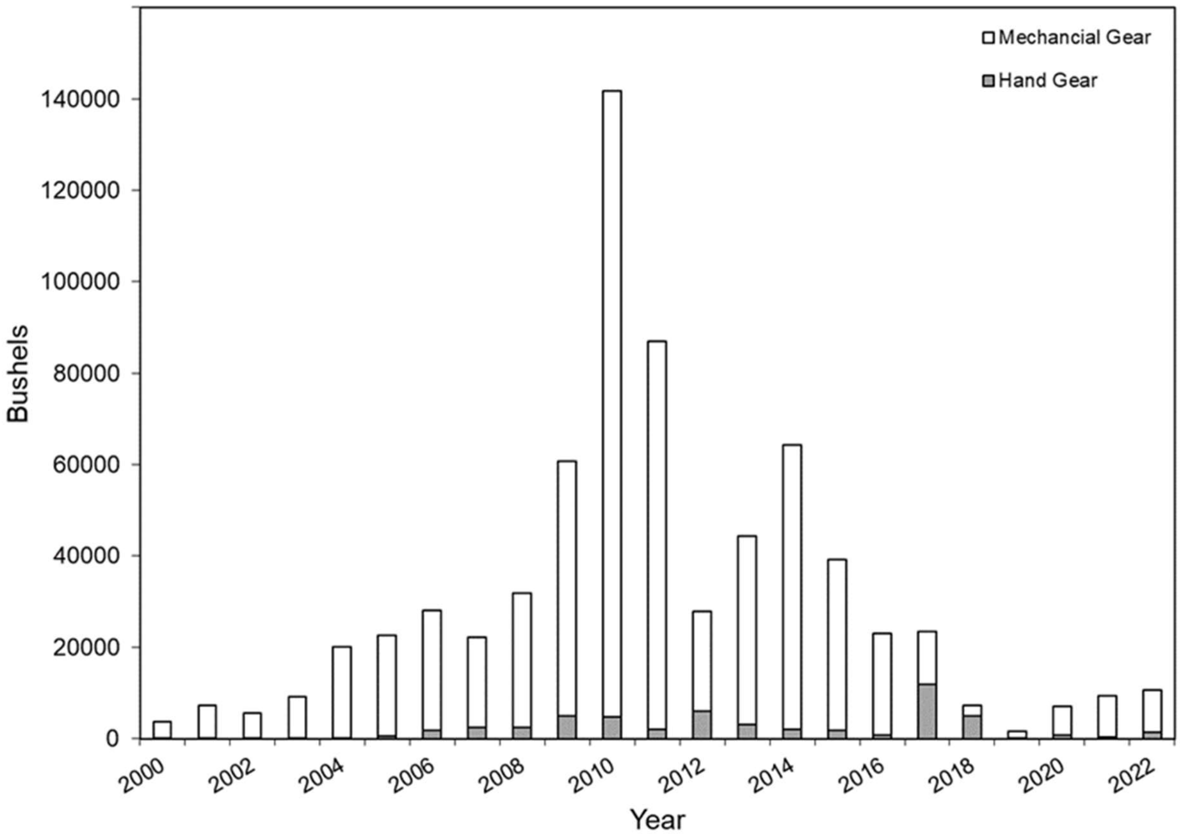

Figure 2.1. Commercial landings of oysters from Pamlico Sound in North Carolina from 2000 to 2022, showing the total annual landings (entire bar height) and the proportion of landings contributed by hand gear (rakes, tongs, hand) as dark gray, and proportion from mechanical gear (dredges) as white.

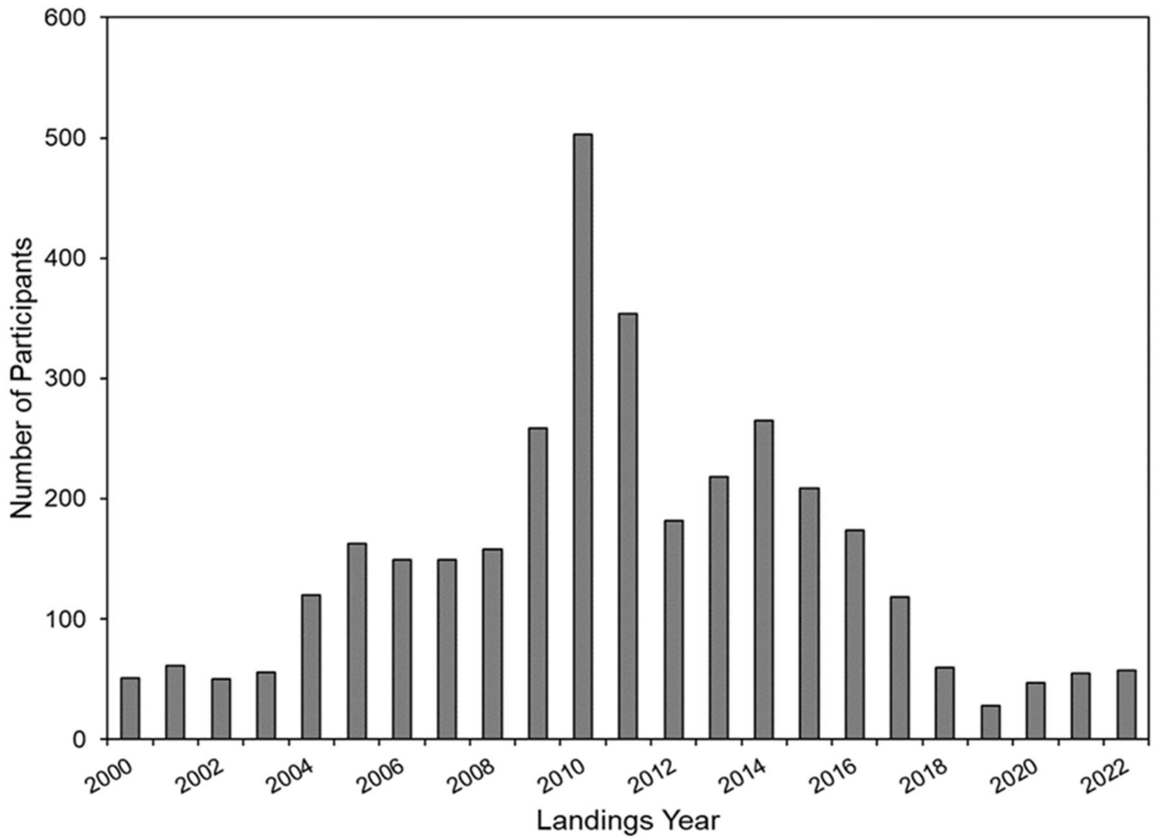

Figure 2.2. Annual number of participants with landings of oyster using mechanical gear in Pamlico Sound, 2000-2022.

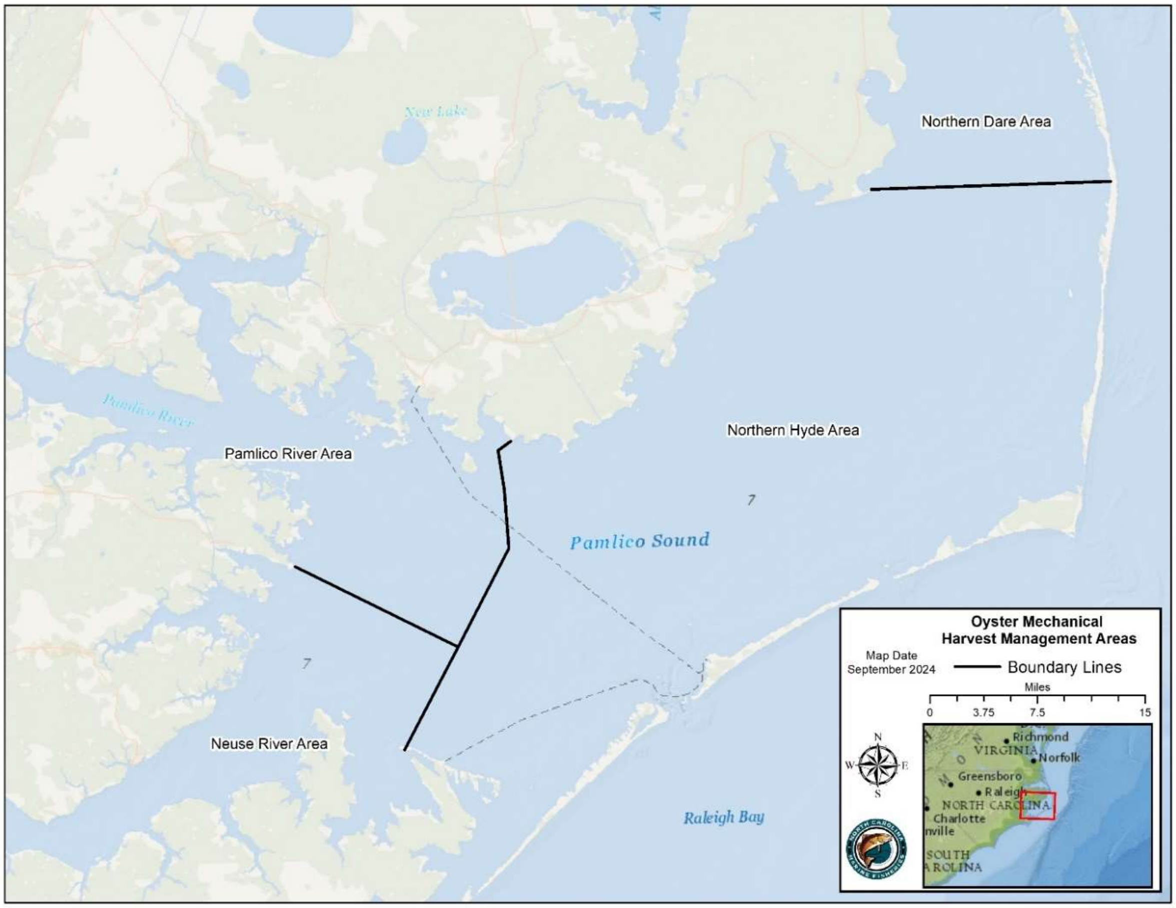

Figure 2.3. Pamlico Sound Oyster Mechanical Harvest Management Areas from south to north: the Neuse River Area, Pamlico River Area, Northern Hyde Area, and Northern Dare Area.

Oyster mortality from Hurricane Irene in 2011 and a low dissolved oxygen event in 2012 resulted in the 2012-2013 mechanical harvest season being closed by the management trigger months shorter than in previous seasons. In 2018, Hurricane Florence caused significant damage to the Pamlico Sound oyster resource, and Hurricane Dorian in 2019 further impacted oysters in Western Pamlico Sound. Over the last five years since these storm events, the mechanical harvest trigger has taken on average three weeks into the mechanical harvest season to be tripped across all management areas (Table 2.1). As the oyster resource recovered, mechanical harvest closures have occurred later in the potential season for the Neuse and Pamlico Management Areas in recent years. The longer time taken to trip the management trigger in the Neuse and Pamlico areas is driven by higher populations of oyster in the 10 bushel-per-day bays, which are capped at a six-week total possible season. While the deep-water regions and bays of a Management Area are not treated separately for the calculation of the management trigger, the deep-water reefs (>5m) which were sampled in the Pamlico and Neuse Areas, were found to have very few legal sized oysters during harvest monitoring in recent years. When the bays are examined separately, they have averaged above the management trigger (Table 2.2).

Table 2.1. The number of open weeks into the mechanical harvest season before the 26% legal management trigger tripped for each Mechanical Harvest Management Area by oyster season years.

	2019-20	2020-21	2021-22	2022-23	2023-24
Dare Management Area	1	10	3	3	2
Hyde Management Area	4	1	3	3	3
Pamlico Management Area	1	2	6	6	6
Neuse Management Area	1	1	6	6	6

Table 2.2. Percentage of legal sized (3 inch shell length or greater) live oysters sampled during the first harvest monitoring program sampling event each year for the Pamlico and Neuse Management Areas by deep-water areas (> 5m) and bays.

	2019-20	2020-21	2021-22	2022-23	2023-24
Pamlico Management Area Deep	13%	0%	0%	0%	0%
Pamlico Management Area Bays	44%	45%	49%	18%	41%
Neuse Management Area Deep	0%	0%	0%	0%	0%
Neuse Management Area Bays	8%	26%	33%	28%	39%

NCDMF has one of the longest running and expansive oyster restoration and enhancement programs in the United States. North Carolina’s Cultch Planting Program began in 1915 to replace shell material removed by harvest. Since its inception, over 21 million bushels of cultch material has been planted in the form of small-scale, low-relief, harvestable oyster reefs. Today, the NCDMF Cultch Planting Program creates oyster reefs which provide both habitat restoration and alleviation of public harvest pressure from natural reefs. Over the last ten years, 624 acres of harvestable oyster reefs have been created on public bottom through this program, with the ongoing goal of creating an additional 50 acres per year into the future. In addition, 789 acres of protected oyster reef have been permitted and constructed across 17 separate no-take Oyster Sanctuaries in Pamlico Sound. For more detailed information about these two programs see Appendix 4: Habitat Enhancement Programs. In areas open to mechanical harvest, cultch planting efforts have been focused primarily in the bays of the Neuse and Pamlico areas as well as in the eastern portion of the sound in the Dare and Hyde areas (Figure 2.4). Between 2000 and 2022, a total of 2,167,638 bushels of cultch material were planted in the mechanical harvest areas of Pamlico Sound, and 452,112 bushels of oyster were mechanically harvested. This resulted in 4.8 times more bushels of cultch being planted than oysters mechanically harvested over this time. Since 2018, 36 times more bushels of cultch have been planted compared to bushels of oysters commercially harvested and removed (Figure 2.5). The return in commercial harvest per unit of cultch planted in North Carolina remains unknown and likely varies across different planting sites. The impact of cultch plantings on oyster landings isn't immediate, as it typically takes between one and three years after planting for new cultch material to yield legal-sized oysters. While some cultch planting sites have relatively short lifespans, others have been observed to continue yielding harvests for decades. Current management of oyster harvest in North Carolina does not distinguish between harvest from division constructed cultch planted reefs and wild naturally occurring reefs.

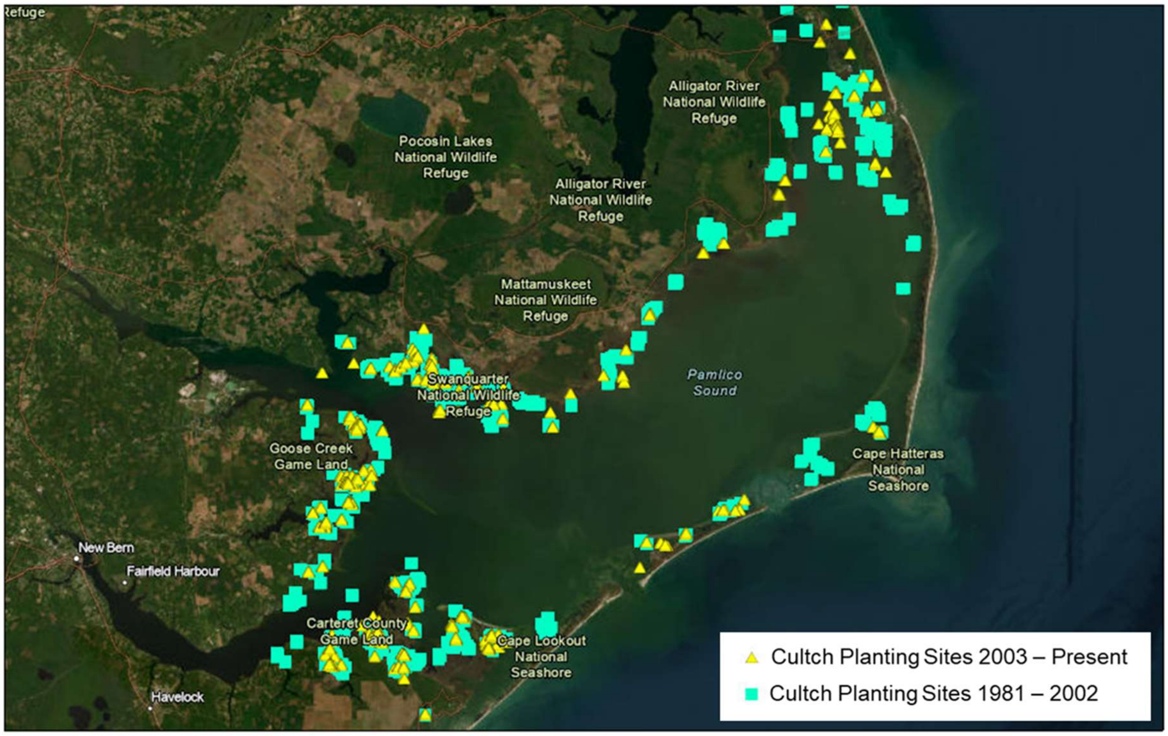

Figure 2.4. Map of cultch planting sites in Pamlico Sound, 1981 to present.

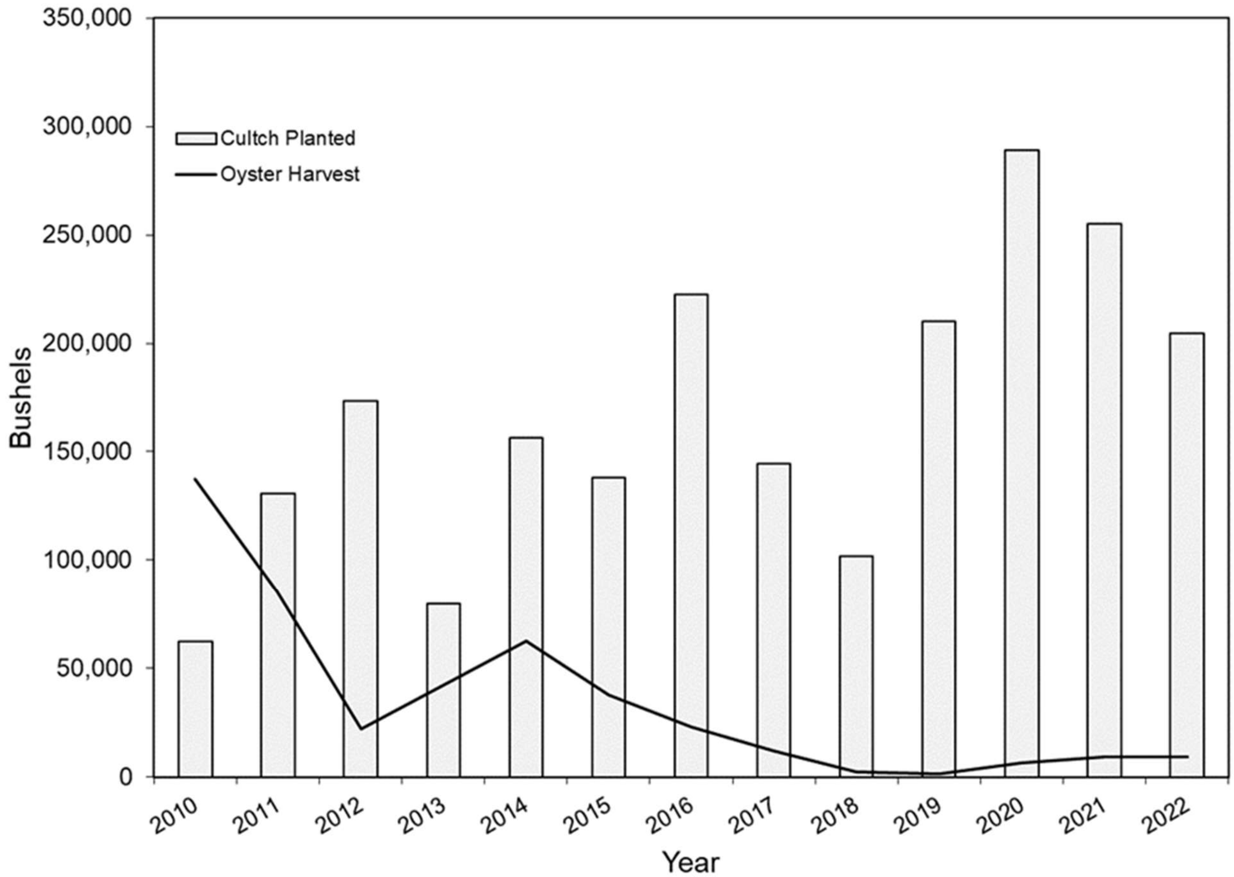

Figure 2.5. Annual amounts of cultch planted (shown as light grey bars) and bushels of oysters mechanically harvested (shown as black line) from the mechanical harvest areas of Pamlico Sound.

AUTHORITY

<u>N.C. General Statute</u>

113-134	Rules.
113-182	Regulation of fishing and fisheries.
113-182.1	Fishery Management Plans.
113-201	Legislative findings and declaration of policy; authority of Marine Fisheries Commission.
113-221.1	Proclamation; emergency review.
143B-289.52	Marine Fisheries Commission – powers and duties.

<u>N.C. Marine Fisheries Commission Rules (15A NCAC)</u>

03K .0201	Oyster Harvest Management

DISCUSSION

The existing mechanical harvest management strategy for oysters in Pamlico Sound aims to monitor in real time the habitat conditions of oyster reefs where mechanical harvest is actively occurring, and then close broad management areas once the condition of the oyster resource reaches a point where the effort required to harvest legal oysters causes excessive damage to the reef habitat. When this reactive management strategy was developed and adopted, participation in this fishery was approximately five times greater than participation has been in recent years. This drop in participation has often made it problematic for division staff to find areas where there is active fishing activity to sample, particularly in the bays of the Neuse and Pamlico Areas. When active mechanical harvest areas are not encountered by staff, knowledge of past harvesting areas or localized areas of current oyster abundance are chosen for trigger sampling locations using their best judgment. Additionally, during pre-season sampling events, or when areas are either closed due to the management trigger being tripped or the break in the 6-week season for the bays and there is no mechanical harvest occurring, staff are again required to make judgment call decisions on where to sample. Given the sometimes-varying conditions between oyster reefs in the region, mechanical harvesters may view sampling locations selected by the division as not representative of areas they fish.

While the potential mechanical harvest season for oyster could run from November through March, the actual season length allowed in each Management Area is ultimately dictated by results of the trigger sampling and opened or closed via proclamation. With fluctuations in the oyster resource due to storm events, the season length for a given area may vary widely between years. If sampling indicates the management trigger has tripped, a proclamation is issued closing that area effective no sooner than 72 hours from issuance. After impacts from multiple hurricanes, the mechanical harvest season in the Pamlico and Neuse Management Areas was only open to mechanical harvest for 10 days in the 2019-2020 season, yet in the 2021-2022 season it was open eight weeks. At the opening of each mechanical harvest season, harvesters are unaware of how long each area will be open and rely on monitoring proclamations for closures. This uncertainty and variability in season length is often viewed unfavorably by harvesters.

The current management trigger uses the percentage of live legal sized oysters as a metric to determine fishery effort impact on oyster reef habitat. While this has been a proactive approach to close mechanical harvest at a point which ensures cultch material and live oysters remain on reefs, it does not consider oyster abundance when triggering area openings or closures. If an area that was being sampled had very few (low oyster abundance) but very large (high percent legal) oysters, the management trigger would not be tripped and remain open to harvest. However, with such a low abundance of oysters, this area may be vulnerable to overharvesting, and damage to the habitat from the effort required to harvest would be high. Conversely, if an area has a healthy and abundant mature oyster population which is experiencing a period of high recruitment (heavy spat set), the relatively high number of spat counted in the live oyster sample would drive down the percentage of legal live oysters and trip the management trigger. The trigger sampling program is designed to monitor impacts from the mechanical fishery as a habitat protection measure and does not currently allow for the estimation of oyster population or abundance.

The Neuse, Pamlico, and Hyde management areas all contain bays which are capped at a total possible six-week season and are limited to 10 bushels per vessel a day. The condition of the oyster resource in the bays is often significantly different than what is found in the deep open water areas of the management area. The bays and deep portions of the management areas are not considered separately during calculation of the management trigger, or during management area closures from the results of trigger sampling. In recent years, the Pamlico and Neuse River area bays have had oyster resources to sustain the full six-week possible season in the bays, while there have been few legal oysters found in the deeper areas. The entire management area remained open due to the greater abundance of legal oysters in the bays, leaving the deeper portions of the management area vulnerable to damage from potential dredge effort. The deep-water reefs and shallow reefs in the bays were likely impacted differently from storm events, with oysters in the bays not suffering the mass mortality observed in those found in deeper portions of western Pamlico Sound (Table 2.2).

Historically deep-water reefs of western Pamlico Sound were reported to reach up to 4 m in height. In the Neuse River, high relief deep water oyster reefs were shown to suffer mass mortality at depths greater than five meters due to low oxygen, while low relief reefs in shallow waters (between three to four meters in depth) did not experience such die offs (Lenihan and Peterson 1998). The historical mounded structure of reefs in Pamlico Sound provided increased habitat complexity for a wide variety of invertebrates and fish and the upper portion of the mounds provided refuge for benthic organisms when lower portions of the reef were hypoxic. Research has shown that oysters at the base of subtidal reefs have a greater proportion of oyster mortality, significantly lower abundance of organisms, and higher incidence of disease occurrence, compared to the crest of reefs (Lenihan and Peterson 1998; Lenihan et al 1999). The survival and recovery of deep-water oyster reefs is contingent on their ability to gain vertical height.

Mechanical oyster harvest using dredges significantly impacts subtidal oyster reefs by reducing their vertical relief, which leads to several negative habitat effects (Lenihan and Peterson 1998; Lenihan et al. 1999). This harvest method causes the scattering of shell and oysters into less suitable substrates, destabilizing the reef structure and increasing its vulnerability to storm damage. The process also decreases the reef's resistance to disease. The removal of live and dead oysters, along with portions of the upper shell layers, leads to a reduction in the potential number of spawning adults (spawning stock biomass) and diminishes the area available for oyster larvae settlement. Furthermore, newly settled oysters are subjected to lower oxygen levels and increased sedimentation due to the reduced depth in the water column. Additionally, it reduces the availability of small spaces within the reef that serve as crucial refuge and foraging areas for juvenile fish.

To investigate the impacts of mechanical harvest methods on oyster reef heights, NCDMF and the University of North Carolina Institute of Marine Science researchers created restored reefs in the Neuse River in 1993, which were experimentally harvested in 1995 and 1996 (Lenihan and Peterson 1998, 2004). The 1995 experimental dredge harvest (designed to approximate the minimum seasonal dredge effort a reef would experience) removed an average of 29 cm of height from the 1-meter-tall reefs (Lenihan and Peterson 1998). The 1996 experimental harvest included dredge, tong, and diver hand harvest methods, which reduced the heights of the 1-meter reefs by averages of 34, 23, and 6 cm, respectively, illustrating that dredge harvest has the greatest impact to reef height out of the harvest methods examined (Lenihan and Peterson 2004).

In Pamlico Sound, changes in abundance of historic oyster reefs since the 1880s were documented by Ballance (2004). Using new technologies to locate subtidal reefs reported by Winslow (1889), Ballance (2004) found many formerly productive high-profile reefs now consisted of low-profile shell rubble, low density reefs, or buried reefs. Ballance (2004) also found the larger shallow reefs had less live oysters, which he attributed to the ease of locating those reefs by fishers. Similarly, Lenihan and Peterson (1998) resurveyed natural oyster reefs in the deeper (>5 meters depth) portions of the Neuse River Estuary that had been marked in an 1868 US Coast and Geodetic Survey, finding that reefs that were 1.8 to 2.4 meters tall in 1868 were only 0.3 to 0.9 meters tall in 1993, and that no reefs in the 1993 survey were taller than 1.2 meters. Lenihan and Peterson (1998) reported that it was “probable that reduction in reef heights in the Neuse River estuary is due to decades of fishery-related disturbances caused by oyster dredging” and suggested reefs in heavily fished NC waters would need to be restored every 3-4 years.

The NCDMF oyster restoration and enhancement program has focused significant effort into creating cultch reefs in areas open to mechanical oyster harvest in Pamlico Sound, with the volume of cultch material planted into the sound greatly exceeding the volume of oysters commercially harvested. Cultch plantings form low relief harvestable reefs and are not planted over areas of existing oyster reefs. No cultch planting or oyster restoration has been documented in the deeper portions of the sound to restore the historic high-relief reefs found at the mouth of the Pamlico and Neuse rivers. The division’s cultch planting efforts have been focused in the bays surrounding the western Pamlico Sound and the area between Stumpy Point and Oregon Inlet and have likely supported a significant portion of the fishery effort. While landings from cultch planted reefs are not currently separated from wild reefs in Trip Ticket landings, division sampling and harvester feedback indicates cultch reefs are used for harvest areas. Since 2018, 36 times more bushels of cultch have been planted compared to bushels of oysters commercially harvested and removed. Given this large disparity and the distribution of cultch planting sites in Pamlico Sound, the current harvest management approach, which does not differentiate between cultch and wild reefs, is not best using the cultch planting program.

To maintain harvestable oyster populations in Pamlico Sound, a three-tiered approach is proposed for Pamlico Sound oyster mechanical harvest management to balance the value of oysters as both a fishery resource and essential habitat. Tier 1 of this approach is to protect highly degraded and threatened oyster habitats by establishing Deep-water Oyster Recovery Areas (ORCAs). Meanwhile, Tiers 2 and 3 modify current management strategies that place equal or greater value on the oyster resource with continued Cultch Supported Harvest and the creation of a series of Rotational Cultch Sites, respectively.

Deep-water Oyster Recovery Areas (Tier 1)

The remnant deep-water natural oyster reefs in the Pamlico and Neuse rivers have suffered mass mortality from water quality impacts. These reefs have likely not supported much fishery effort since 2018 and have had very few live or legal oysters sampled during division monitoring efforts. Additionally, no cultch planting effort is occurring in these areas. Goal 3 of the 2016 CHPP is to “enhance and protect habitats from adverse physical impacts,” which includes reducing the impacts of mobile bottom disturbing fishing gear, the negative effects of which are described in Section 8.1.1 of the 2016 CHPP. Under Goal 3, the primary relevant recommended actions are 3.3 “Protect habitat from adverse fishing gear effects through improved compliance” and 3.8 “Develop coordinated policies including management adaptations and guidelines to increase resiliency of fish habitat to ecosystem changes." To meet the NCMFC goals as adopted in the CHPP and allow deep-water oyster reefs to accumulate shell material to gain the height necessary to be resilient to storm events, Tier 1 proposes Deep-water Oyster Recovery Areas (DORAs) where mechanical harvest would not be open. Oyster habitat (cultch planting sites and natural shell bottom) in Pamlico Sound has been mapped across multiple years and includes habitat below 5 meters (the depth at which oyster reefs have been documented to suffer mortality during low oxygen events) (Figures 2.6). Using existing navigation aids (lights, buoys, and beacons) as corner points for ease of compliance and enforcement, Pamlico River DORA and Neuse River DORA are proposed (Figure 2.7). The two proposed DORAs contain no known cultch planting sites and encompass known shell habitat in Pamlico Sound deeper than 5 meters. The deep-water oyster reefs which are not captured in the proposed areas may be used as control sites for future evaluation of this management strategy. Deep-water Oyster Recovery Areas would prioritize the habitat value of these oyster reefs over the potential fishery resource they could provide.

Cultch Supported Harvest (Tier 2)

Significant cultch planting effort has gone into creating harvestable reefs and replenishing cultch material lost in areas open to mechanical harvest in Pamlico Sound. Cultch planting has been central to Pamlico Sound oyster management, with some planted reefs over 40 years old and still producing harvestable oysters. Over time, extensive cultch planting initiatives have blurred the distinction between 'natural' reefs and those created by the division. The proposed Cultch Supported Harvest strategy would cover the portions of the Neuse and Pamlico areas not designated as DORAs, and the entire Northern Dare and Northern Hyde Management Areas (Figure 2.3). Cultch planting effort will continue in these areas as long as the cultch planting program remains funded and operational. Cultch Supported Harvest Areas will be subject to the previously established bushel limits (15 bushels per day open water, 10 bushel per day bays; Figure 2.8 and 2.9) and the bays will continue to be capped to a total six-week possible season. This strategy would replace the current reactive approach of the mechanical harvest monitoring program established in 2010. The primary changes from previous management in the proposed strategy is that season length will be predetermined and based on division pre-season sampling of the oyster resource in these areas, and the 10-bushel per day bays and 15-

bushel per day deep areas will be considered differently for each management area. This change eliminates the unpredictability in mechanical harvest season length experienced by harvesters and considers differences in oyster mortality experienced at varying depths of Pamlico Sound.

Past trigger sampling data can be used to examine the relationship between condition of the oyster resource during pre-season sampling and how many weeks of mechanical harvest occurred prior to sampling reaching the management trigger of having two consecutive sampling events below 26% legal. Harvest rates are driven by effort in the fishery, and steep declines have been observed since implementation of the trigger sampling program in 2010. Effort after the 2016-2017 season has stabilized at a relatively low level, and data from that point forward can be considered representative of the current mechanical fishery. Any significant changes in effort and or participation in the future would require adaptive management to address.

Using trigger sampling data from the oyster mechanical harvest seasons between November 2017 and March 2023, the pre-season condition (percent legal oyster) of each management area was compared to the number of weeks it took for the management trigger to trip and close mechanical harvest in that area (Figure 2.10). This relationship was used to assign potential season lengths for starting conditions by area (10-bushel bays, 15-bushel deep). The two samples with the lowest percent legal oyster per management area were dropped before calculating overall precent legal, then compared to how long it took for two consecutive sampling events to be at 26% legal or less (current trigger to close a management area; Table 2.4). Dropping the sites in poorest condition, which may have not been used by harvesters, prevents those sites which were sampled from impacting the overall area pre-season condition. However, the typical difference when these sites were dropped was an increase of less than five percent for legal oysters. Proposed maximum season lengths in the 10-bushel per day bays reflect that these areas are capped to a six-week possible season, and 18 total possible weeks for the 15 bushel per day areas to reflect the end of the possible mechanical harvest season on 31 March.

The proposed season lengths underestimated the actual time it took to trip the current management trigger two times by an average of two days across the entire period examined (Figure 2.11). The proposed season lengths have a minimum threshold for opening of 10% legal, if an area is less than 10% legal, mechanical harvest will not open. Using a minimum threshold of 10% would have resulted in openings not occurring in two areas under current management between 2017 and 2023.

Table 2.3. Proposed weeks of oyster mechanical harvest for management areas by results of sampling for 10-bushel and 15-bushel limit areas.

	Weeks of Mechanical Harvest Season	
Starting Condition	10 bushel per day bay areas	15 bushel per day areas
<10%	0	0
10-14%	2	2
15-19%	3	3
20-24%	4	4
25-29%	5	5
30-34%	6	6
35-39%	6	8
40-44%	6	10
45-49%	6	13
50-54%	6	16
>55%	6	18

Pre-season sampling would occur prior to the mechanical harvest season for all four management areas. At least ten sites would be sampled per management area (with potentially more if resources allowed). As with previous trigger sampling, the percentage of legal live oysters for each management area would be calculated for samples pooled for each management area, with the 10 bushel per day and 15 bushel per day areas considered separate. The bottom 20% of sites sampled with the lowest percent legal for each management area would be dropped from calculating the pre-season percentages. This would prevent errant sites with poor oyster resources which would likely not be fished by mechanical harvesters from impacting potential season length.

Once pre-season sampling occurred, the season length for each management area for the 10 bushel per day and 15 bushel per day areas would be determined by using Table 2.3 which shows the corresponding number of weeks of mechanical harvest to be allowed based on pre-season conditions present in each area. Any areas in the 10-bushel bays would continue to follow the split open period of the six-week possible season (the first opening on Monday of the week prior to Thanksgiving through the Friday after Thanksgiving, and the second opening on the Monday two weeks before Christmas) as adopted in Amendment 4 of the Oyster FMP (NCDMF 2017).

Better sampling of mechanical harvest areas which fishers actively oyster or plan to oyster, encourages participation from the industry to inform sampling locations allowing fishers the opportunity to direct division staff to sampling locations used to determine season length. Harvesters would have the opportunity via a dedicated e-mail address or by leaving a voicemail to report sites they feel are productive and likely to be fished in the upcoming season. Currently, the Cultch Planting Program mails out an annual survey to commercial license holders who have had any oyster landings over the past three years to solicit feedback and input on cultch planting locations. Participation from commercial stakeholders will be critical for the implementation of this strategy. Without input from mechanical harvesters, the division will rely on knowledge of prior fishing activity and known locations of oyster resources. Without industry input, pre-season sampling locations may not be representative of potential in-season harvest locations.

After initial season lengths have been determined, a proclamation will be issued establishing the mechanical season length by area. After the mechanical harvest season begins, one in-season sampling event will occur to potentially extend mechanical harvest for each area. Harvesters will be encouraged to report areas they are actively harvesting to the dedicated e-mail address or voicemail to inform in-season sampling locations. In-season sampling will occur prior to the midpoint of the proclaimed season for all four management areas. At least ten sites would be sampled per management area. Like the pre-season sampling, the percentage of legal live oysters for each management area would be calculated for samples pooled for each management area, with the 10 bushel per day and 15 bushel per day areas considered separate. The bottom 20% of sites sampled with the lowest percent legal for each management area would be dropped from calculating the pre-season percentages.

Once in-season sampling occurs, Table 2.3 would again be used to determine if the initial fixed season would be extended via proclamation. First, the number of weeks left in the initial fixed season for an area would be calculated. Next, Table 2.3 would be consulted using the in-season sampling to determine the potential number of weeks to extend the season. The number of weeks left in the proclaimed season at the time of sampling would be subtracted from the number of weeks identified based on oyster condition in Table 2.3. If the number of weeks is greater than zero, that number of weeks would be added to the mechanical harvest season, and an additional proclamation extending the mechanical harvest season for that area would be issued. Mechanical harvest in the 10-bushel bay areas is capped at a total possible six weeks, so the season cannot be extended in these areas beyond a total of six weeks. Mechanical harvest in the 15-bushel areas cannot be extended past 31 March. See Table 2.4 for steps and examples.

If pre-season sampling results in a management area not opening to mechanical harvest due to not meeting the 10% legal oyster threshold for opening, in-season sampling would still occur by January 15th of that mechanical harvest season. Any additional industry input received from harvesters would be used to inform sampling locations. If the in-season sampling event results in a percent legal of 10% or above, Table 2.3 would be used to determine the number of weeks of mechanical harvest allowed via proclamation.

Cultch Supported Managed Harvest Areas place equal value on the fishery and habitat value of oysters in these areas. The amount of cultch material planted in these areas has exceeded the amount of oyster harvested since 2010, and many of these plantings have formed oyster reefs which have persisted for decades. Given the long history of cultch planting in North Carolina, many older cultch plantings in Pamlico Sound are considered “naturalized” and may be hard to distinguish from wild reefs. The purpose of setting season lengths in these areas is to protect oyster habitat from excessive damage caused by harvest, and to maintain substrate for juvenile oysters to recruit. The cultch planting program will continue to supplement oyster populations in these areas by providing hard substrate.

Table 2.4. Steps used to determine mechanical harvest season lengths in the proposed Cultch Supported Harvest management strategy. Examples are provided to demonstrate how initial proclaimed season length may be extended (Example 1) or how the initial proclaimed season may remain the same (Example 2).

Step	Example 1	Example 2
1. Pre-season Industry Reports	*Receive reports from fishers about locations of sites in the 10-bushel areas of Pamlico Management Area*	*Receive reports from fishers about location of sites in the 15-bushel area of Dare Management Area*
2. Pre-season Sampling	*Division sampling including areas reported by fishers. Pre-season condition 25% legal.*	*Division sampling including areas reported by fishers. Pre-season condition 40% legal.*
3. Set Season Length *(See Table 2.3)*	*25% legal = 5 weeks. Mechanical harvest season set via proclamation for 5 weeks in 10 bushel/day areas of Pamlico Management Area*	*40% legal = 10 weeks. Mechanical harvest season set via proclamation for 10 weeks in 15 bushel/day area of Dare Management Area*
4. In-season Industry Reports	*Reports from fishers about specific locations in the 10 bushel/day areas.*	*No additional reports from fishers*
5. In-season Sampling	*Division in-season sampling occurs 2 weeks into the proclaimed 5-week season targeting areas reported by fishers. In-season condition = 20%*	*Division in-season sampling occurs 5 weeks into the proclaimed 10-week season using initial fisher reports and prior experience. In-season condition = 24%*
6. Evaluate Season Length *(See Table 2.3)*	*20% legal = 4 weeks* *4 weeks - 3 weeks (amount of season left) = 2 additional weeks* *In-season sampling shows 2 additional weeks may be added to the initial 5 week proclaimed season for this area for a total of 7 weeks.* *The 10-bushel areas are capped to a total possible season of 6 weeks, limiting the extension of the season to 1 additional week.*	*24% legal = 4 Weeks* *4 weeks – 5 weeks (amount of season left) = -1 weeks.* *The number of additional weeks from the in-season evaluation is less than 0.* *No additional weeks will be added or removed for this area.* *Season length is not modified.*
7. Modify Season *(If needed)*	*New proclamation issued to extend the initial set harvest season by 1 week.*	*The initial proclaimed harvest season remains. No change.*

Rotational Cultch Sites (Tier 3)

The Cultch Planting Program has implemented a reef building strategy in Pamlico Sound to create large 10-acre cultch planting sites in areas open to mechanical harvest, with the goal of having at least 16 sites planted by 2026. These sites are distributed across the sound with four planned for each management area. As of 2024, 10 large sites have been constructed. To better take advantage of the Cultch Planting Program, a new fishery management approach is proposed for these large cultch sites. Currently, cultch sites are available to harvest from as soon as they are planted. Typically, it takes three years for a new cultch site to produce legal oysters, and when fishing first occurs on these sites is ultimately left to the harvesters. The proposed management strategy for a Rotational Cultch Site is to not allow harvest to occur for three years post-construction, and then open harvest on the fourth year. After one season of harvest, the site would then be closed to harvest for the following three years. Immediately after the harvest season, a site which was harvested would be evaluated by the division and replenished with additional cultch material as needed during annual cultch planting activities. The site would open and close via proclamation on a four-year rotational schedule. With at least 16 sites constructed, there would be at least one large rotational cultch site open per management area each season. Rotational Cultch Sites would not be subject to the season lengths set for Cultch Supported Harvest Areas. The open large sites in a management area would open to mechanical harvest on the third Monday of November, and close on May 31st. Rotational Cultch Sites would be limited to 15 bushels per day per vessel. This strategy focuses on the fishery value of these reefs and gives harvesters relatively open access to these cultch plantings.

Without a stock assessment or metrics of abundance for oysters in Pamlico Sound, management focused on protecting oyster habitat and cultch planting to restore hard substrate ensures ongoing populations of harvestable oyster. The proposed three tier approach seeks to balance the habitat and fishery values of oysters in Pamlico Sound. Deep-water Oyster Conservation Areas identify and protect reefs where continued shell loss prevents remnant natural reefs from recovering. The habitat value of these areas is prioritized over their potential function as a harvestable fishery resource. Cultch Supported Harvest Areas (Tier 2) aim to allow harvest but prevent damage to oyster habitat through excessive removal of cultch material. Effort is limited by setting season lengths by management area according to conditions of the oyster resource. Additionally, cultch planting in these areas helps mitigate substrate loss via oyster harvest. Rotational Cultch Sites (Tier 3) are constructed with the goal of supporting the mechanical harvest oyster fishery. The fishery value of these sites is prioritized. Sites will be evaluated at the end of the harvest season and replenished with cultch before being allowed to re-grow harvestable sized oysters. The division will modify sampling and data collection protocols to better incorporate abundance indices into future management to be addressed in a subsequent fishery management plan.

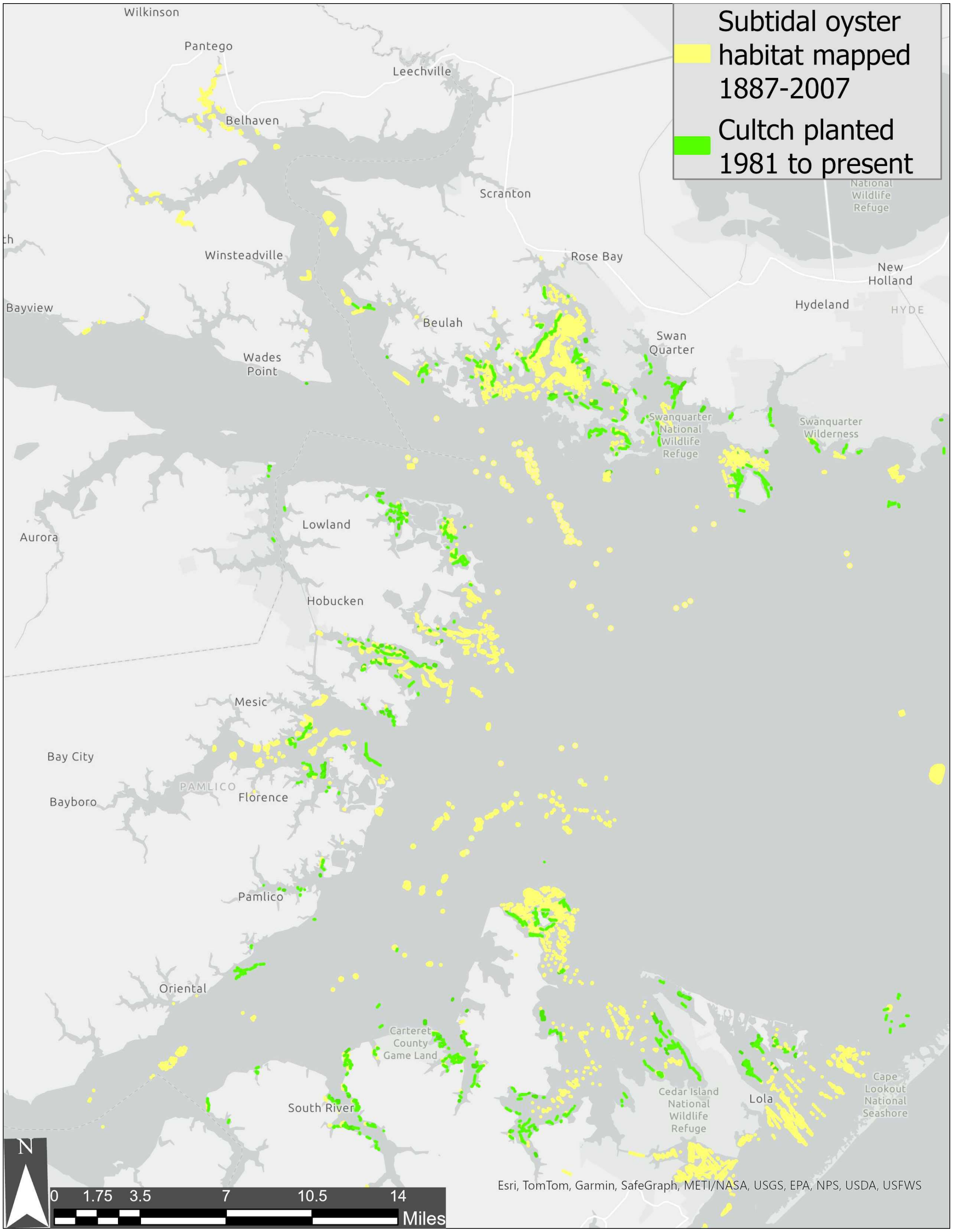

Figure 2.5. All known potential subtidal oyster habitat (natural shell and cultch sites) in Pamlico Sound. All available historic and current data sources were used to illustrate potential locations for oyster reefs. Potential oyster habitat shown may not currently contain living oysters.

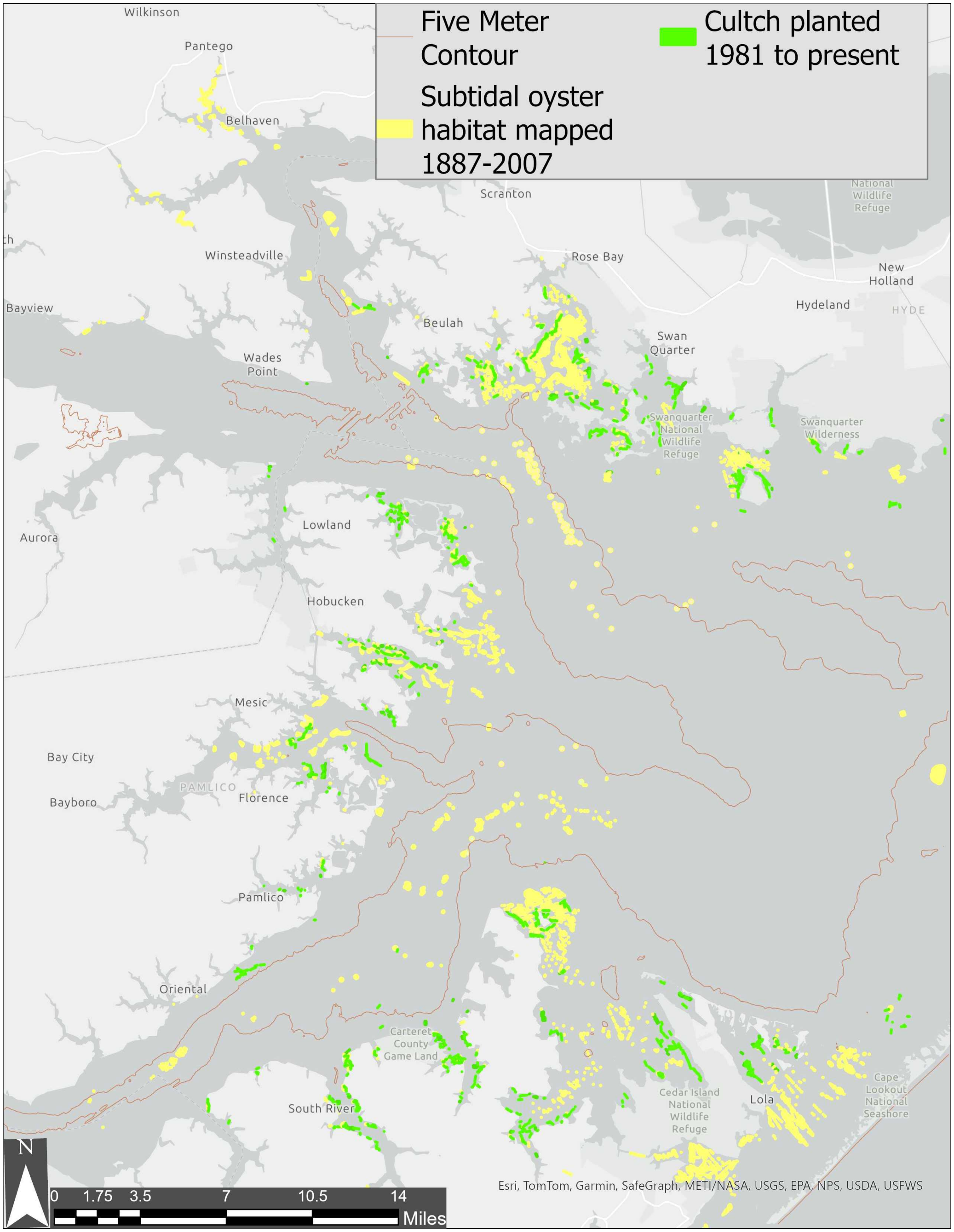

Figure 2.6. Documented potential oyster habitat (natural and cultch sites) in Pamlico Sound. The 5-meter contour line is shown to illustrate areas of oyster habitat which are located at this depth and below.

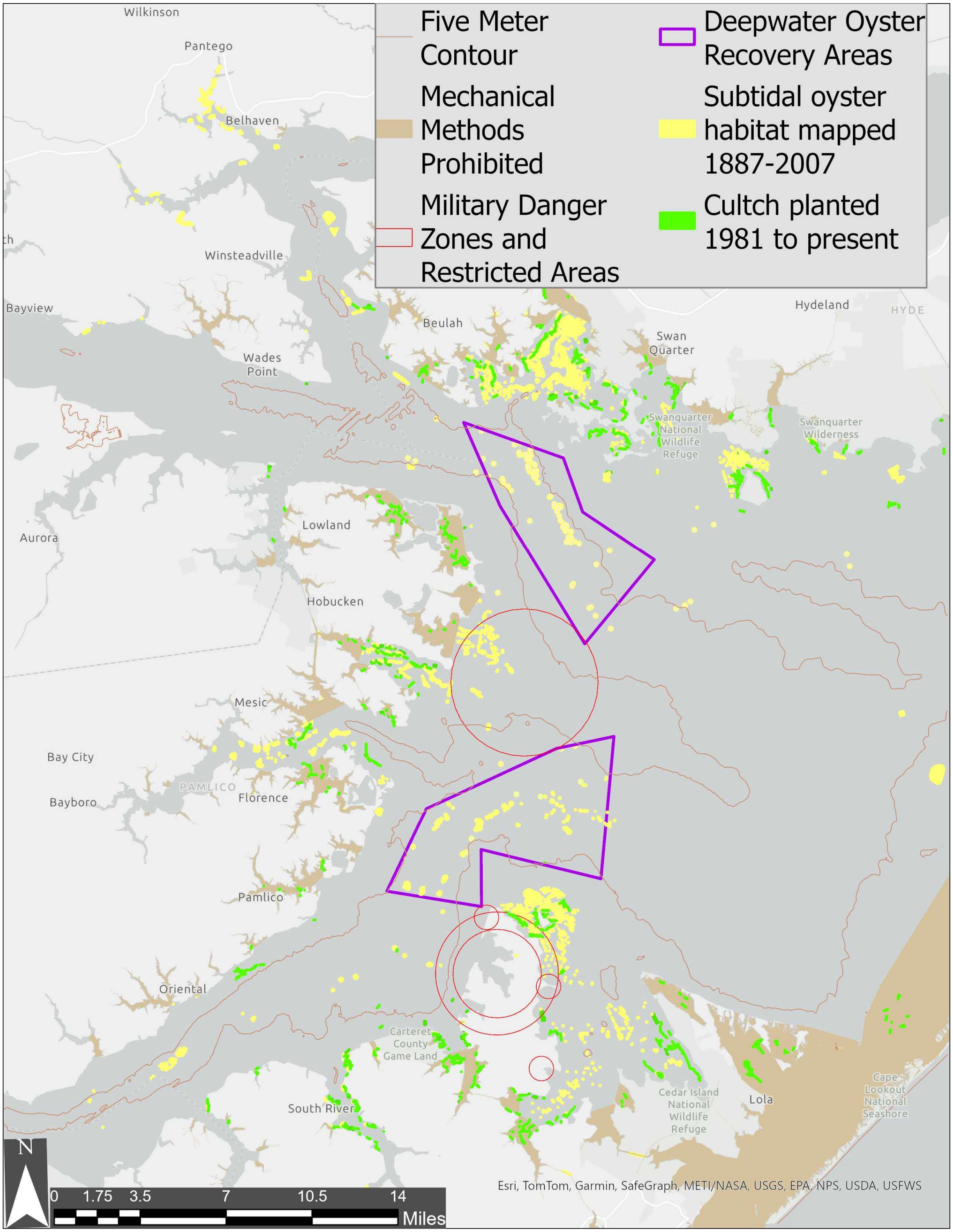

Figure 2.7. Potential management boundaries using existing navigational markers for proposed Deep-water Oyster Recovery Areas (DORAs) in Pamlico Sound. Documented oyster habitat and the 5-meter contour line are also shown.

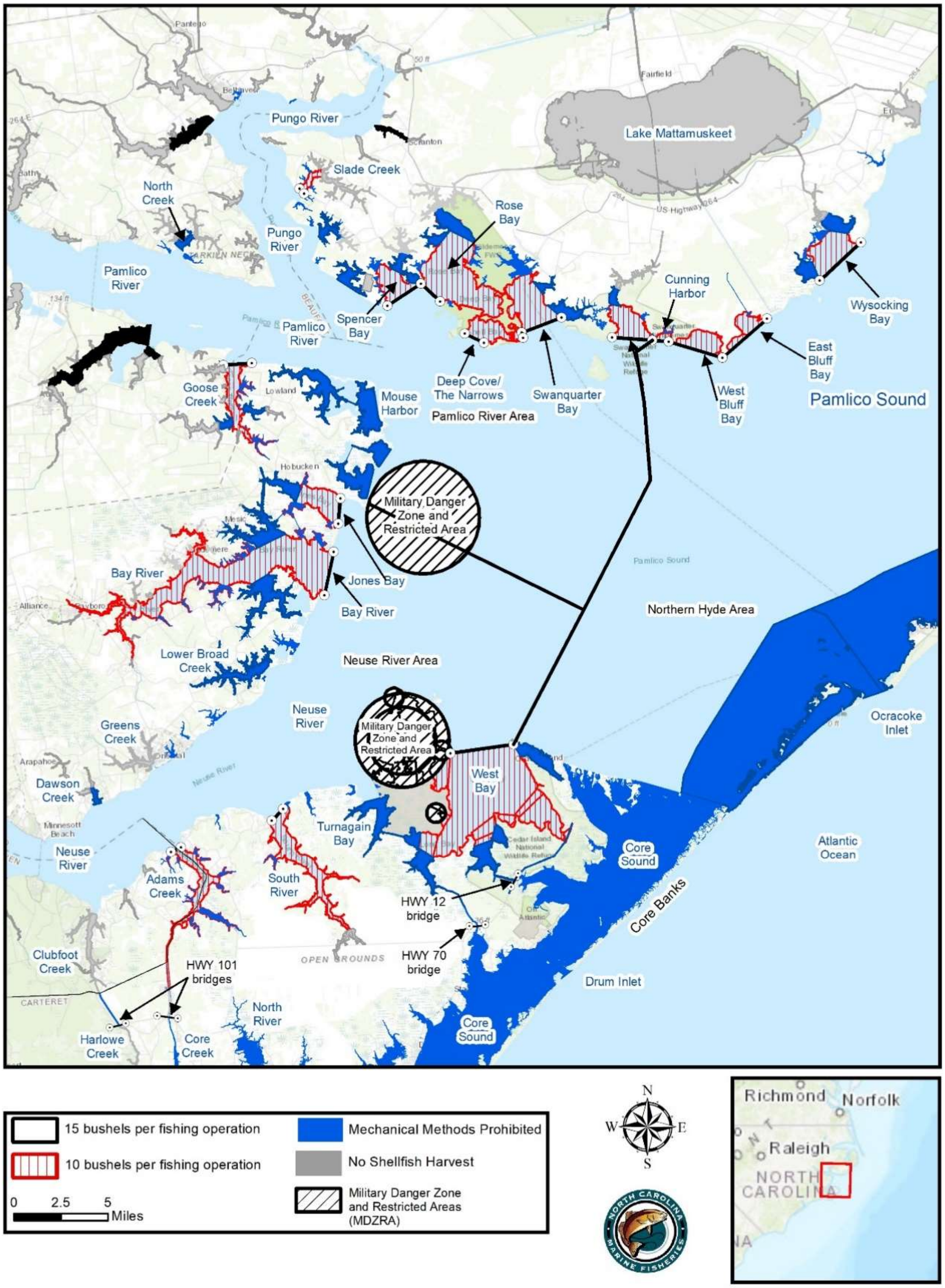

Figure 2.8. Bushel limits for bays and deep-water areas of western Pamlico Sound.

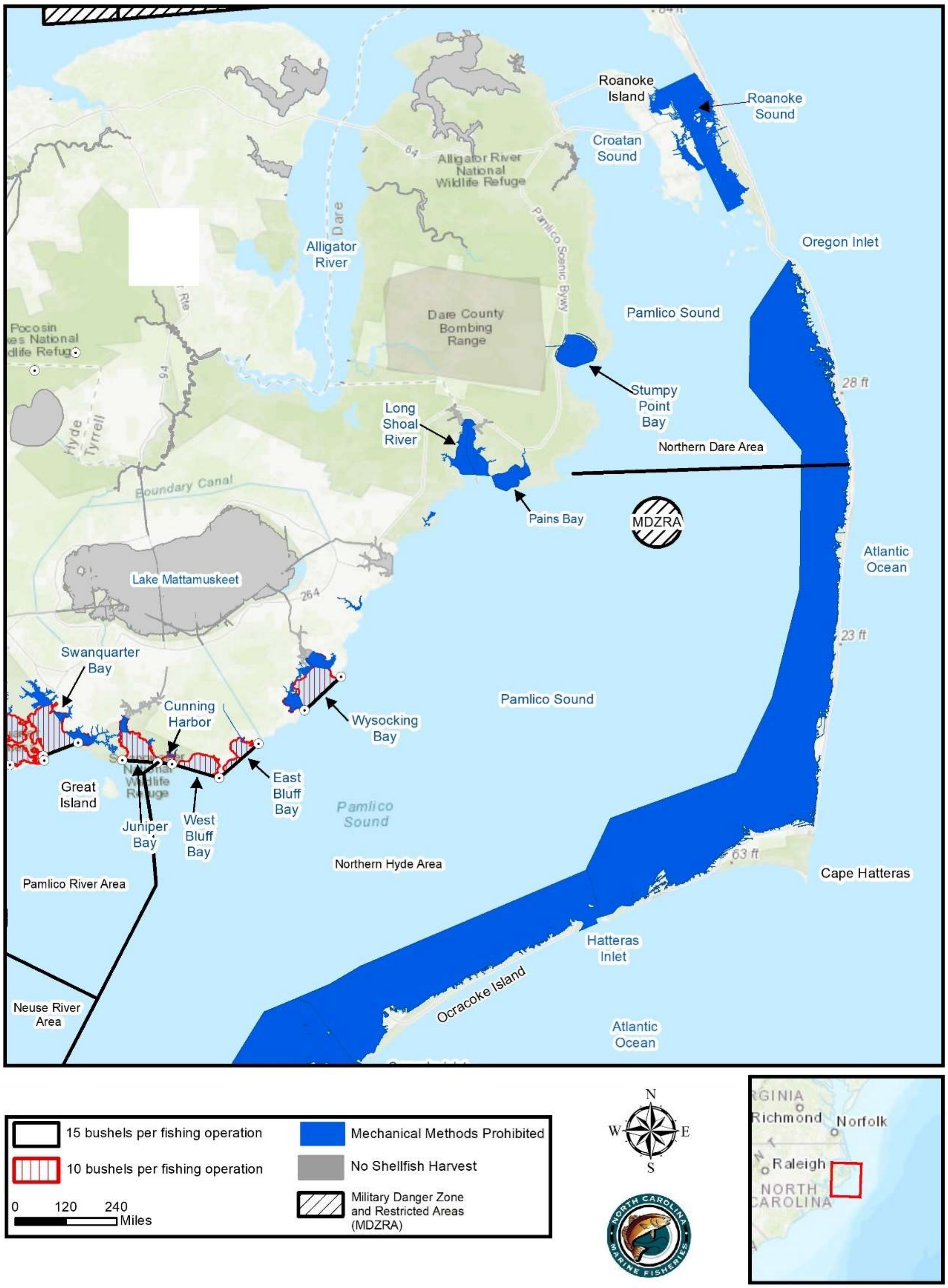

Figure 2.9. Bushel limits for bays and deep-water areas of eastern Pamlico Sound.

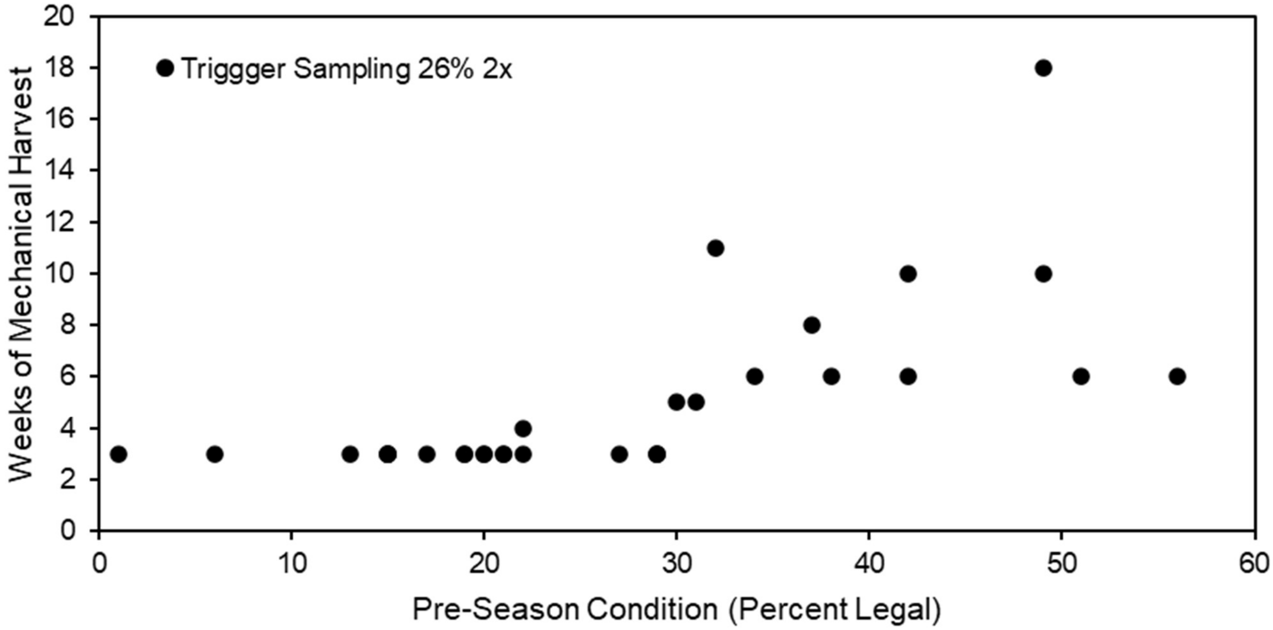

Figure 2.10. Pre-season condition (percent legal) of oysters in management areas sampled during mechanical harvest monitoring and the number of weeks into the harvest season for that management area to be sampled at 26% legal or less for two consecutive sampling events shown as black circles. The two lowest percent legal samples per area were dropped before calculating the pre-season condition of that area.

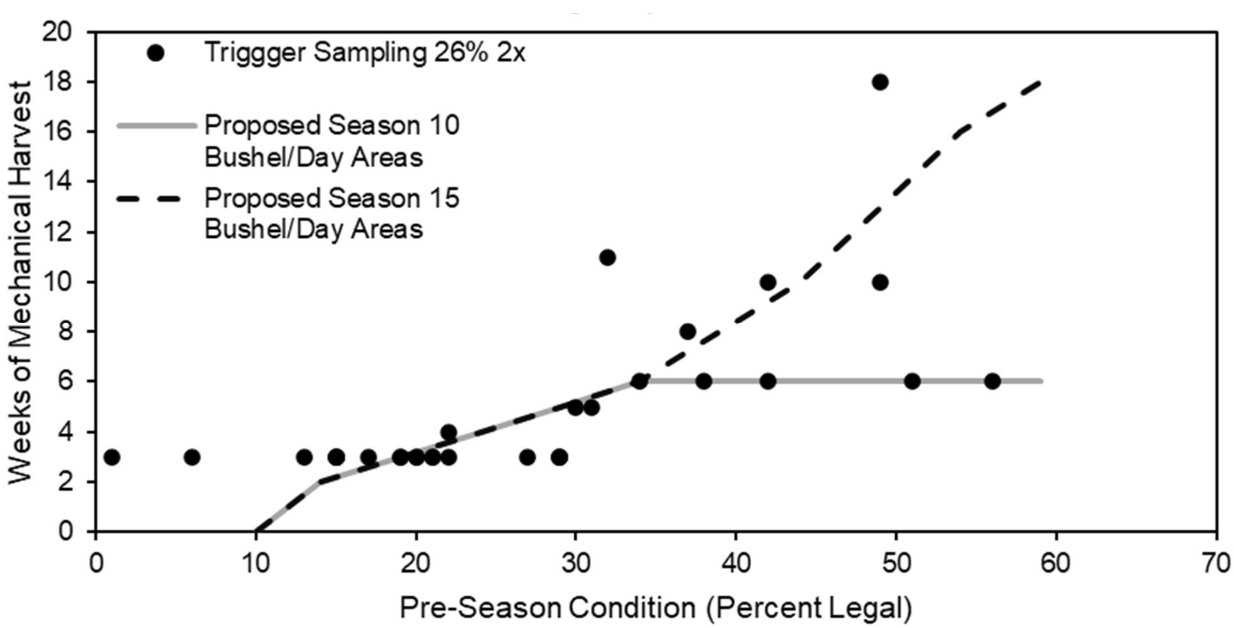

Figure 2.11. Pre-season condition (percent legal) of oysters in management areas sampled during mechanical harvest monitoring and the number of weeks

into the harvest season for that management area to be sampled at 26% legal or less for two consecutive sampling events shown as black circles. The two lowest percent legal samples per area were dropped before calculating the pre-season condition of that area. The light grey line shows the proposed season length for the 10 bushel/day areas, and the dashed black line shows the proposed season length for the 15 bushel/day areas.

Adaptive management

The fixed mechanical season lengths for Cultch Supported Harvest developed in this issue paper used fishery monitoring data for the five oyster mechanical harvest seasons between November 2018 and March 2023. Any large changes in effort would potentially result in fixed season lengths becoming either inadequate to provide protection to the oyster resource with increased participation in the fishery, or too restrictive with decreased fishery participation. On average, 93 participants landed oysters with mechanical gear between 2018 and 2023. If the three-year running average of participants in the mechanical oyster fishery changes by more than 25%, fixed season lengths (Table 2.3) will be re-evaluated. Effort and landings data as well as division mechanical harvest season sampling data will be used to assess the effectiveness of adopted fixed season lengths in relation to the condition of the oyster resource. If adaptive management is triggered, season lengths may be lengthened, shortened, or maintained as previously adopted. For example: if participation dropped to a 3-year average of 65 participants, and in-season sampling of management areas consistently results in 2 additional weeks of mechanical harvest being added to the initial proclaimed season length, Table 2.3 can be modified to extend the season length to reflect this change.

- Three year running average of participants less than 70 or greater than 116 (calculated during annual FMP Update), triggers examination of oyster sampling data and potential adjustment to fixed season lengths for Cultch Supported Harvest.

MANAGEMENT OPTIONS

Deep-water Oyster Recovery Areas (DORAs)

- Status Quo (do not support)
    - Does not protect deep-water (>5m) oyster reefs in Pamlico Sound from mechanical harvest methods which reduce reef height.
    - Does not allow deep-water (>5m) oyster reefs in Pamlico Sound to gain height and resiliency from negative water quality impacts.
    - Allows for harvest in areas of western Pamlico Sound which may periodically have harvestable oyster resource.

- Adopt Deep-water Oyster Recovery Areas (DORAs)
    - Protects deep-water (>5m) oyster reefs in Pamlico Sound from mechanical harvest methods which reduce reef height.

    - Allows deep-water (>5m) oyster reefs in Pamlico Sound to gain height and resiliency from negative water quality impacts.
    - Does not allow harvest in areas of western Pamlico Sound which may periodically have harvestable oyster resource.

Cultch Supported Harvest

- Status Quo (maintain current trigger sampling approach)
    - Uncertainty and variability in season length annually.
    - Does not provide a standardized opportunity for industry to provide input into management sampling locations.
    - Maintains current habitat protection measures in the mechanical oyster fishery.

- Adopt Proposed Cultch Supported Harvest Strategy
    - Provides more certainty in annual season length by area.
    - Incorporates industry input into management sampling locations for pre and in-season sampling.
    - Provides habitat protection measures in the mechanical oyster fishery.

Rotational Cultch Sites

- Status Quo (maintain current cultch site management)
    - All cultch planting sites are open to harvest of legal-size oysters.
    - No differentiation in management of wild and cultch planting sites.
    - Does not formalize Division cultch planting efforts into an adopted fishery management strategy.

- Adopt Rotational Cultch Site Strategy
    - Some cultch sites would be closed to harvest on a rotational schedule.
    - The fishery value of these cultch planting sites is prioritized.
    - Formalizes Division cultch planting efforts into an adopted fishery management strategy.

Adaptive Management

- Do not support Adaptive Management
    - Does not allow for changes in set season length based on changes in fishery participation.

- Adopt Adaptive Management (only applies if proposed Cultch Supported Harvest Strategy is adopted)
    - Allows for modification of set season length based on changes to fishery participation.

Recommendations

DMF RECOMMENDATION: Adopt the proposed Pamlico and Neuse River DORAs which are bound by existing navigational aids.

DMF RECOMMENDATION: Adopt the proposed Cultch Supported Harvest strategy as described in the Issue Paper.

DMF RECOMMENDATION: Adopt the proposed Rotational Cultch Site strategy as described in the Issue Paper.

DMF RECOMMENDATION: Adopt the proposed adaptive management framework.

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Appendix 3: Intertidal Oyster Harvest Management Information Paper

ISSUE
Addressing management needs for intertidal oyster stocks in North Carolina.

ORIGINATION
The Division of Marine Fisheries and the North Carolina Marine Fisheries Commission (NCMFC) selected management strategies from the Eastern Oyster Fishery Management Plan (FMP) Amendment 4.

BACKGROUND
The North Carolina Eastern Oyster FMP Amendment 5 is focused on management of wild oyster stocks, and this information paper does not pertain to farm raised or private cultured oysters.

North Carolina's wild oyster stocks are composed of both intertidal (exposed to air during portions of the tidal cycle) and subtidal (continuously submerged) populations. Oyster populations in the southern region of the state (Onslow, Pender, New Hanover, and Brunswick counties) are primarily intertidal reefs. There is not currently a stock assessment or fishery independent sampling program for intertidal oysters in the state.

Commercial harvest of oysters in North Carolina requires a Standard or Retired Commercial Fishing License (SCFL, RSCFL) with a shellfish endorsement, or a commercial shellfish license. The number of SCFL/RSCFL available within the state is capped, placing a limit on the potential amount of participation from these license holders. The commercial Shellfish License is not limited to a maximum number of participants and is available at a much lower cost than the SCFL or RSCFL to any resident of the state. Harvest is limited to hand methods from Core Sound south to the NC/SC state line, with harvesters walking out onto exposed oyster reefs to manually collect legal sized (3 in shell length or greater) oysters. Exposed intertidal oyster reefs are easily accessible to harvest by hand and are vulnerable to impacts from harvest pressure.

The southern region of North Carolina contributes consistently to the overall public landings of oyster within the state (Figure 3.1). From 1994 to 2022 the southern region produced 51% of the state's total oyster harvest, contributing between 20 and 91% of the harvest annually. The southern region of the state encompasses just 5.7% of the total coastal water body area yet has contributed over half of the total oyster landings since 1994.

The North Carolina Eastern Oyster FMP Amendment 4 examined increasing landings and participation from commercial Shellfish License holders with decreasing catch per unit effort (average bushels landed per trip), and the potential of effectively open entry on a finite fishery resource via the shellfish commercial license as management issues (NCDMF 2017). For more information see the following issue papers in Amendment 4 of the Eastern Oyster FMP: Assessing and Mitigating Harvest Effort Impacts on Oyster Resources in the Southern Region and Consider Elimination of the Shellfish License and Require All Shellfish Harvesters to Have a SCFL or RSCFL. To address these concerns, the Marine Fisheries Commission (NCMFC) adopted specific management strategies. These included reducing the daily oyster harvest limit for commercial Shellfish License holders from five bushels to two. Additionally, the NCMFC recommended excluding oysters harvested from public bottoms as eligible for harvest with the commercial Shellfish License. They also proposed development of a fishery independent sampling program for intertidal oysters in the southern region. Beginning in October of the 2017-2018 season, hand harvest for Shellfish License holders was limited to two bushels of oyster per person per day, not to exceed four bushels per vessel per day if two or more Shellfish License holders are on board the vessel. The elimination of oyster from the commercial Shellfish License requires legislative action.

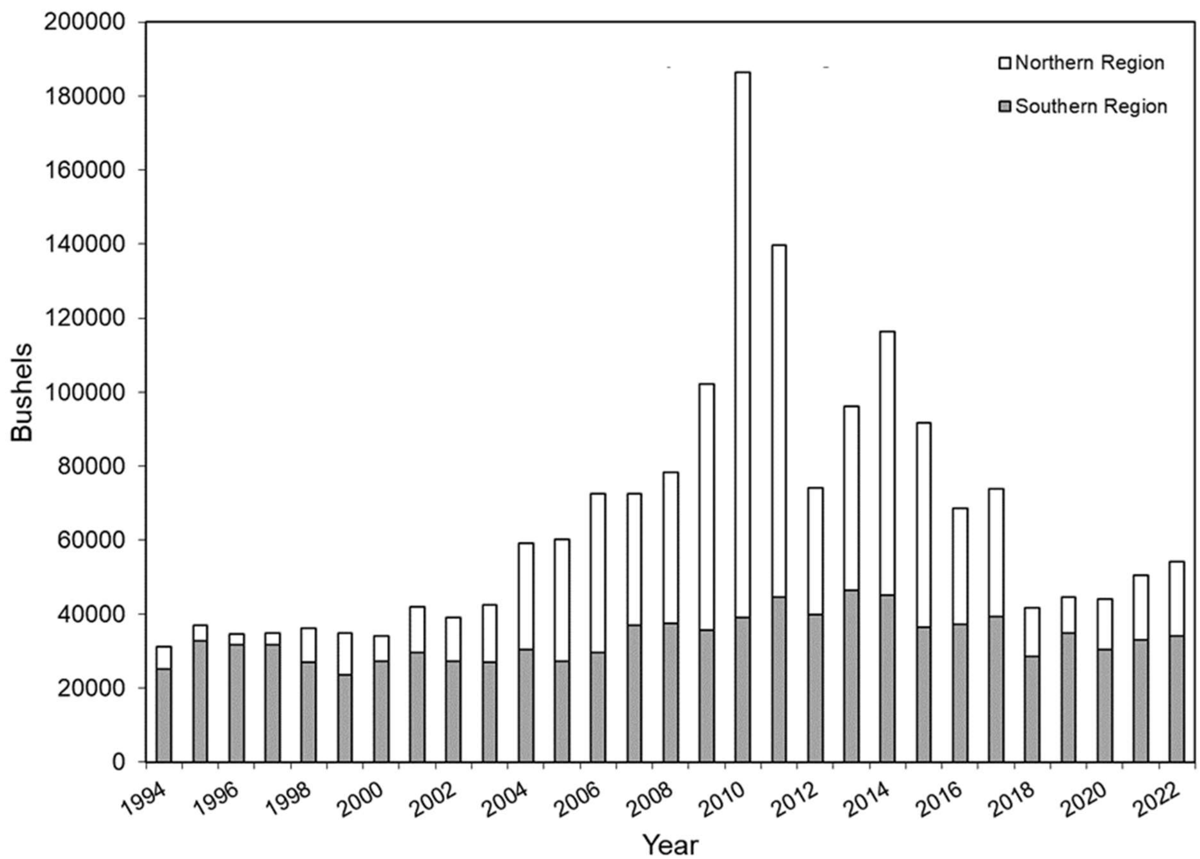

Figure 3.1. Commercial landings of oysters from public bottom in North Carolina from 1994 to 2022, showing the total annual landings (entire bar height) and the proportion of landings contributed by the southern region (waterbodies south of Bogue Sound) as dark gray, and proportion from the northern region as white.

Commercial oyster fishery effort in the southern region experienced a period of growth between 2000 and 2014, with the total amount of trips nearly doubling during that time (Figure 3.2). The increase in participation was primarily driven by increasing participation from harvesters with commercial Shellfish Licenses, with a 388% increase in trips by commercial Shellfish License holders over that period. The number of trips made by

Shellfish License holders declined sharply in 2018. This coincides with NCDMF enacting the bushel reduction limit for Shellfish License holders as recommended by the MFC.

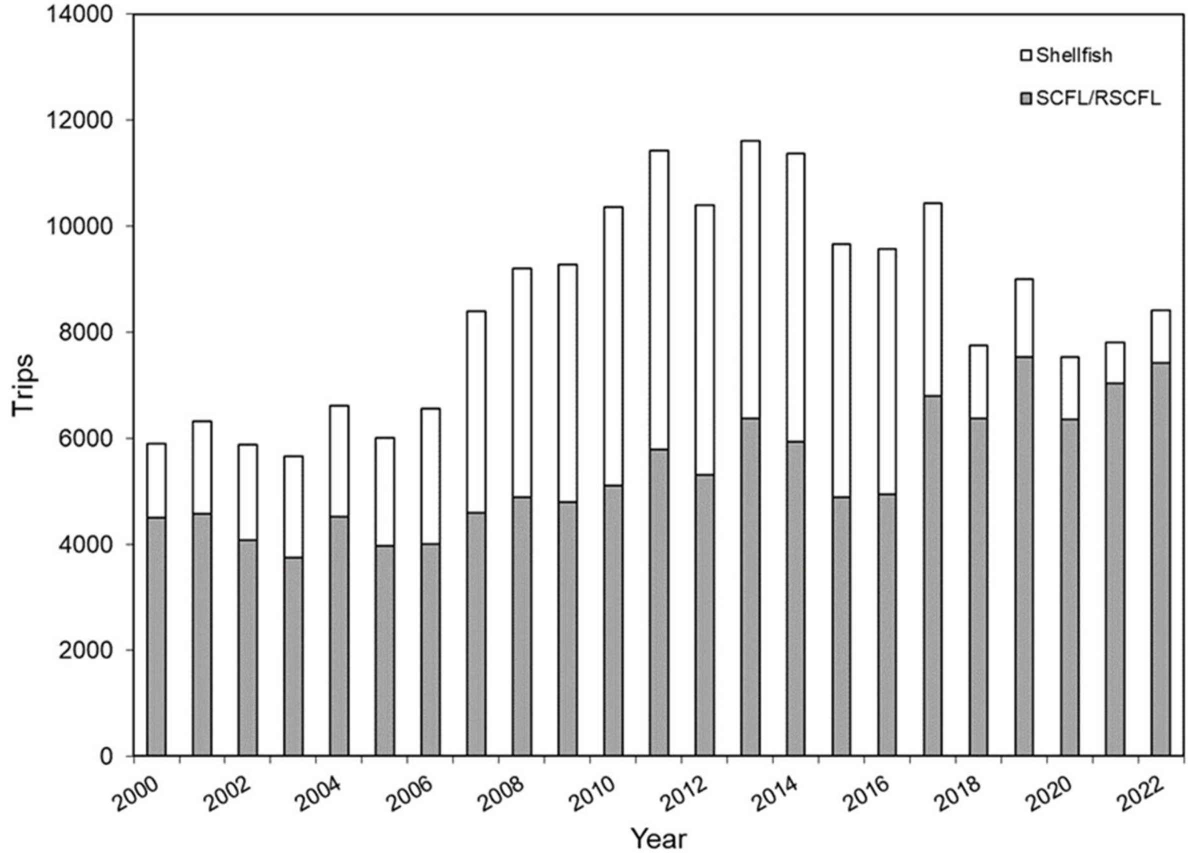

Figure 3.2. Effort in trips for the southern region (waterbodies south of Bogue Sound) commercial oyster fishery from 2000 to 2022. Total annual number of trips is represented by the entire bar height, with the proportion of trips made by Shellfish License holders shown as white and the proportion of trips made by SCFL/RSCFL holders as dark gray.

Since there is currently no independent sampling or stock assessment for intertidal oysters in the southern region of North Carolina, one way to gauge the health of the oyster stocks is by looking at the average catch-per-unit-effort (CPUE) of commercial fishers. This is measured by the average annual number of bushels landed per fishing trip, as recorded in the NC Trip Ticket Program (NCTTP). Since 1994, all commercially harvested oysters in North Carolina must be reported through the NCTTP. However, it is important to interpret CPUE data from commercial fisheries cautiously because factors like regulations, market demand, and weather all influence fishing behavior and catch levels. In the case of oyster, if declines in average number of bushels landed while fishers are expending the same amount of effort (trips) are observed, there may be concern the resource may not be able to sustain the amount of harvest pressure occurring. However, without fisheries independent data to provide information about oyster abundance or population structure, it is impossible to verify if trends in fisheries dependent data are reflective of the oyster population.

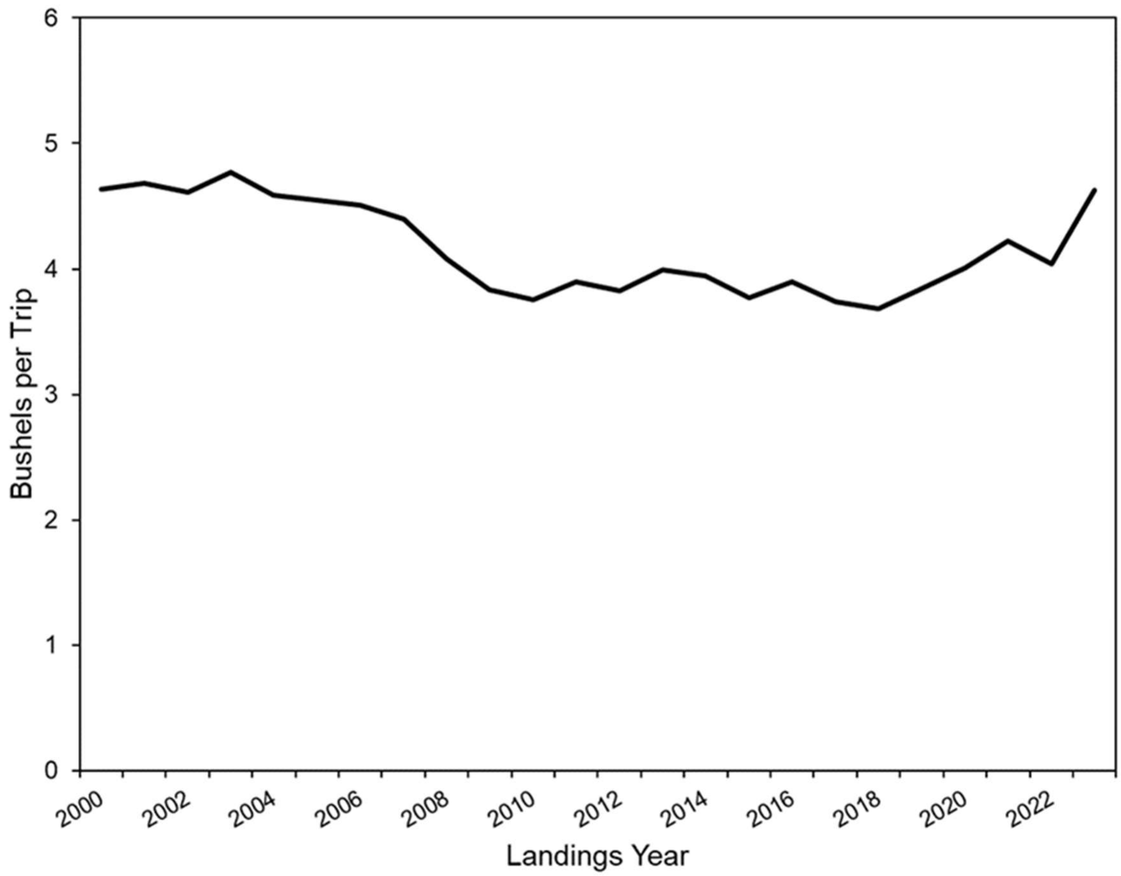

Figure 3.3. The catch-per-unit-effort (CPUE) for oyster commercial harvest in the southern region (waterbodies south of Bogue Sound) from 2000 to 2023. The black line represents the average annual bushel amount landed per trip by SCFL/RSCFL holders.

From 2000 to 2006, the average number of bushels landed per trip by SCFL/RSCFL holders in the southern region remained relatively close to the trip limit of five bushels, averaging 4.6 bushels per trip (Figure 3.3). However, starting in 2007, the average annual bushel amount landed per trip began to decline, reaching 3.7 bushels per trip by 2010. Between 2008 and 2017, the average annual bushel amount fluctuated but remained below four bushels per trip. Beginning in 2018 after the bushel limit for Shellfish License holders was reduced, there was an increase in the average annual bushels per trip, reaching an average of 4.6 bushels per trip by 2023.

Four waterbodies, Lockwood Folly River, Shallotte River, Masonboro Sound, and Topsail Sound contributed 68% of the region’s total commercial oyster landings from public bottom since 1994 and are representative of the intertidal hand harvest fishery in the region. Since 2000, landings trends from these areas fluctuated annually, Topsail and Masonboro sounds showed increasing landings until a decline in 2014; however, Lockwood Folly and Shallotte rivers were more variable. (Figures 3.4 – 3.7). Yearly changes in landings from these water bodies generally reflect the number of participants in the fishery (Figures 3.4 – 3.7). Like the rest of the region, generally increasing numbers of Shellfish License holders participated in the fishery until 2018. Despite variation in participation and landings across the region, the number of bushels landed per commercial trip decreased between 2000 and 2010. This decrease in CPUE was concurrent with the overall increase in participation and effort in the oyster fishery for these waterbodies, with lowest average bushels per trip landed during periods of highest participation. (Figure 3.8). Lockwood Folly and Shallotte rivers both showed increased annual average bushels per trip in recent years as participation decreased, while Masonboro and Topsail sounds showed relatively flat trends in bushels per trip.

The NCDMF Shellfish Rehabilitation Program carries out annual efforts to plant cultch (material suitable for oyster spat settlement, including oyster shell or limestone marl) in the southern region of the state. Cultch reefs are created in waters open to shellfishing to improve oyster recruitment and increase biomass in areas where suitable substrate is otherwise limited. For more information on the division's cultch planting program see Appendix 4: Habitat Enhancement Programs. The quantity of material planted each year varies considerably based on availability and funding. Between 2000 and 2022, a total of 1,054,243 bushels of cultch material were planted, and 744,311 bushels of oyster were commercially harvested across the entire southern region of the state (Figure 3.9). The return in commercial harvest per unit of cultch planted remains unknown and likely varies across different planting sites. The impact of cultch plantings on oyster landings isn't immediate, as it typically takes between one and three years after planting for new cultch material to yield legal-sized oysters. While some cultch planting sites have relatively short lifespans, others have been observed to continue yielding harvests for decades.

The existing management strategy in the southern region relies on the Marine Fisheries Director's authority to close the oyster season before March 31st by proclamation. In the Pamlico Sound mechanical oyster fishery, a mechanical harvest monitoring program is used to regulate fishing activity to protect oyster habitat during the harvest season. For additional information see Appendix 2: Pamlico Sound Oyster Mechanical Harvest Management. Currently, no harvest monitoring program or closure trigger exists for hand harvest areas. In Brunswick County, waterbodies close to oyster harvest on March 15th due to concerns stemming from excessive harvest pressure in past years.

Intertidal oyster reefs in the southern region are readily accessible to recreational harvesters. However, the extent of recreational shellfish harvesting compared to commercial harvesting is currently unknown. There is no established mechanism for accurately quantifying the number of recreational shellfish harvesters in North Carolina, which limits the division's ability to estimate total recreational shellfish harvest in the southern region. For further details, please refer to Appendix 1: Recreational Harvest.

NCDMF has implemented a pilot fishery independent sampling program to monitor the intertidal oyster resource. Fifteen sentinel sites have been proposed across the southern region of the state to represent the intertidal oyster population. Sites include areas both open and closed to shellfish harvest. These sentinel sites will be surveyed using UAS (uncrewed aerial systems; drones), allowing for high-resolution repeated mapping, as well as traditional sampling for biological and water quality data. Sampling is planned to occur before and after the open harvest season, allowing development of fishery independent indices and assessment of fishing impacts on the oyster resource.

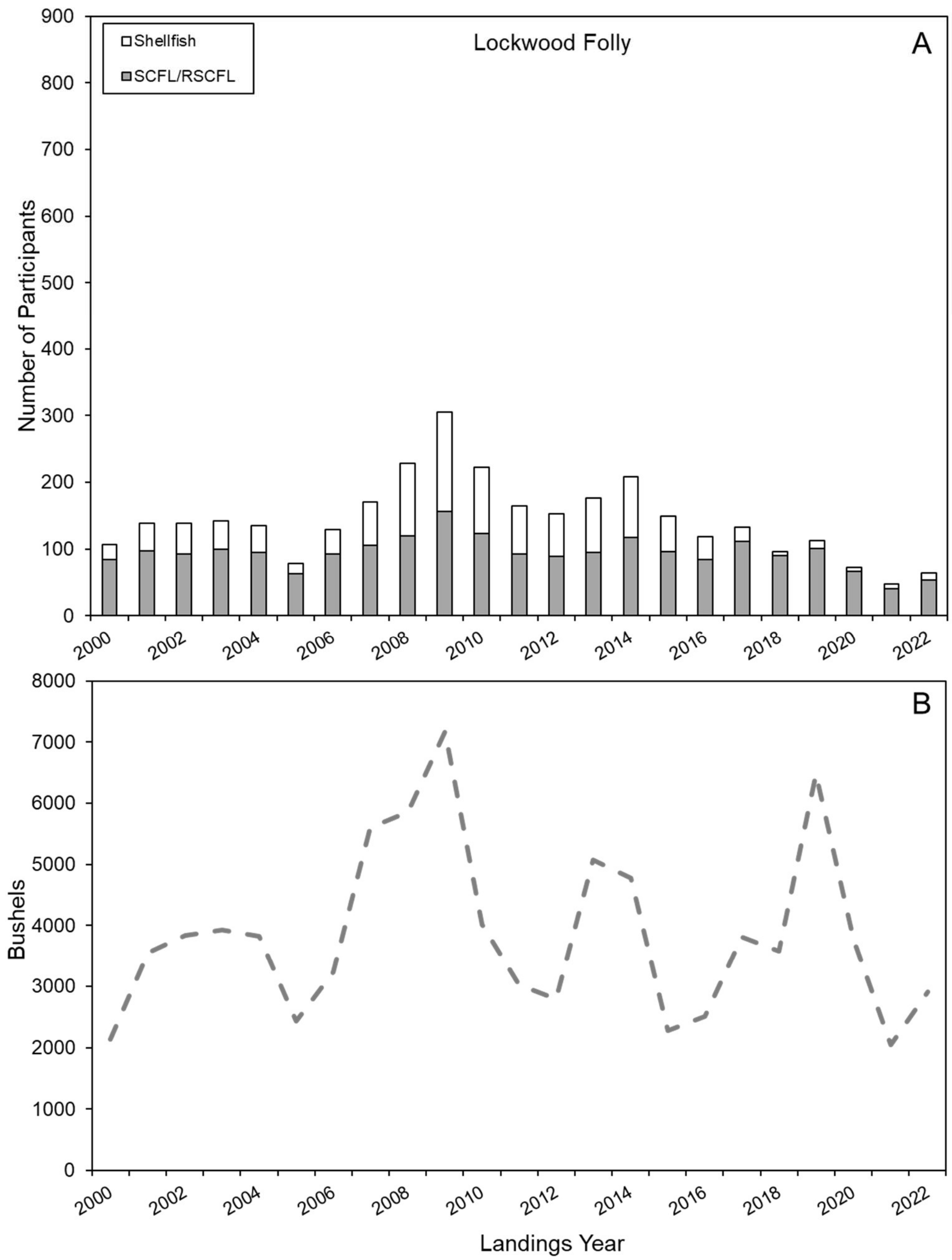

Figure 3.4. (A) Annual number of participants with oyster landings for Lockwood Folly River, the entire bar height shows total number of participants, with the

proportion of participants with Shellfish Licenses shown as white, and the proportion with SCFL/RSCFL shown as grey. (B) Total commercial landings of oyster in bushels by year for the Lockwood Folly River.

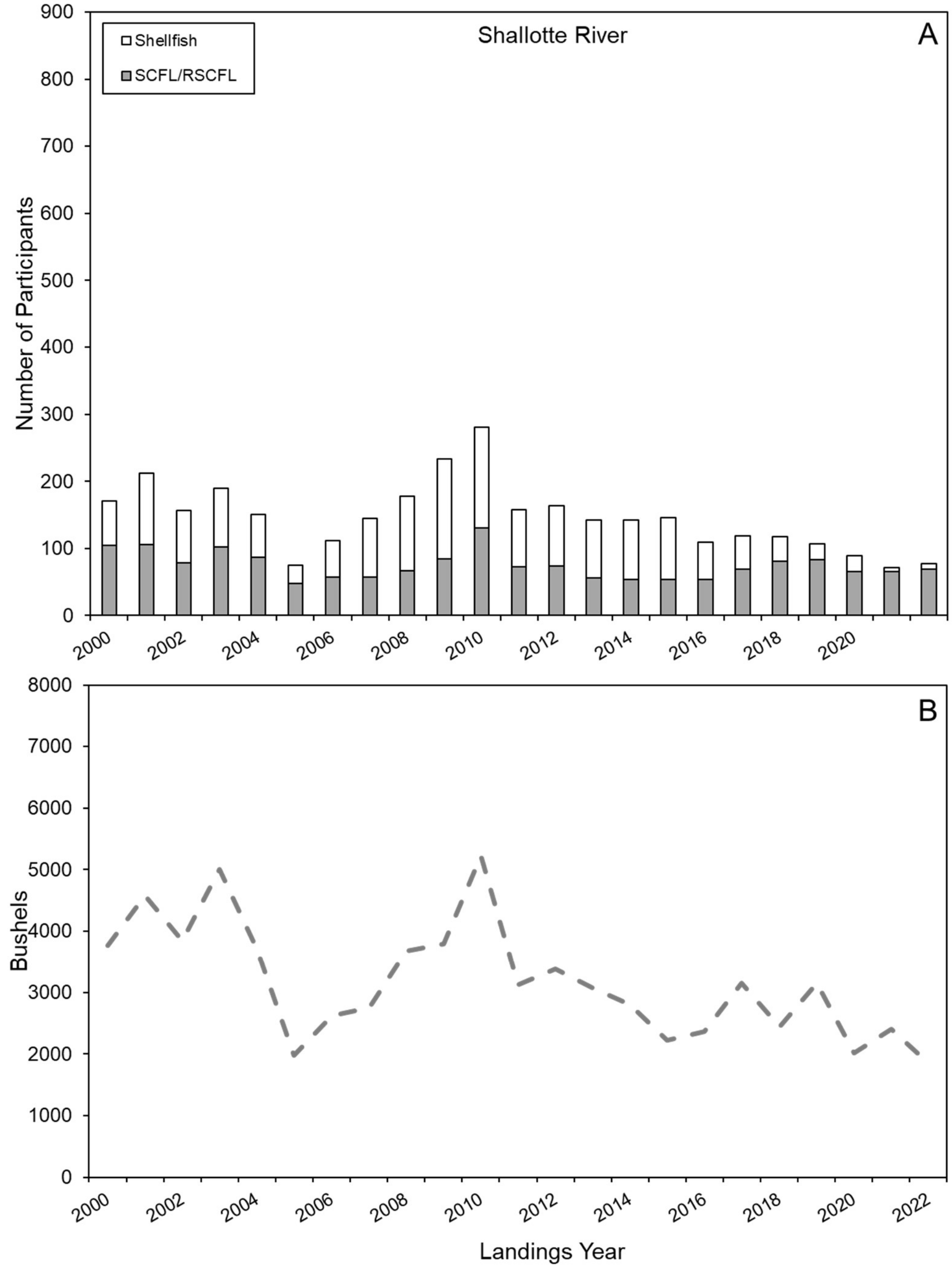

Figure 3.5. (A) Annual number of participants with oyster landings for Shallotte River, the entire bar height shows total number of participants, with the proportion of participants with Shellfish Licenses shown as white, and the proportion with SCFL/RSCFL shown as grey. (B) Total commercial landings of oyster in bushels by year for the Shallotte River.

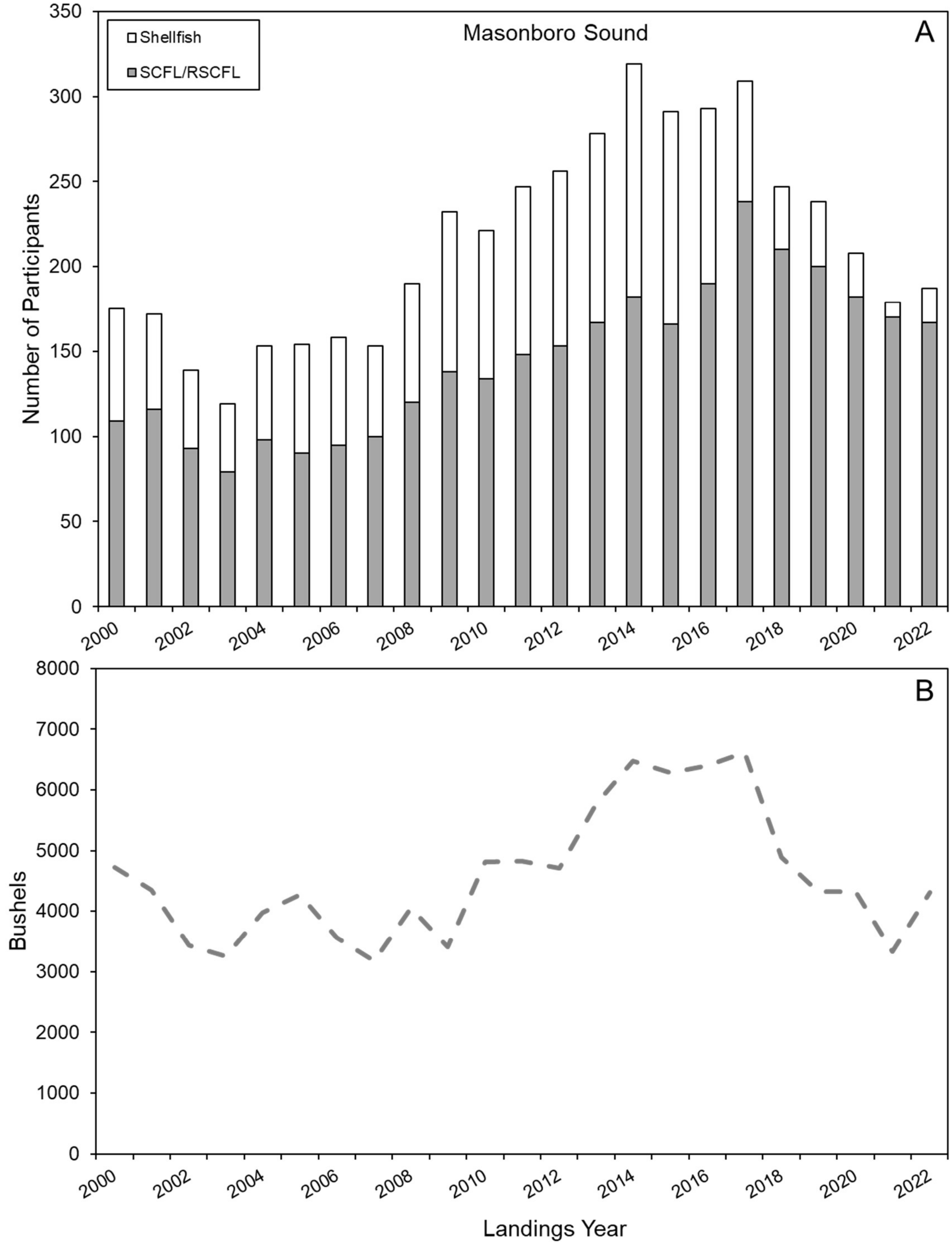

Figure 3.6. (A) Annual number of participants with oyster landings for Masonboro Sound, the entire bar height shows total number of participants, with the proportion of participants with Shellfish Licenses shown as white, and the proportion with SCFL/RSCFL shown as grey. (B) Total commercial landings of oyster in bushels by year for Masonboro Sound.

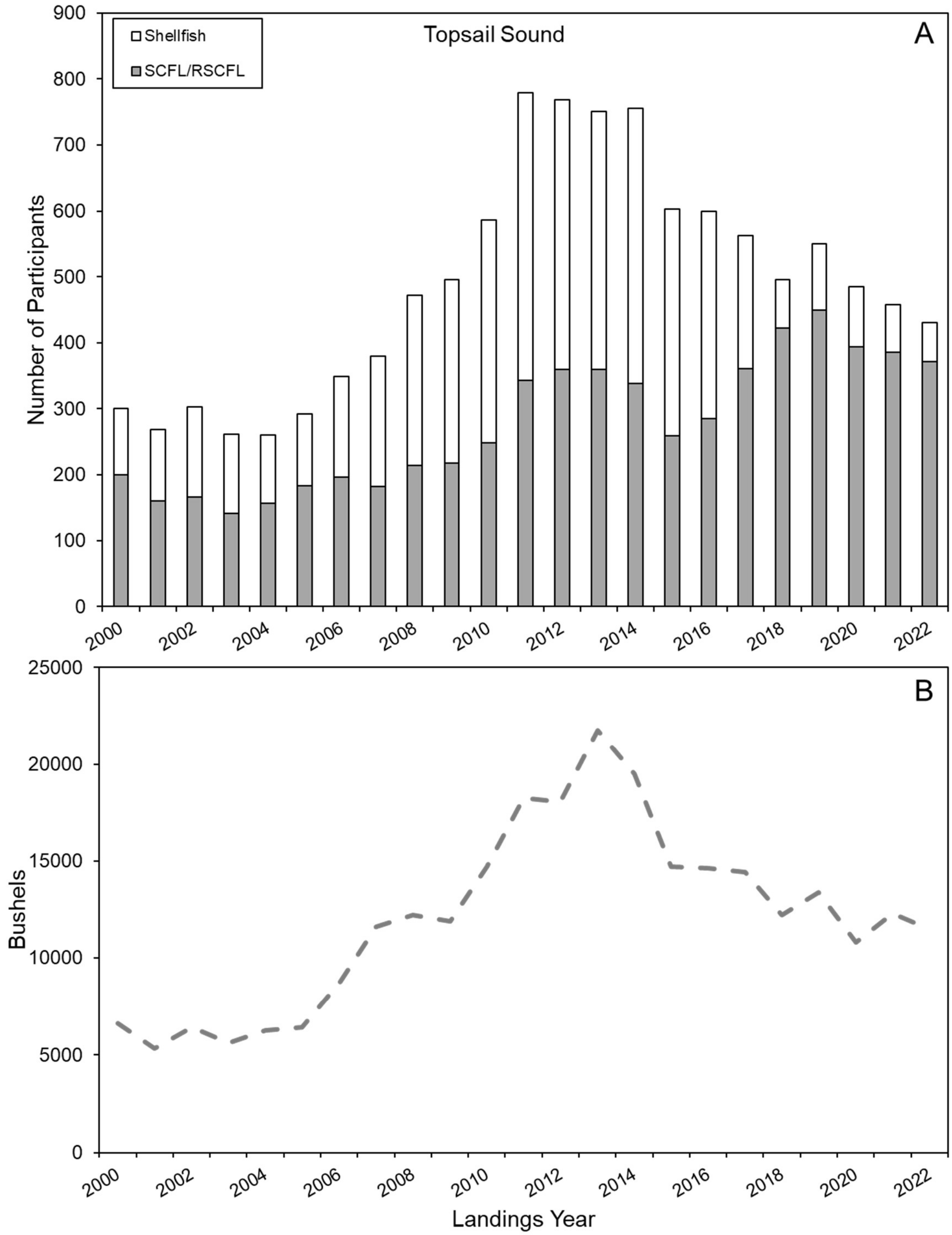

Figure 3.7. (A) Annual number of participants with oyster landings for Topsail Sound, the entire bar height shows total number of participants, with the proportion of participants with Shellfish Licenses shown as white, and the proportion with SCFL/RSCFL shown as grey. (B) Total commercial landings of oyster in bushels by year for Topsail Sound.

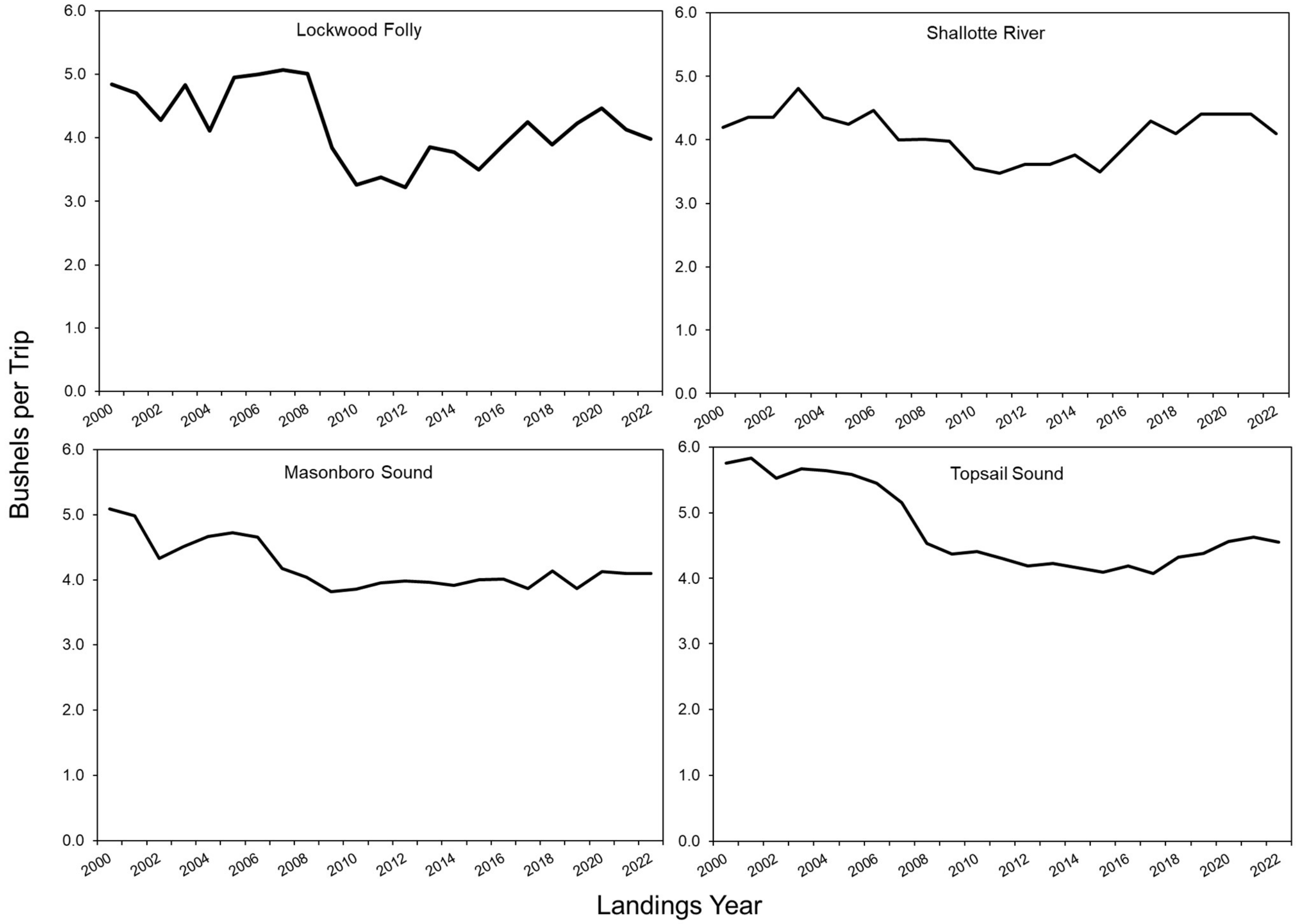

Figure 3.8. The catch-per-unit-effort (CPUE) for oyster commercial harvest in Lockwood Folly River, Shallotte River, Masonboro Sound, and Topsail Sound from 2000 to 2022. The black line represents the average annual bushel amount landed per trip for SCFL/RSCFL holders, separated by waterbody into individual panels.

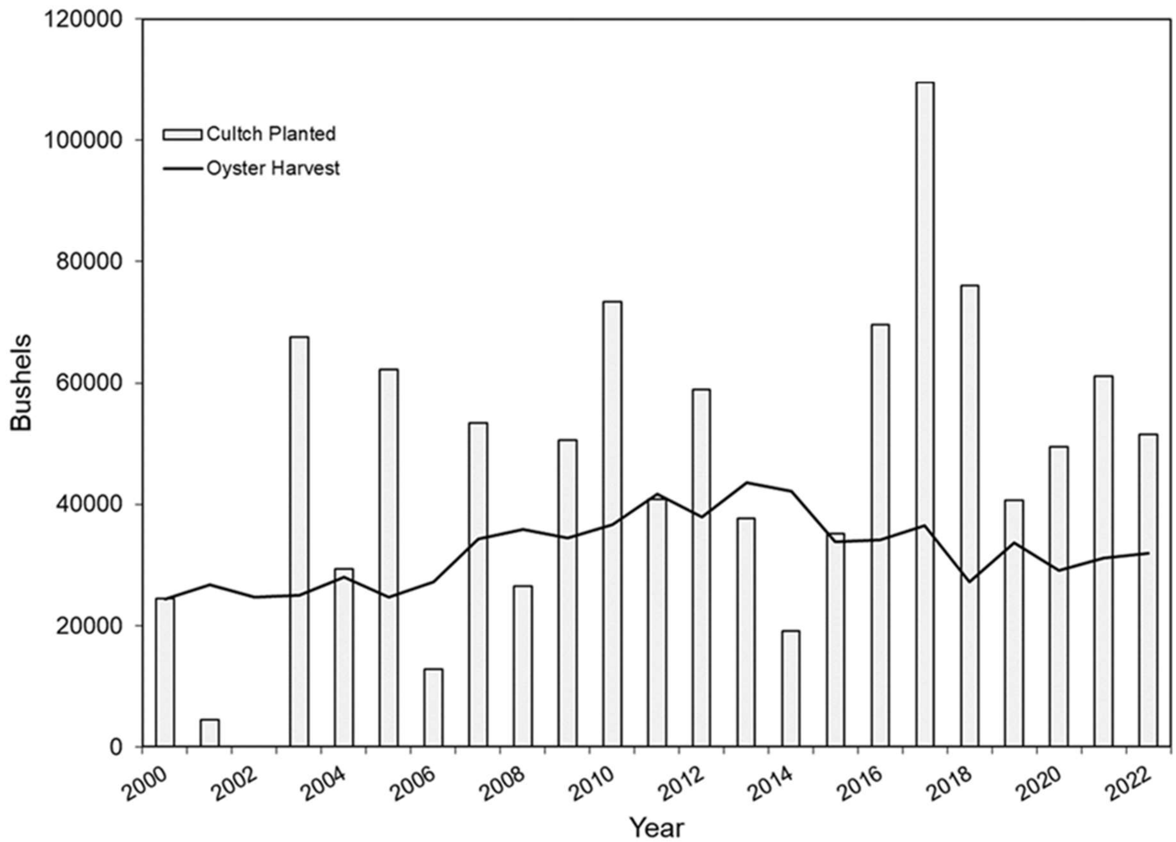

Figure 3.9. Annual amounts of cultch planted (shown as light grey bars) and amount of oyster commercially harvested (shown as black line) in bushels for the southern region (waterbodies south of Bogue Sound).

AUTHORITY

N.C. General Statute

113 134	Rules
113 182	Regulation of fishing and fisheries
113-201	Legislative findings and declaration of policy; authority of Marine Fisheries Commission.
113221.1	Proclamations; emergency review
143B-289.52	Marine Fisheries Commission – powers and duties.

N.C. Rule

North Carolina Marine Fisheries Commission Rules (15A NCAC)

03K .0201	Open Season and Possession Limit
03K .0202	Size Limit and Culling Tolerance

DISCUSSION

Landings in the intertidal hand harvest commercial oyster fishery, in the southern region, tend to generally follow trends in effort/participation, with periods of higher participation resulting in greater landings. Without fishery independent indices of oyster abundance, it is unclear whether fluctuations in oyster abundance influence or are influenced by effort in the fishery. When looking at trends in CPUE, it becomes apparent that periods of greater effort/participation result in lower annual average bushels landed per trip (Figures 3.2 and 3.3). This may be interpreted as when the oyster resource can support the amount of harvest pressure exerted, fishers are able to easily land a full limit of oysters each trip. As the oyster resource becomes impacted by additional harvest pressure, it becomes harder for all fishers to land a full limit each trip, and the average number of bushels landed per trip decreases. Because exposed intertidal oysters are relatively easy to find and harvest, reefs in the southern region are at risk of suffering impacts due to harvest pressure. To prevent excessive damage to these reefs, a minimum size limit of 3 inches was established. This rule ensures smaller mature oysters are left unharvested and can remain to act as breeding stock or sites for future oyster recruitment. As reefs become depleted of legal sized oysters during the harvest season and greater effort is required to find legal oysters, fishers generally move to more productive areas. As participation in the fishery increases, harvesters may have trouble finding areas with legal oysters and be willing to exert more effort to thoroughly harvest one reef, causing greater damage to the resource.

Considering the rising effort and declining CPUE observed in the southern region before development of the Eastern Oyster FMP Amendment 4 in 2015, the Marine Fisheries Commission chose management strategies focused on curbing the increase in effort from Shellfish License holders. This sector of the oyster fishery is potentially open to all state residents and was experiencing rapid growth. To limit landings and effort from the Shellfish License holders, in October of 2017 the bushel limit was reduced from five bushels per day to two only for those license holders. After this was implemented, the number of trips made by Shellfish License holders in the region quickly dropped, resulting in lower overall effort (Figure 3.2). Some Shellfish License holder participants transitioned to a SCFL, resulting in a slight increase in average SCFL/RSCFL trips and participants from 2018 onward when compared to years prior to the limit reduction. In all four waterbodies examined, number of participants with Shellfish Licenses dropped notedly after 2017 (Figures 3.4 – 3.7). This management approach appeared to have the desired effect on the region, decreasing overall commercial oyster effort (Figure 3.2). Additionally, CPUE for the region increased in the years following 2017 (Figure 3.3). When CPUE is examined on a waterbody scale, Lockwood Folly and Shallotte Rivers show increasing trends, while CPUE in Masonboro and Topsail Sounds has remained relatively consistent (Figure 3.8), indicating effort may remain elevated despite some reduction in participation.

In the southern region, 1.42 times more bushels of cultch material has been planted compared to bushels of oysters commercially harvested between 2000 and 2022. While the cultch planting program in this region is not designed to function as direct replacement for oysters harvested in this region, the goal is to at least mitigate the amount of shell removed by commercial harvest and provide adequate substrate for oyster spat to settle. On a regional scale, the cultch planting program has been able to keep up with or exceed the amount of shell removed from the system via harvest overall. However, due to logistical constraints the cultch material is not distributed across all waterbodies, creating localized cultch surpluses and deficits when compared to harvest amounts. Recent cultch planting locations in the southern region have been limited to areas near one of two current cultch stockpile locations, Mile Hammock Bay (Onslow County), or Morris Landing (Onslow County). With deployment of the R/V Oyster Creek for the 2024 cultch planting season, cultch planting efforts in the southern region can be extended to sites in Pender, New Hanover, and Brunswick counties. Cultch planting efforts statewide are reliant on continued funding.

With implementation of the fishery independent sentinel site monitoring program for intertidal oysters in the southern region, NCDMF will be able to use trends in oyster abundance and changes in demographics to inform future management options. This program will need several years of data collection before indices can be created and trends can be used to inform management decisions. Management strategies informed by this new program can be developed in a future amendment to the Eastern Oyster FMP.

LITERATURE CITED

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Appendix 4: Habitat & Enhancement Oyster Programs Information Paper

ISSUE

Provide further context behind current shellfish rehabilitation programs to be used in leveraging management strategies regarding subtidal oyster stocks in Pamlico Sound, North Carolina.

ORIGINATION

The Blue-Ribbon Advisory Council on Oysters (BRACO, 1995), the North Carolina Division of Marine Fisheries (NCDMF) Oyster/Clam Plan Development Team (PDT).

BACKGROUND

The North Carolina Eastern Oyster FMP Amendment 5 is focused on management of wild oyster stocks, and this information paper does not pertain to farm raised or private cultured oysters.

Oyster reefs can be likened to coral reefs as successive generations build on top of the calcium carbonate remains left by their predecessors. This process adds spatial complexity to the oyster reef habitat, creating colonization space, refuge, and foraging substrate for many economically important fishes and invertebrates in these estuarine environments (Arve 1960; Bahr and Lanier 1981; Zimmerman et al. 1989; Lenihan and Peterson 1998). Furthermore, as prolific filter feeders, reefs with dense oyster assemblages can affect phytoplankton dynamics and water quality, which can be beneficial to submerged aquatic vegetation (SAV) and reduces excessive nutrient loading that could otherwise lead to hypoxic conditions (Thayer et al. 1978; Newell 1988, Everett et al. 1995; Newell and Koch 2004; Carroll et al. 2008; Wall et al. 2008). Oyster reefs may also offer a degree of shoreline stabilization, protecting coastline habitats such as marshes (Coen et al. 2007). In sum, oyster reefs offer an array of ecosystem services that directly benefit the coastal communities living alongside them. Annual value of the services provided by oyster reefs has been estimated to be between $10,325 and $99,421 per hectare (Grabowski et al. 2012).

However, as a result of heightened demand, decades of intensive pressure from harmful fishing practices diminished oyster habitat, resulting in an 85% loss of oyster reef habitat worldwide (Rothschild et al. 1994; Lenihan and Peterson 1998). Additional anthropogenic stressors including increased nutrient run off, declining water quality, and increased sediment loads have exacerbated the decline of oyster reefs (Lenihan and Peterson 1998). In North Carolina, historical data shows a decline in oyster stocks and decreased water quality following the introduction of the oyster dredge (Marshall 1995). Such harvesting practices result in removal of vital oyster shell substrate, which serves as the foundation for subsequent generations, leaving many remaining populations functionally extinct (Gross and Smyth, 1946; Rothschild et al. 1994; Kirby 2004; Beck et al. 2011). As subtidal oyster populations have declined, so has the quality and availability of shell and hard bottom substrate, limiting the ability of oyster larvae to settle and build upon degraded reefs.

In response to rapid global declines and subsequent low harvest rates, resource managers and researchers identified habitat restoration as the best management practice to combat reef loss from harmful harvesting practices (Brown et al. 2013). Subtidal oyster restoration often involves replenishing settlement substrate removed during harvest, or protection of broodstock from harvest (e.g., no-take reserves), or a combination of both (Coen and Luckenbach 2000; Powers et al. 2009; Schulte et al. 2009).

In North Carolina, state officials recognized early on the importance of restoration in the face of a declining fishery. In response to rapidly declining harvests, the Fisheries Commission Board began the Cultch Planting Program in 1915 to rebuild oyster stocks by planting shells for substrate (cultch) and seed oysters on sites that would later be available for harvest. North Carolina's Division of Marine Fisheries (NCDMF) oversees the Cultch Planting Program as it continues today as one of the oldest and most extensive oyster restoration efforts in the country.

In 1996 NCDMF sought to integrate no-take reserves into restoration efforts via establishment of the Oyster Sanctuary Program. The primary goal was to improve oyster sustainability by developing a large, self-sustaining network of no-take reserves that support oyster brood stock and ultimately supply wild harvest reefs and cultch sites with viable larvae. North Carolina has 17 protected oyster reefs encompassing 789 acres within the Oyster Sanctuary Network throughout Pamlico Sound. The goal of creating a self-sustaining network of oyster larvae "sources" and "sinks" illustrates how NCDMF's Sanctuary and Cultch Programs serve as complements to one another in its shellfish rehabilitation strategy.

Among the management strategies implemented within the oyster fishery, NCDMF also recognizes the effectiveness and importance of continued habitat restoration efforts. Today these supplementary strategies are carried out by NCDMF's Habitat and Enhancement Section. Together the Cultch and Sanctuary programs help NCDMF achieve its goal of promoting sustainable fisheries by creating oyster habitat. The benefits of these programs are multifaceted as they not only promote an improved oyster stock, but also restore vital ecosystem services including water filtration, increased fish and macroinvertebrate habitat provisions, and food web diversity (Peterson et al. 2003). The Cultch and Sanctuary programs use data-driven approaches to determine subsequent enhancement projects with the aimed benefit of improving oyster habitat throughout North Carolina's estuaries. This information paper provides detailed information on the history and current methodologies for site selection and monitoring protocols for both programs.

Terminology

While the state of North Carolina has been creating artificial reefs since the 1970s, not all reefs serve the same purpose. Of the 72 artificial reefs, only 17 are oyster sanctuaries. It is important to distinguish that while all artificial reef habitat is considered "reef," not all reefs are considered "sanctuary." The term "oyster sanctuary" refers to reefs protected from oyster harvest and some bottom disturbing gears through North Carolina Marine Fisheries Commission (NCMFC) rule 15A NCAC 03K .0209. It is also important to consider that created habitat within sanctuary boundaries always exists as a collection of separate reef habitat patches. Therefore, sanctuaries are sometimes referred to as reef sites. In most cases concerning reef sites managed by the Oyster Sanctuary Program, the entire reef site authorized by state and federal permits is protected from oyster harvest. Therefore, the terms “reef,” “sanctuary,” and “reef site” are often used interchangeably. Conversely, the term “cultch site” refers to any site where a thin layer of material (recycled shell or marl limestone #4) has been laid out with the intention of creating oyster habitat open to harvest.

Site Selection Methodology

NCDMF’s Shellfish Rehabilitation program aims to incorporate sound science into both the Cultch and Sanctuary programs to maximize cost-effectiveness of material acquisition and oyster production. Data from shellfish monitoring efforts and historical environmental data are incorporated into the site selection process. This approach utilizes a habitat suitability index (HSI) model, which considers several environmental variables that influence oyster survivability.

When building an HSI model for Pamlico Sound, for instance, the waterbody is divided into approximately 6,000 individual one square kilometer squares. Each square receives a value for the variables used in the model. The variables are weighted and averaged to calculate a total score which indicates the relative habitat suitability for oysters. Variables may either be “exclusionary” or “threshold” layers. Exclusionary variables are binary (the square may be assigned a 0 or 1) and include variables such as depth, shellfish lease areas, and military exclusion zones. Threshold variables are scaled on an optimum and include salinity, dissolved oxygen, and larval dispersal patterns. For more information on the methodology used in the first iteration of the HSI for Pamlico Sound, refer to Puckett et al. (2018).

The HSI is used in tandem with a broadscale multiyear permit from the US Army Corps of Engineers (Nationwide 27). The Nationwide 27 (NW 27) is renewed every five years and grants the state 200 acres combined of acceptable inland water for oyster restoration. This permit restricts reef material from being planted in areas with Submerged Aquatic Vegetation (SAV) or existing natural shellfish populations to prevent destruction of important established habitat. Desirable areas found within the constraints of the NW 27 and HSI are then considered depending on logistic variables such as distance from cultch material stockpile sites. Staff review and further ground truthing are conducted to ensure permit compliance and physical suitability of the proposed site. Surveys are also sent to commercial fishers to solicit public input and comment.

CULTCH PLANTING PROGRAM

For over a century, NCDMF has worked to create cultch reefs to alleviate fishing pressure on North Carolina’s natural oyster reefs. Research has demonstrated the ability of cultch planted reefs to support significant oyster densities over time, with cultch sites hosting 9.6 times more oysters than natural subtidal reefs found throughout Pamlico Sound (Peters et al. 2017). Perhaps even more indicative of their effectiveness as a fisheries management strategy, North Carolina's cultch reefs were found to have 4.5 times more legal sized oysters than on natural oyster reefs (Peters et al. 2017). Since its inception, over 21 million bushels of cultch material have been planted in the form of small-scale, low-relief, harvestable oyster reefs (Figure 4.1). The program has been a longstanding collaboration between state government and local oyster harvesters to ensure cultch reefs are built in the best available locations for oyster recruitment.

Program History: The First 100 years of Cultch Planting

The Cultch program began with state funding to plant up to 12,000 bushels of shell each year from 1915 to 1920. After initial success and apparent rebound in harvests, additional state funding allowed the program to scale up and plant around 100,000 bushels of seed oysters and substrate in the early 1920s. Harvest statistics show a rebound in landings from 1923 to 1931 with landings ranging from 326,659 to 441,307 bushels. However, harvest numbers began to decline between 1932 and 1934, reaching a low of 271,192 bushels. The state then doubled down on its efforts, planting 825,000 bushels of seed oysters and 78,567 bushels of shell in the largest oyster enhancement project at the time. These planted areas were closed until 1936. Upon reopening those areas, oyster harvest more than doubled to 651,050 bushels in 1936.

However, in the following decade, no significant investments were made to rebuild oyster stocks with the events of World War II. During this period, harvest declined significantly until the end of the War in 1945. Soon after, Governor Cherry created a special oyster commission in 1946. The legislation resulting from the commission's recommendations contained landmark changes in oyster management, including appropriated funds and several provisions for supporting the renewed oyster enhancement effort—the Shellfish Rehabilitation Program (later named the Cultch Planting Program). Among these provisions were: 1) a continuation of large-scale planting shell and seed oyster planting efforts; 2) an oyster tax to support the program; 3) a requirement that 50% of the shell from shucking operations be contributed to the program; and 4) a $0.50 per bushel tax on shell stock shipped out-of-state. The first ten years of the program saw 838,000 bushels of shell and 350,734 bushels of seed oysters planted.

Figure 4.1. Map of cultch reefs from Dare County to the South Carolina border.

However, by the mid-1950s, appropriated funds had been exhausted while the shell tax collection had not increased. Furthermore, up until this point fishers had been employed to carry out enhancement activities, putting additional financial stress on the program. All the while, harvest numbers fluctuated from 149,489 to 331,472 bushels during this time. To alleviate costs, the state purchased a 40-foot wooden barge and began deploying material on its own in 1954. In 1956, a request for an $80,000 annual appropriation was approved by the N.C. General Assembly, allowing oyster enhancement efforts to increase to 500,000 bushels per year. Oyster harvest remained greater than 200,000 bushels each year until 1962. A state report would later conclude that fluctuating harvest numbers were likely the result of repeated severe hurricanes, which would have negated most oyster rehabilitation efforts conducted since 1947 (Munden 1981).

In the 1970s, new approaches and strategies to rebuild oyster stocks were undertaken with the state budget increasing appropriations for enhancement activities several times throughout the decade. For instance, the Cultch program began acquiring its own barges and equipment, and hired support staff for the next few decades. Additionally, the program received a grant from the Coastal Plains Regional Commission in 1980 along with state appropriations that allowed it to pay for its operations, including the procurement of two large surplus military landing crafts that were repurposed to deploy shells. In the following two years, more than 700,000 bushels of substrate were planted. During this period, oyster harvest peaked in 1987 at 226,283 bushels before declining significantly, not exceeding 100,000 bushels through 2008. Meanwhile, continued state appropriations allowed the program to deploy 250,000 bushels of substrate each year until 1997.

In 1998, the legislature revised the Cultch Program, namely by appropriating an annual budget of approximately $300,000 for purchasing and transporting cultch material. This equated to planting 30-40 acres of harvestable oyster reefs each year. In fiscal year 2015-2016, funds for cultch increased to approximately $600,000; then increased again in fiscal year 2016-2017 to $900,000. In recent years, annual appropriations for the program have increased to over $1 million in some years to cover the cost of substrate, staffing, and vessels. Increases in appropriations resulted in substantial increases in annual deployments and investments in much needed modernization and improved efficiencies of fleet equipment.

The approach and methodology used by managers for cultch planting have remained consistent since 1998. Planting sites were selected based on input from local fishers, historical production, and environmental criteria (bottom substrate type, salinity, currents, & historical production). These variables were used to weigh possible effects of fishing operations in the area before deciding on a new cultch planting site. While NCDMF vessel crews typically deploy shell and small marl limestone (#4) rock, other methods were explored with varying levels of success, such as hiring fishers to gather and transplant seed oysters and hiring marine contractors for deployments. Additionally, managers experimented with site size in an effort to maximize deployment efficiency and fishery impact. The result meant fewer total sites planted per year but saw an improvement in integrity and effectiveness of cultch reefs as large as 10 acres.

Monitoring efforts to quantify the performance of cultch sites was typically limited to a three-year period post-construction. NCDMF would survey each cultch planting site to observe trends in population demographics (annual recruitment, size frequency, and population density). However, monitoring of cultch planting sites beyond three years was not conducted due to resource limitations. Initial cultch reef sampling was conducted using imperfect methodology, including small sample sizes, variable sampling intervals, and uncertain area estimates covered by the dredge, all of which made estimating densities and size class distribution difficult and not standardized.

Modern Cultch Planting Program: 2020 – Present

The goals defined by internal Cultch Planting Program documentation are: 1) to provide suitable substrate for the attachment of natural oyster larvae, and 2) to increase oyster production. The Cultch Planting Program relieves harvest pressure from degraded natural reefs by developing permanent and routinely managed areas. In 2020, NCDMF hired the first biologist dedicated solely to the Cultch Planting Program with an objective to update and standardize site selection and sampling processes. NCDMF currently plants between

300,000 and 400,000 bushels of cultch material annually, covering over approximately 40 acres of undeveloped inshore bottom (Table 4.1).

Data from the Cultch Program are captured in three monitoring programs: P600 (cultch planting), P610 (spatfall evaluation), and P627 (trigger sampling). P600 records location, type, and amount of material planted annually across the state. This is used to update the public facing interactive cultch map, allowing commercial oystermen to find cultch reefs. The current Nationwide 27 Permit limits materials that can be used for cultch planting to oyster shell, crushed concrete, and limestone marl. Of these materials, limestone marl is readily available and cheapest.

Recycled oyster shells are a well-known valuable resource for oyster restoration but remain in short supply in the state. Other states, including Virginia and Maryland, have legislative-backed shell recycling programs that offer tax credits and incentives to businesses in exchange for oyster shells. Growing demand has increased the price of oyster shell and subsequently resulted in shell being exported out of North Carolina. Without sufficient incentives or funding, shell has become a rare resource for restoration efforts, further limiting cultch planting efforts to marl and concrete materials.

P610 monitors cultch enhanced reefs for three years post-planting. Hydraulic tongs are used to collect random point samples within a cultch site. The oysters are counted and measured to determine spat recruitment rates and mortality metrics. The data collected under P610 provides insight into oyster spat recruitment and once analyzed could be incorporated into a future state eastern oyster stock assessment.

Peer-reviewed research has also independently quantified oyster recruitment on cultch sites. For instance, cultch reefs successfully hosted 4.5-times more legal oysters than natural reefs where no restoration effort had occurred (Peters et al. 2017). On average, cultch sites had 27 legal oysters (≥3 inches) per square meter (Peters et al. 2017). With 27 legal oysters/m^2 on cultch material, a conservative estimate suggests that one acre of harvestable cultch reef should yield approximately 368 bushels of legal oysters (300 oysters/bushel).

P627 trigger sampling occurs in the fall and lasts the duration of the commercial oyster mechanical harvest season. A pre-season sample is taken as a baseline for mechanical harvest areas in the Pamlico Sound. Once the season is open, monitoring occurs throughout the season to ensure legal catch does not fall below an allowable threshold. For further details on P627 (trigger sampling), refer to Supplement A and Appendix 2 (Mechanical Oyster Harvest Management Issue Paper). Methodology for P627 is subject to change regardless of selected management strategies following adoption of Amendment 5 to the Eastern Oyster FMP.

Cultch for Future Management

Throughout the course of the Cultch Program's history, the acquisition and deployment of materials has been limited by funding, which has been inconsistent. Yet, with growth of the program in the last decade, there is potential for the Cultch Program to become an integral strategy to meet the goal and objectives of the oyster FMP. An example strategy for the Cultch Program is further outlined in Appendix 2: Mechanical Oyster Harvest Management Issue Paper, specifically with a proposed rotational harvest management plan. It is worth noting that Virginia utilizes a rotational harvest system as a management strategy in tandem with oyster restoration efforts.

Additionally, with monitoring of cultch sites post-construction, useful oyster metrics can be analyzed and used for development of a stock assessment in the future. However, the utility of data collected from cultch sites can be further maximized if harvest locations on trip tickets are categorized as cultch or natural reefs. However, consistent funding is required to effectively integrate and anchor the Cultch Program as an effective long-term management strategy.

OYSTER SANCTUARY PROGRAM

Overview

The 1995 Blue-Ribbon Advisory Council on Oysters highlighted the importance of restoring North Carolina's oyster population in Pamlico Sound. Accordingly, NCDMF responded by incorporating no-take marine reserves into its oyster restoration efforts with the creation of the Oyster Sanctuary Program. No-take marine reserves support increased size and density of target species—for oysters a larger size equates to greater reproductive output (Duran and Castilla 1989; Coen et al. 2007; Lester et al. 2009). The aim of NCDMF's protected subtidal oyster sanctuaries is to supplement larvae to decimated natural oyster reefs and cultch sites throughout Pamlico Sound via the "spillover effect" created by these protected areas with heightened reproductive output (Peters et al. 2017). Secondary objectives of the sanctuaries are to increase the impact of environmental services provided by oysters, and to provide North Carolina residents with relatively accessible recreational fishing and diving opportunities.

The creation and preservation of oyster sanctuaries represents both a long-term, large-scale ecological restoration project as well as a long-term fisheries investment to the state of North Carolina. The network of sanctuaries provides ecosystem services that improve the quality of habitat throughout Pamlico Sound. Sanctuary sites offer nursery habitat for other species, increasing their abundance for commercial and recreational fishing; provide refuge and forage habitat for marine life; form travel corridors for transient finfish; and increase water filtration, reducing turbidity and excess nutrients in the estuary. The impacts of sanctuary sites expand far beyond their boundaries as brood stock populations supplement the growth of natural reefs and cultch sites. Furthermore, the necessity of oyster sanctuary construction falls within Recommendation 3.1 in the NC Coastal Habitat Protection Plan – "Greatly expand habitat restoration, including creation of subtidal oyster reef no-take sanctuaries."

Table 4.1. Bushels (bu.) and acres planted per year by county for the cultch program from, 2010-2022.

County		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
Brunswick	bu.	3,447	24,509	6,294	9,403	4,991	4,053	5,470	-	-	-	-	-	-	58,167
	acres	0.3	0.9	0.7	1.8	1.0	0.7	3.2	-	-	-	-	-	-	8.5
Carteret	bu.	53,741	5,470	93,943	23,440	43,756	48,889	81,725	-	35,234	46,112	88,857	70,576	13,276	593,909
	acres	17.8	2.7	20.1	5.4	11.5	10.5	13.6	-	5.9	12.0	11.4	7.3	1.0	119.2
Dare	bu.	41,501	71,226	39,156	37,856	32,428	22,829	48,251	70,516	43,257	80,342	50,359	55,057	71,120	663,898
	acres	2.8	7.0	4.2	2.7	3.8	2.5	4.7	6.0	4.2	8.0	4.1	9.8	10.0	69.8
Hyde	bu.	32,104	44,071	62,324	46,908	108,261	48,889	114,583	73,832	21,179	76,992	85,423	62,100	79,863	856,529
	acres	6.2	9.1	6.3	9.5	10.8	5.7	12.8	7.9	1.8	8.4	9.9	6.7	10.0	105.1
New Hanover	bu.	2,611	2,244	-	8,385	-	4,059	-	-	-	-	-	-	-	17,299
	acres	1.2	0.4	-	5.2	-	2.8	-	-	-	-	-	-	-	9.6
Onslow	bu.	65,176	21,198	50,960	19,800	14,119	27,073	82,996	109,634	56,444	40,696	49,524	64,916	90,767	692,300
	acres	48.7	2.0	32.5	12.7	8.1	11.6	41.3	24.2	12.6	23.6	7.2	9.0	11.0	244.5
Pamlico	bu.	14,372	35,738	22,002	11,885	28,863	54,479	91,815	79,331	38,676	47,696	80,162	84,656	53,625	643,300
	acres	4.8	8.3	5.1	2.6	3.7	8.0	12.9	10.1	6.7	6.2	9.9	6.7	10.0	95.0
Pender	bu.	-	-	-	-	-	-	3,687	-	-	-	-	-	-	3,687
	acres	-	-	-	-	-	-	1.6	-	-	-	-	-	-	1.6
Total	bu.	212,952	204,456	274,679	157,677	232,418	210,271	428,527	332,313	183,680	291,838	354,322	337,305	308,651	**3,529,089**
	acres	81.8	30.4	68.9	39.9	38.9	41.8	90.1	48.2	31.2	58.2	42.5	39.5	42.0	**653.4**

Various research projects and analyses have been conducted to quantify the intended performance of North Carolina's oyster sanctuaries as larvae production sites and their overall economic benefit to the state. It has been estimated that one out of every four larvae settling on commercially harvested oyster reefs (natural or cultch) in Pamlico Sound originated from an oyster sanctuary (Peters et al. 2017). Furthermore, an independent economic analysis estimated that for every dollar invested in oyster sanctuaries, there was $4 return in the form of economic opportunity or ecosystem services (RTI International 2016). By 2026, the Oyster Sanctuary Program will be comprised of 17 sanctuary sites, totaling 789 permitted acres. With an additional 140,000 tons of marl limestone and granite planned for deployment at Maw Point and Brant Island combined, there will be over 373,000 tons of aggregate material used for the creation of protected oyster reef habitat in Pamlico Sound by 2026 (Figure 4.2; Table 4.2).

Legislation and Rules

As part of the 2008 Oyster Fishery Management Plan Amendment 2, the NCMFC moved the protection of oyster sanctuaries from proclamation into rules 15A NCAC 03K .0209 and 03R .0117, Oyster Sanctuaries, which in effect prohibits the harvest of oysters and use of trawls, long haul seines, and swipe nets in sanctuary boundaries, thereby promoting growth and enhancing survivability of large oysters within the sanctuary sites. Oyster sanctuaries under construction but not yet incorporated into 15A NCAC 03R.0117 can be protected under Rule 15A NCAC 03H .0103 and 03K. 103 through proclamation authority.

In the 2014 legislative session, the North Carolina General Assembly established the Senator Jean Preston Oyster Sanctuary Network (Figure 4.2). This was done "to enhance shellfish habitats within the Albemarle and Pamlico Sounds and their tributaries to benefit fisheries, water quality, and the economy…achieved through the establishment of a network of oyster sanctuaries, harvestable enhancement sites, and coordinated support for the development of shellfish aquaculture."

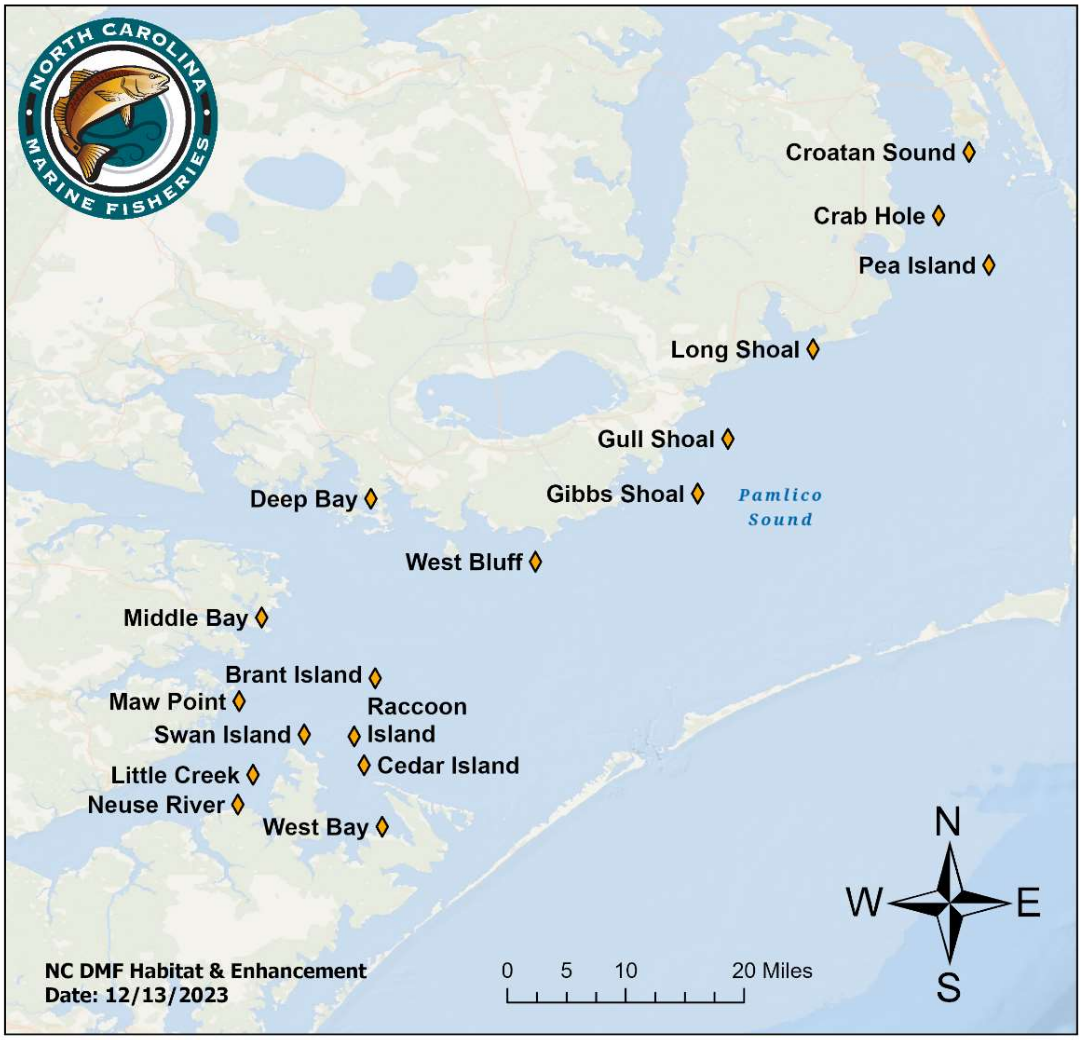

Figure 4.2. Jean Preston Oyster Sanctuary Network, Pamlico Sound, NC.

Table 4.2. A comprehensive list of North Carolina's Oyster Sanctuaries found throughout Pamlico Sound. Permit area refers to the total protected boundary area delineated by rule or proclamation. Developed habitat area includes material footprints and surrounding unconsolidated soft bottom, whereas habitat footprint area- refers to the cumulative total area of reef patches only, not to include unconsolidated soft bottom. For example, Croatan Sound Oyster Sanctuary has 3.10 acres of habitat within the overall boundary of 7.73 acres, meaning 4.63 acres of the site do not have habitat material present, but harvest is prohibited within the entire site.

OS Name	Permit Area (Acres)	Developed Habitat (Acres)	Habitat Footprint (Acres)	Aggregate Material (Tons)	Established	Most Recent Addition	Materials
Croatan Sound	7.73	7.73	3.10	2,093	1996	2013	Marl, Reef Balls, Clam Shell, Oyster Shell
Deep Bay	17.20	17.20	4.15	1,749	1996	2014	Marl, Reef Balls, Clam Shell, Oyster Shell
West Bay	6.57	6.57	2.27	2,329	1996	2014	Marl, Reef Balls
Crab Hole	30.52	30.52	13.26	36,489	2003	2009	Marl
Middle Bay	4.59	4.59	0.27	900	2004	2004	Marl
Neuse River	11.21	11.21	3.55	7,357	2005	2008	Marl
West Bluff	29.42	9.97	2.82	10,162	2005	2013	Marl, Reef Balls
Gibbs Shoal	54.69	54.69	8.19	22,447	2009	2013	Marl, Reef Balls
Long Shoal	10.01	6.79	1.13	2,173	2013	2013	Reef Balls
Raccoon Island	9.97	9.97	1.61	1,824	2013	2016	Crushed Concrete, Consolidated Concrete, Reef Balls
Pea Island	46.36	33.9	2.62	3,420	2015	2015	Crushed Concrete, Consolidated Concrete, Reef Balls
Little Creek	20.71	20.71	6.14	5,700	2016	2016	Marl, Crushed Concrete, Basalt, Reef Balls, Granite, Consolidated Concrete
Swan Island	80.32	62.6	10.93	55,000	2017	2021	Marl, Granite
Cedar Island	75.01	70.32	12.43	51,800	2021	2022	Marl, Crushed Concrete
Gull Shoal	158.40	TBD	TBD	36,000	2022	TBD	TBD
Maw Point	126.66	TBD	TBD	TBD	2024	2024	Marl
Brant Island	99.26	TBD	TBD	TBD	2024	2024	Crushed Concrete, Granite
Total	**788.63**	**346.77**	**72.47**	**239,443**			

Funding History

Initially, oyster sanctuaries were built by NCDMF's Artificial Reef Program, which provided funding for materials, and the Shellfish Program, which deployed materials. In 2002, relief money was available from a National Marine Fisheries Service Grant (NMFS) for Hurricane Floyd damages. NCDMF has continued to expand the Oyster Sanctuary Program via funding and collaboration with the North Carolina General Assembly, The Nature Conservancy, National Oceanic and Atmospheric Administration (NOAA), National Estuarine Counsel, Coastal Recreational Fishing Licenses, North Carolina Coastal Federation, and other mitigation sources. These funds have been used to cover material purchasing and deployment costs.

Beginning in 2017, and still in effect through 2026, NCDMF entered a partnership agreement with North Carolina Coastal Federation (NCCF) to significantly increase funding availability and deployment efficiency for the construction of multi-year sanctuary projects. From 2017 to 2020, Swan Island (OS-15) was constructed in southern Pamlico Sound encompassing 80 acres. In 2021, NCDMF and NCCF began construction of Cedar Island (OS-16) within a 75-acre site. The most recent plans for further construction include two large sites, both 100+ acres – Maw Point (OS-18) and Brant Island Shoal (OS-19). Funding for these two sites was acquired through a successful NOAA proposal submitted by NCCF.

Additionally, North Carolina's Division of Mitigation Services undertook the task of funding, planning, and constructing an oyster sanctuary site at Gull Shoal (OS-17). Details of this project do not fall under NCDMF supervision; however, it will be incorporated into the OS Network and NCDMF plans to take over monitoring efforts after five years post-construction.

Sanctuary Site Selection

Historically, oyster sanctuary construction and site selection were largely dependent upon where historic oyster reefs once existed. By 2014 the Program placed greater emphasis on establishing a connected oyster network in Pamlico Sound, stemming from research and hydrological models on currents and wind patterns that drive distribution of oyster larvae (Xie & Eggleston 1999; Puckett et al. 2014). To ensure larval connectivity and to further safeguard subtidal oyster populations, new sanctuary sites are selected based on a habitat suitability index (HSI) model for Pamlico Sound. This model weights environmental and biological variables, including dissolved oxygen, salinity, bottom substrate type, tidal flow, larval transport, wave action, and prevailing wind data to determine ideal locations conducive to building long-lasting and effective sanctuaries (Puckett et al. 2018). Planning and logistic constraints are also considered to narrow down potential sites. After determining several areas with high suitability scores, site investigations ground-truth bathymetric and environmental conditions and check for existing oysters or SAV.

Reef Design & Construction

The Oyster Sanctuary Program has utilized various materials to create artificial subtidal oyster reefs, including marl limestone rock, crushed concrete, crushed granite, reef balls, recycled concrete pipe, basalt, and a variety of recycled shell materials. Aggregate materials (marl, concrete, granite, basalt) are large in diameter to deter attempts to illegally dredge sanctuary reefs. Material selection for new sanctuary mounds is both opportunistic and cost dependent. Materials are secured by program staff or by outside partnerships. Environmental factors are taken into consideration for material selection as well. For instance, higher salinity sites may be built with granite or crushed concrete as these materials may be less susceptible to “pest” species such as boring sponge, which may otherwise inhibit sustained oyster growth.

NCDMF oyster sanctuary reefs have been constructed with the goal of providing vertical relief and structural complexity to oyster populations. Vertical relief and structural complexity contribute to increased flow speed, which enhances mixing of the water column and thus food availability for oysters (Butman et al. 1994). Conversely, oysters on low vertical relief reefs are exposed to greater sedimentation and increased exposure to low dissolved oxygen events (Lenihan and Peterson, 1998; Lenihan 1999). Up until 2017, sanctuaries were designed with clusters of high-relief mounds 3-6 ft in height. More recently, Swan Island, Cedar Island, Maw Point, and Brant Island oyster sanctuaries were designed with parallel ridges arranged in a grid-like pattern. These ridges are approximately 200-250 ft long, 30-40 ft wide, with a height of 4-6 ft (Figure 4.3). This approach increases the efficiency of the permitted areas and may improve the long-term integrity of reef habitat.

Sanctuary material deployments are designed around project objectives and vary widely according to project specifics, such as material type and size, site location, material quantity, funding, sea conditions, etc. As of 2017, reef enhancements are completed by Habitat and Enhancement staff using NC state vessels and with the assistance of contractors. All reef construction activities are subject to local, state, and federal permitting agencies. Any deployment activity must fall within permitted boundaries and environmental restrictions.

Monitoring and Analyses

Each year biologists and technicians conduct SCUBA surveys at each Sanctuary across Pamlico Sound to quantify the performance of each site and the materials used in construction. Performance metrics include: 1) oyster population and density metrics; 2) material performance as bottom substrate; and 3) material stability over time. Annual monitoring efforts began in 2007, and apart from a few data gaps, has yielded a rare long-term data set on a large scale, long-term ecological restoration project.

Measuring oyster density and size frequencies are some of the most effective ways to assess oyster reef performance (Baggett et al. 2015). NCDMF divers collect random samples for each material type within each sanctuary to measure density and population structure. Insights from oyster population metrics provide insight into material selection and improve site selection for future projects. Side scan sonar of sanctuaries every few years provides further insight into the stability of deployed materials at each sanctuary. For instance, reefs built with recycled shell can persist if heavily colonized by oysters, and oyster growth and recruitment rates exceed mortality and shell degradation. However, constructed shell reefs rapidly degrade if not heavily colonized by oysters and are prone to being displaced in areas of heavy currents (Powell et al. 2006). Heavier and larger materials offer several advantages including long-term persistence and cost-effectiveness.

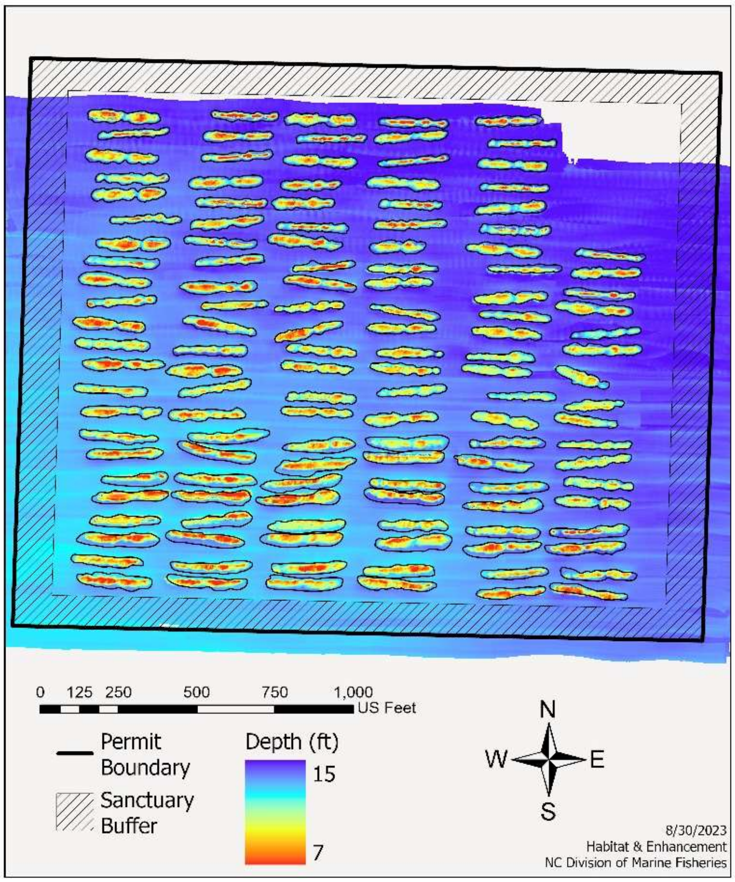

Figure 4.3. Side scan view of Cedar Island Oyster Sanctuary located in Pamlico Sound, North Carolina. Construction of the sanctuary began in 2021, using marl limestone rip rap and crushed concrete in a grid design with parallel ridges.

Data from sanctuary monitoring in 2023 suggests North Carolina's oyster sanctuaries had an average total density of 1,333 oysters/m^2 and an average legal density of 127 oysters/m^2. These estimates, along with those from independent peer-reviewed studies, verify and quantify the effectiveness of the Sanctuary Program. For instance, total oyster density at sanctuary sites was 72 times greater than natural reefs open to harvest, and 7.5 times higher than restored harvested (cultch) areas (Peters et al. 2017). This trend extended to legal oyster density (>75mm), as sanctuary sites demonstrated 27 times greater density than natural harvested reefs and six times greater density than restored harvested reefs (Peters et al. 2017). The potential larval output per m^2 of sanctuary sites was significantly higher than at natural reefs (700 times greater) and cultch areas (four times), illustrating the high potential for larval spillover as intended in the design of the Oyster Sanctuary Network (Peters et al. 2017).

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Appendix 5: Eastern Oyster Management & Stock Status in Other States. Fishery type categorized as either recreational (‘Rec.’) or commercial (‘Com.’); Mechanical gear type abbreviated as ‘Mech.’; bushels abbreviated as ‘bu.’.

State	Fishery	License Issued by	Gear	Daily Trip Limit	Season	Size Limit	Stock Assessment	Management
ME	Rec.	Town	Hand	1 peck/person	Nov 1 - Apr 30	2.5"	No	Co-managed towns may further restrict harvest via shellfish control ordinance. Oyster habitat restoration program.
	Com.	State	-	-				
NH	Rec.	State (resident only)	Hand	0.2 bu./person	1 Sep - Jun 30	None	No	Managed by towns and municipalities.
	Com.	No Wild Harvest	-	-				
MA	Rec. & Com.	Town	Hand	Consult Town Regs	Consult Town Regs	3"	No	Managed by towns and municipalities.
RI	Rec.	License for Non-residents	Hand	0.5 - 1 peck (varies by area)	15 Sep- 15 May	3"	No	Managed in state shellfish management areas and closed spawner sanctuaries. Habitat restoration program.
	Com.	State	Hand	3 bu./person, 6 bu./vessel	Fixed Season Varies by Management Area			
CT	Rec.	Town	Hand	Between 24 oysters to 0.5 bu./person (varies by town)	Year round, exceptions by town	3"	No	Habitat restoration. Allows seed oyster harvest for relay and sale.
	Com.	State	Hand, Mech.	Seed Oyster Harvest Fishery Only	20 Sep - 20 Jul			
NY	Rec.	Town	Hand, Sail power	0.5 bu.	1st Monday Nov - 31 Mar	3"	No	Habitat restoration.
	Com.	State	Hand, Sail power	None				

State	Fishery	License Issued by	Gear	Daily Trip Limit	Season	Size Limit	Stock Assessment	Management
NJ	Rec.	State	Hand	150 (total mollusks)	Year round (no Sunday harvest)	3"	Yes (Delaware Bay Only)	Annual assessment for Delaware Bay. Quota set by dredge survey of six management areas. 2024 stock status, thresholds and reference points from times series 1989 onward. 224 grids sampled to determine 2023 stock status. >100sq miles of area. Partnership with Rutgers.
	Com.	State	Tong, Dredge	Quota for Delaware Bay (Direct Market Fishery)	Apr - Nov			
DE	Com.	State	Dredge	Quota set by Dept Fish & Wildlife (split between license holders)	Set by Dept Fish & Wildlife (2024 split: 1 Apr - 31 May & 2 Sep - 31 Dec)	2.75"	Population Survey	Survey used to set landings quota. 2% of population as target set in 2018. Limited entry into oyster fishery. Rec harvest prohibited.
MD	Rec.	None (resident only)	Hand	100 oysters	1 Oct - 31 Mar (M-Sat, before noon)	3"	Yes	Stage-structured model with various integrated sources (buy ticket data, MDDNR surveys, oyster/shell planting data, bottom mapping, etc.) to estimate sustainable fishing reference points. MD area of Chesapeake ~1,500 sq miles.
	Com.	State	Hand	12 bu./person, 24 bu./vessel	1 Oct - 31 Mar (M-F)			
			Power Dredge	10 bu./person, 20 bu./vessel	1 Nov - 31 Mar (M-F)			
			Sail Dredge	100 bu./person, 100 bu./vessel				
VA	Rec.	None	Hand	1 bu./vessel	1 Oct - 31 Mar (M-F until 3:00 pm)	3"	Yes	Virginia Oyster Stock Assessment and Replenishment. Partnership with VIMS and VMRC. Assessment Program and

State	Fishery	License Issued by	Gear	Daily Trip Limit	Season	Size Limit	Stock Assessment	Management
	Com.	State	Hand	8 bu./person, 16 bu./vessel	Season length varies by areas, time allowed to fish varies by season			Restoration activities for Chesapeake Bay. Managed and surveyed by individual public oyster reefs. Virginia Public Oyster Grounds, 243,000 acres (380 sq miles) Fishing mortality limited by area using season length and fishing times.
			Hand Tong	14 bu./person, 28 bu./vessel				
			Mech.	8 bu./person, 16 bu./vessel				
NC	Rec.	None	Hand	1 bu.	1 Oct - 31 Mar	3"	No	Oyster restoration and enhancement programs in closed sanctuaries and public shellfish grounds. Mechanical harvest monitoring to close harvest when trigger falls below 26% legal by area.
	Com.	State	Hand	3-15 bu. (varies by license, area)	1 Oct - 31 Mar (Brunswick Co., Mar 15) (Mon-Sat)			
			Mech.	10 or 15 bu. (varies by area)	3rd Monday in Nov until closure by management trigger (M-F)			
SC	Rec.	State	Hand	2 bu., no more than 4 bu. per seven-day pd.	1 Oct - 27 May	None	No	Restoration and enhancement on public shellfish grounds.
	Com.	State	Hand, Mech.	None				
GA	Rec.	State	Hand	2 bu./person, 6 bu./vessel	1 Oct - 27 May	3"	No	Restoration and enhancement.
	Com.		Hand	None		2"		

State	Fishery	License Issued by	Gear	Daily Trip Limit	Season	Size Limit	Stock Assessment	Management
FL	Rec.	State	Hand	120 lbs per person/vessel	1 Sep - 31 May or 1 Oct - Jun 30, depending on County	3"	No	Restoration and enhancement.
	Com.		Hand Tong	1200 lbs per person/vessel				
AL	Rec.	None	Hand	100 oysters	1 Oct - 30 April (M-F until 2 pm)	3"	No	Reefs are assessed annually by divers to determine if management changes are needed. Enhancement program funded from sale of oyster tags.
	Com.	State	Hand, Mech.	6 sacks				
MS	Rec.	State	Hand	3 sacks per week	1 Oct - 31 Mar	3"	No	Restoration and enhancement.
	Com.	State	Hand, Mech.	15 sacks, quotas by area				
LA	Rec.	State	Hand	2 sacks	Wed after Labor Day to 30 Apr	3"	Yes	over 1,700 dredge samples and 1,000 diver quadrat samples used to inform fishery independent portion of stock assessment. 2,656 sq. miles of oyster ground. Shell Recycling and restoration and enhancement programs.
	Com.	State	Hand, Mech.	5 - 30 sacks per vessel (varies by region)				
TX	Rec.	State	Hand	220 lbs	1 Nov - 30 April	3"	No	Restoration and enhancement. Area and season closures determined by monitoring and a traffic light approach.
	Com.	State	Hand, Mech.	330 lbs	1 Nov - 30 April (M-F until 3:30 pm)			

Appendix 6: Eastern Oyster Fishery Management Plan Advisory Committee Workshop Summary

ISSUE
Summarize input received from stakeholders from the Oyster & Clam Fishery Management Plans Advisory Committee Workshop.

ORIGINATION
The North Carolina Division of Marine Fisheries (NCDMF).

BACKGROUND
The Oyster-Clam Fishery Management Plans (FMPs) Advisory Committee (AC) met for a three-day workshop July 15, 16, and 17 at Craven Community College in New Bern. As these two fisheries share considerable overlap in their ecology and management, the FMPs are being revised simultaneously though written separately. The purpose of the workshop was for the AC to assist DMF staff in evaluating management issues and options included in the draft documents of Amendment 5 to the Eastern Oyster FMP and Amendment 3 to the Hard Clam FMP. NCDMF sought to solicit feedback and input on the impacts of management options on the oyster and clam resources and user groups. It is important to note the aim of the AC workshop was to receive input from committee members based on their experiences, expertise, and sector relationships, not to build a consensus among AC members or to recommend specific management strategies.

For the Eastern Oyster FMP, NCDMF staff presented overviews of the base plan (life history, stock assessment, description of the fisheries, habitat impacts), Habitat and Enhancement information paper, intertidal hand harvest information paper, mechanical harvest issue paper, and the recreational shellfish harvest issue paper. Each presentation was followed by an opportunity for the AC to ask clarifying questions and discuss the content and management options included in each paper or section of the draft. Below is a summary of the input and subsequent discussions for each of the Amendment 5 information and issue papers. These ideas represent the management options the AC suggested the division explore. Division staff explored these options and incorporated many of them directly into the relevant information and issue papers.

DISCUSSION
Base Plan

AC members suggested adding more information to the stock assessment section within the base plan. Discussion revolved around comparing management of eastern oyster in other states along the Atlantic coast and Gulf of Mexico. At the time of the workshop, a table summarizing management strategies, gear, season length, limits, and stock assessment status of other states was available as an appendix. However, members of the AC expressed their interest in having a paragraph summary of information pertaining to the status of stock assessment completion in other states, including methodologies and findings.

In the description of the fishery, the AC brought up that on many trip tickets, oysters may be an opportunistically harvested species rather than the target fishers. To this point, the AC suggested including an economic analysis of the landings brought in by the top 30 participants compared to all other participants. The AC was curious about discerning where fishing effort of full-time oystermen is directed. Furthermore, the AC suggested an economic analysis of landings from specific areas would better contextualize the potential impact of large scale closures as suggested in the initial draft of the mechanical harvest issue paper.

An analysis of trip ticket data was added to the base plan illustrating relative landings contribution of the top 25% of participants in the oyster mechanical fishery. This data, along with the number of participants from 2010 to 2023, was added to the Mechanical Harvest section. Trip ticket data currently does not record specific water body locations, so a spatial analysis on fishing effort by top contributors could not be conducted.

The AC emphasized the importance of water quality and its importance to the oyster fishery. Since water quality issues are explored extensively in the Coastal Habitat Protection Plan and enforced by the Division of Water Resources, the AC suggested strengthening the tie to the CHPP in the base plan. The AC also brought up the difficulty of reporting shellfish die-offs. AC members from the commercial shellfish sector expressed interest in developing a mechanism for anonymous reporting of observed die-offs. Currently, there is a way to report fish kills, but no easy, online mechanism to report shellfish die-offs.

The AC suggested the table of fish species found on oyster reefs should include the current stock status of each species to further stress the indirect benefits of oyster reefs on other fisheries.

Throughout the workshop, the importance of geospatial data was highlighted. Members of the AC wished to see all available historical and modern mapping data of naturally occurring oyster reefs. When discussing the cost of resources needed to map Pamlico Sound, the AC recommended that exploring novel mapping methods should be added to the list of research needs.

Habitat and Enhancement Programs

The AC suggested including more information on the weighting and scaling of variables used in the Habitat Suitability Index model to clarify why certain areas scored higher when planning cultch and sanctuary sites. On this topic, the AC sought more detail on the Army Corps permit used for planning cultch planting as it constrains where material can be planted.

As it pertains to the cultch planting program, the AC suggested elaborating on the status of the state’s shell supply, including why the resource might be shipped to other states.

AC members highlighted that further detail on this topic would lay out the framework put in place by other states for keeping shell resources in-state.

The cultch planting program also conducts monitoring of oyster spat recruitment on newly constructed reefs. The AC emphasized the importance of this dataset and its potential contribution to a future stock assessment. The AC expressed interest in that dataset being analyzed and reported within the next FMP iteration.

Mechanical Oyster Harvest

For areas in Pamlico Sound that are subject to in-season management triggers, the AC felt strongly about including more information about current trigger sampling methods. The division plans to revamp trigger sampling methodology regardless of which management strategies are selected in Amendment 5. To this end, the AC supported revisiting the trigger sampling procedure, though they were made aware that this effort was not tied to adoption of Amendment 5.

As it pertains to the large-scale, rotational harvest site proposed in this issue paper, AC members were largely supportive of formalizing the cultch program as a management strategy and expressed the desire for increased planting efforts.

Additionally, during discussion of cultch sites, the AC pointed out there is currently no easy way to distinguish where oysters had been harvested in landings data. The AC expressed interest in assigning location codes to harvest areas and including a field for reporting if oysters were harvested at a cultch site or natural reef as part of data collection efforts.

Another approach outlined in this issue paper was to establish deep-water closure areas. AC members recognized the importance of vertical relief for the growth of oyster reefs, however there was no consensus for the recommended extent of these closure areas. While some believed these deep-water areas are still harvestable, albeit about once every eight years, others believed extensive closures are necessary to counter the impacts of mechanical gear on natural reefs.

Intertidal Oyster Harvest

No proposed management changes to the intertidal oyster hand harvest industry were brought to the AC workshop. Rather the draft of this information paper further highlighted the same data gaps described in other Amendment 5issue papers. Currently, there is no approved methodology for assessing important oyster metrics along intertidal habitats, which prevents completion of a stock assessment. Members of the AC recognized the importance of filling current data gaps related to North Carolina’s oyster resource. As fishery independent data is required for a stock assessment, the AC emphasized the importance of researching intertidal sentinel sites. Currently, NCDMF is working to establish and monitor sentinel sites to estimate oyster metrics in intertidal areas in the southern part of the state. Additionally, the AC suggested another research priority in southern cultch sites whereby alternative materials be tested for oyster recruitment as marl limestone has demonstrated limited recruitment for commercial oyster harvest. Due to limited shell availability, other materials besides marl should be considered for future cultch planting efforts.

Recreational Shellfish Harvest

AC members recognized the potential widespread impact of recreational shellfish collection, particularly with high tourism occurring along the coast and harvest efforts have mostly been undocumented. The AC workshop further highlighted the importance of understanding this impact as recreational harvest estimates would be necessary for completion of a stock assessment. AC members recognized the potential scale of recreational harvest and the importance of filling the data gap. As such, the AC voiced their support for taking steps to collect this data, either through a survey or temporary permit, until a recreational license could be put in place. Additionally, the AC identified having such a system in place would improve public education of safe harvest practices and reduce consumption during warm months. Listing public health as a concern furthered the discussion to the potential economic impact Vibrio cases might have on North Carolina's shellfish fisheries. Ultimately, the AC agreed a nominal permit would be a great step before a license to promote education and to collect recreational data.

DECISION DOCUMENT

Hard Clam Fishery Management Plan Amendment 3

This document was developed to help the MFC track previous activity and prepare for upcoming actions for Hard Clam FMP Amendment 3.

November 2024

Summary

At their November 2024 business meeting, the Marine Fisheries Commission will review and provide input on the draft of Amendment 3 to the Hard Clam Fishery Management Plan (FMP). They will then vote on sending draft Amendment 3 out for review by the Marine Fisheries Commission Advisory Committees and the public.

Background

The Hard Clam FMP is undergoing its five-year review. Since there is no stock assessment for status determination, the goal is to manage the resource to maintain the species population to provide long-term harvest and continue to offer protection and ecological benefits to North Carolina estuaries.

A joint issue that will also be addressed in Amendment 5 of the Eastern Oyster FMP is recreational shellfish harvest. Recreational shellfish harvest does not require a license in NC, resulting in the inability of the division to adequately collect recreational landings data. This data gap has been cited as a major need in all past FMPs and needs addressed to account for all removals from the populations. Additionally, shellfish harvest is subject to changing area closures due to human health and safety concerns. Without licensing or permitting requirements, the division is unable to ensure that every recreational harvester is informed of shellfish sanitation concerns. The FMP contains an issue paper outlining the broad need to capture recreational harvest sector information and have an effective means to provide health and safety information to all recreational shellfish harvesters.

The mechanical clam fishery is highly managed to very specific areas for operation during a season opening in early Dec. through March. Over time, some of the mechanical clam harvest areas have been encroached by SAV and oyster rocks. Since the last amendment in 2017, modifications to the mechanical clam harvest areas have occurred in Core Sound and North River, along with discontinued use in Bogue Sound. The use of mechanical gear to harvest clams had historically made up an important portion of total clam harvest but participation has declined rapidly in this fishery along with landings.

DMF has allowed harvesters access to clams before maintenance dredging and can continue to do so through Rule 15A NCAC 03K .0301 (b); and through communication with the USACE on their schedule to ensure timely notification of dredging activities. This activity has not occurred since 2007.

The mechanical clam harvest fishery from public bottoms has sharply declined since the 1990s, reaching historic lows in both participation and landings. Historically significant, this fishery has seen substantial reductions due to habitat impacts, pollution, market changes, and environmental events. With diminishing economic value, high management costs, and significant habitat concerns regarding SAV and oyster beds, this issue considers options for the fishery's future.

Amendment Timing

(gray indicates a step is complete)

You are here

September 2023	Division holds public scoping period
November 2023	MFC approves goal and objectives of FMP
December 2023 – June 2024	Division drafts FMP
July 2024	Division held workshop to review and further develop the draft FMP with the Oyster/Clam FMP Advisory Committee
August – November 2024	Division updates draft plan
November 2024	**MFC Reviews draft and votes on sending draft FMP for public and AC review**
January 2025	MFC Regional and Standing Advisory Committees meet to review draft FMP and receive public comment
February 2025	MFC selects preferred management options
March – April 2025	DEQ Secretary and Legislative review of draft FMP
May 2025	MFC votes on final adoption of FMP
TBD	DMF and MFC implement management strategies

Goal and Objectives

The goal of the N.C. Hard Clam FMP is to manage the hard clam resource to provide long-term harvest and continue to offer protection and ecological benefits to North Carolina's estuaries. To achieve this goal, it is recommended that the following objectives be met:

- Use the best available biological, environmental, habitat, fishery, social, and economic data to effectively monitor and manage the hard clam fishery and its environmental role.
- Manage hard clam harvesting gear use to minimize damage to the habitat.
- Coordinate with DEQ and stakeholders to implement actions that protect habitat and environmental quality consistent with the Coastal Habitat Protection Plan (CHPP) recommendations.
- Promote stewardship of the resource through public outreach to increase public awareness regarding the ecological value of hard clams and encourage stakeholder involvement in fishery management and habitat enhancement activities.

Summary of
Preliminary Management Recommendations

A summary of the DMF's preliminary recommendations can be found below. ***Please note: these are the Division's initial recommendations and are subject to change.***

Recreational Harvest
Support the NCDMF to further explore potential options and develop a solution to quantify recreational shellfish participation and landings, and to establish a mechanism to provide all recreational shellfish harvesters with Shellfish Sanitation and Recreational Water Quality health and safety information outside of the FMP process.

Mechanical Clam Harvest
The Division recommends a phase out to be completed three years from the adoption of this plan unless fishery participation increases to 10 participants and landings increase to 1 million clams in any year prior to 2027. If these increases are met, the issue would be reconsidered by the MFC at their May 2027 business meeting, or the next meeting that participation and harvest estimates are available from 2026. The PDT also recommends the immediate end to the allowance for mechanical clam harvest in conjunction with maintenance dredging.

Management Options

Recreational Harvest
Implementing a licensing or permitting requirement for recreational shellfish harvesters would give the Division the opportunity to inform participants of where to find information on harvest closure boundaries, where to sign up to receive polluted area proclamations or to access temporary closure maps, and where to find information on safe handling practices, particularly as it relates to Vibrio bacteria.

To pursue any of these solutions, significant time and effort will be needed to assess internal program and resource capabilities and limitations. Any legislative changes require a specific process and are ultimately out of NCDMF or MFC control. Given these constraints, NCDMF recommends exploring potential options and solutions outside of the FMP process.

Mechanical Clam Harvest
Due to the requirements of G.S. 113-221 (d), the division does not think the mechanical clam harvest fishery can be ended abruptly upon adoption of this amendment. An immediate closure of this fishery could "result in severe curtailment of the usefulness or value of equipment in which fishermen have any substantial investment" as outlined in statute. This would require "a future effective date so as to minimize undue potential economic loss to fishermen". Possible management options include, but are not limited to; status quo, ending the allowance for mechanical clam harvest in conjunction with maintenance

dredging activities, further limiting mechanical clam harvest areas, and phasing out the fishery. These management options would only affect mechanical clam harvest from public bottom and would not affect their use on private bottom.

Status quo would allow the fishery to continue to operate as it currently does. The fishermen currently operating in the fishery could continue, and new harvesters could join. The cost to the state for demarcation and enforcement would remain the same, making up a significant cost compared to the total value of the fishery. Concerns about effects of bottom disturbing gears on structured habitats would not be addressed.

Discontinuing the allowance for mechanical clam harvest in conjunction with maintenance dredging could also be considered. This would end a program that has not been utilized since 2007. This option could be pursued on its own, or in conjunction with a closure or phase out of the whole fishery. This would require a change to rule 15A NCAC 03K .0301 (b).

Mechanical clam harvest areas could be further limited to create boundaries that are more easily enforceable that also create buffers around critical habitat to protect them from sedimentation associated with bottom disturbing gears, as was done in the North River (Figure 4). To improve enforceability the boundaries would be based on permanent structures or known geographic features, be rectangular or rhomboid in shape without zig-zagging lines and have complete line of sight visibility. As with status quo, The fishermen currently operating in the fishery could continue, and new harvesters could join. The cost to the state for demarcation would be reduced, but the resources required for enforcement would likely remain the same, making up a significant cost compared to the total value of the fishery. This would help address habitat concerns, but sedimentation would still occur from mechanical harvesting operations.

The mechanical clam harvest fishery could be phased out over a set timeframe, as was done with the shellfish relay program. This option would allow fishermen currently operating in the fishery to continue during the phase out period but would discourage new participants. The phase out period would allow current mechanical harvesters time to get rid of gear and transition to other clam harvesting methods or fisheries. This option would address the division's cost concerns with demarcation and enforcement, as well as the habitat concerns. This option is consistent with G.S. 113-221 (d), as it gives "a future effective date so as to minimize undue potential economic loss to fishermen".

After hearing concerns from the FMP Advisory Committee about participants wanting the ability to re-enter the fishery, the division recommends a phase out timeframe of three years from adoption of this amendment unless minimum landings and participation increases occur in the fishery in any year prior to 2027. This increase in landings and participation would show the fishery is no longer diminishing and is valuable enough to maintain. The division recommends the threshold for participants in the mechanical clam harvest fishery on public bottom be set at 10. Ten participants have not been active in a single year in the fishery since 2017 and is over three times the number of active participants in 2022 (three participants), but still less than a tenth of the peak participation in 1996 (132 participants).

The division recommends the threshold for landings in the mechanical clam harvest fishery on public bottom be set to one-million clams. The fishery last landed over one million clams in 2014 (1.5 million clams) and is over six times the number caught in 2022 (less than 200,000 clams), but still less than an eighth of the peak landings in 1995 (8.2 million clams). If both thresholds are met in any single year prior to 2027, the issue would be brought back to the MFC for consideration at their May 2027 business meeting, or the next meeting that participation and harvest estimates are available from 2026, where they would decide whether to move forward with phase out of the fishery. This timing ensures that if the phase out continues as planned, fishermen would still have three years to sell their gear and exit the fishery before the phase out is complete and the fishery closes in 2028, which would be consistent with G.S. 113-221 (d) (Figure 1).

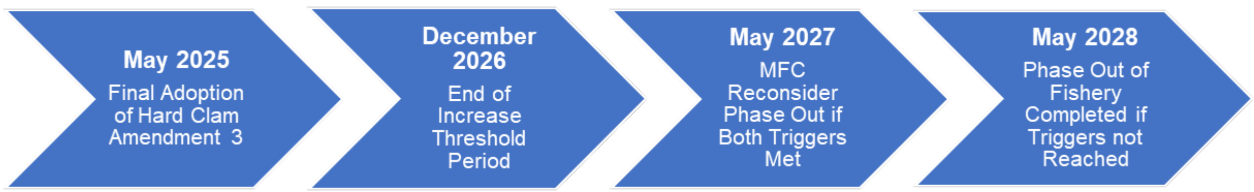

Figure1. Proposed timeline for the phase out of the Mechanical Clam Harvest Fishery on public bottom.

Next Steps

At their November business meeting the Marine Fisheries Commission will review draft Amendment 3 to the Hard Clam FMP, including the full list of management options. This is an opportunity for the Commission to provide input on the management strategies and options that are included in the draft FMP for public and MFC Advisory Committee review.

Following their review and input, the Commission will vote to send draft Amendment 3 out for public and MFC Advisory Committee review. If approved, the draft is expected to go out to the appropriate MFC Advisory Committees in January 2025 with a public comment period held around that same time. The outcome of that comment period and MFC AC review would then be presented to the Commission during their February business meeting.

DRAFT SUBJECT TO CHANGE 2024

HARD CLAM FISHERY MANAGEMENT PLAN AMENDMENT 3

NC Division of Marine fisheries
3441 Arendell St. P.O. Box 769
Morehead City, NC 28557

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The following Division staff were also invaluable in assisting with the development of this document: Kathy Rawls, Mike Loeffler, Catherine Blum, and the many reviewers of the multiple drafts of this plan. Also grateful for the administrative support from Deborah Manley, Michelle Brodeur, and Patricia Smith.

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EXECUTIVE SUMMARY

*** added before secretarial review***

INTRODUCTION

This is Amendment 3 to the Hard Clam 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 2) was approved by the N.C. Marine Fisheries Commission (NCMFC) in 2017. FMPs are the product that ultimately 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 hard clam fishery is vested in the State of North Carolina. The NCMFC adopts rules and policies and implements management measures for the hard clam fishery in Coastal and Joint Fishing Waters in accordance with 113-182.1. Until Amendment 3 is approved for management, hard clams are currently managed under Amendment 2 (NCDMF 2017).

The status of the hard clam stock in North Carolina is unknown due to data limitations preventing the NCDMF from conducting a hard clam stock assessment and calculating sustainable harvest metrics. Data available for the stock are commercial landings, data collected from fish houses, and an annual recreational survey. Data is obtained from the North Carolina Trip Ticket Program, where catch rates are estimated for both hand and mechanical harvest. Landing trends will reflect population abundance to an extent, but other factors like market demand, regulations, changes in effort and gear technology also affect trends (NCDMF 2017).

For more information about previous and current management, see the original Hard Clam FMP (NCDMF 2001) and the previous amendments, all of which are available on the North Carolina Division of Marine Fisheries Fishery Management website.

Fishery Management Plan History

Original FMP Adoption:	2001
Amendments:	Amendment 1 (2008)
	Amendment 2 (2017)
Revisions:	None
Supplements:	None
Information Updates:	None
Schedule Changes:	None
Next Comprehensive Review:	Five years after adoption of Amendment 3

Past versions or revisions of the Hard Clam FMP (NCDMF 2001, 2008, 2017) are available on the NCDMF website: Fishery Management Plans | NC DEQ

Management Unit
Includes the hard clam, *Mercenaria mercenaria*, and its fisheries in all Coastal and Joint Fishing Waters of coastal North Carolina.

Goal and Objectives
The goal of the N.C. Hard Clam FMP is to manage the hard clam resource to provide long-term harvest and continue to offer protection and ecological benefits to North Carolina's estuaries. To achieve this goal, it is recommended that the following objectives be met:

- Use the best available biological, environmental, habitat, fishery, social, and economic data to effectively monitor and manage the hard clam fishery and its environmental role.
- Manage hard clam harvesting gear use to minimize damage to the habitat.
- Coordinate with DEQ and stakeholders to implement actions that protect habitat and environmental quality consistent with the Coastal Habitat Protection Plan (CHPP) recommendations.
- Promote stewardship of the resource through public outreach to increase public awareness regarding the ecological value of hard clams and encourage stakeholder involvement in fishery management and habitat enhancement activities.

DESCRIPTION OF THE STOCK

Biological profile

General life history
DISTRIBUTION

The hard clam, *Mercenaria mercenaria*, is a large bivalve distributed along the east coast of North America from the Gulf of St. Lawrence, Canada to the central coast of eastern Florida (Harte 2001, Abbott 1986, Mackenzie et al. 2002). This species has been transplanted in the northwest Pacific (Crane et al. 1975, Carlton 1992, Chew 2001), Puerto Rico, Europe (Heppell 1961, Chew 2001), China (Chavanich et al. 2010), and Japan (Hiwatari et al. 2006). Another species, *M. campechiensis*, also known as the southern quahog, inhabits ocean waters off North Carolina and occurs mainly from North Carolina to Florida (Hadley and Coen 2006). The hard clam is not native to the Gulf of Mexico (Abbott 1986); however, a subspecies, *M. mercenaria texana*, and *M. campechiensis* inhabit the Gulf Coast and have been mistaken for *M. mercenaria* (Dillon and Manzi 1989a,b).

Common names for *M. mercenaria* include hard clam, quahog, quahaug, northern quahog, littleneck clam, and cherrystone clam. Hard clams occur throughout the south Atlantic region in estuaries from the intertidal zone to depths exceeding 18 m (Abbott 1974; Eversole et al. 1987). In North Carolina, hard clams are most abundant in higher salinity waters inside the barrier islands from Ocracoke southward to the South Carolina border (NCDMF shellfish bottom mapping data, unpublished). Hard clams are found near Oregon and Hatteras inlets and the western side of Pamlico Sound, but are much less abundant compared to those that inhabit waters inside and south of Ocracoke Island.

HABITAT PREFERENCES AND TOLERANCES

Hard clams occupy mostly shallow, estuarine environments and can inhabit a variety of sediment types, including sand or muddy sediments, bare, course substrates, as well as seagrass and near oyster beds (Wells 1957, Roegner and Mann 1991, Harte 2001). Localized adult population densities can vary considerably, ranging from small patches to extensive beds, and density is dependent on many environmental factors, including organic content and composition of sediment and localized flow (Fegley 2001). Experimental and field studies have shown that areas with heterogeneous substrate mixtures of sand or mud with shell or gravel often support more clams than homogeneous substrates as the larger substrate can act as a spatial predator refuge (Anderson et al. 1978, Arnold et al. 1984). Increased densities and survivorship have also been observed for hard clams that inhabit seagrass beds (Peterson et al. 1984; Peterson 1986b).

Hard clams have a wide temperature and salinity tolerance which likely contributes to their extensive species range and successful transplantations worldwide. Adult hard clams can tolerate temperatures between -6 and 35°C (21.2 and 95°F; Stanley and Dewitt 1983); below freezing temperatures, subtidal clams have a higher survival rate than those exposed in the intertidal areas (Eversole et al. 1987). Growth rates of hard clams are most favorable at water temperatures around 20°C (68°F) and growth ceases at 9°C (48.2°F) and 31°C (87.8°F; Ansell 1968; Eversole et al. 1986). Hard clams have been found in waters with salinity ranging from 4 to over 35 parts per thousand (ppt) but cannot survive extended periods in salinities less than about 12 ppt. Growth is optimal at salinities from 24 to 28 ppt for adults (Chestnut 1951a) and 26 to 27 ppt for larval growth and survival to settlement (Davis 1958, Davis and Calabrese 1964). Hard clams cease siphoning water below 15 and above 40 ppt (Hamwi 1968), or below about 4°C (39.2°F; Loosanoff 1937) and above 34°C (93.2°F; Roegner and Mann 1991), and will close their valves tightly during periods of stress and respire anaerobically to reduce mortality (Eversole et al. 1987).

Adequate water circulation is essential for successful growth and recruitment of hard clams. Water currents move food, maintain water quality, remove waste, and transport eggs and larvae in the water column (Eversole et al. 1986). Hard clams obtain food by filtering suspended particulate matter and absorbing dissolved organics directly from the water. Larvae and adult hard clams can select their food and regulate the quality and quantity of food they consume. Hard clams adapt well to a changing food supply, but are sensitive to the presence or absence of particular algal species that can affect growth (Eversole et al. 1986; Eversole et al. 1987). More detailed habitat and water quality information is available in the Environmental Factors section.

REPRODUCTIVE BIOLOGY

The gametogenic and spawning cycle of the hard clam varies with latitude (Eversole et al. 1984; Eversole et al. 1987). Spawning occurs in North Carolina from spring through fall, when water temperatures reach 20°C (68°F; Loosanoff and Davis 1950; Porter 1964). Spawning clams release eggs and sperm through the exhalent siphon into the water where fertilization occurs and rapid development begins. The first larval stage is the trochophore stage that lasts about a day, followed by several veliger/pediveliger stages that last approximately 20 days. Juvenile clams (spat) settle along edges of sandbars and channels where varying water currents occur (Carriker 1959). Hard clams will also settle in substrates with shell and subtidal vegetation. These substrates appear to have better conditions for spat survival than unstructured substrates because they offer protection from predators (Kerswill 1941; Wells 1957; MacKenzie 1977; Peterson 1982).

Precursors to both male and female sex cells are found in the gonads of juveniles (Eversole 2001). During the juvenile stage, gonadal cells differentiate and clams develop predominately as males. As adults, many clams transform into females. The sex ratio of adult clams is approximately 1:1 across its geographical range (Eversole 2001).

Sexual maturity in hard clams tends to be a function of size not age, therefore maturity is dependent on growth. Sexual maturity is usually reached during the second to third year at a shell length of 1.3 inches (33 mm), but faster growing clams may mature at an earlier age (Eversole et al. 1987). The legally harvestable size of one-inch thick (25.4 mm) is typically reached by age two to five with three as a reasonable average expectation in North Carolina (C. Peterson, UNC Institute of Marine Science, personal communication).

Although estimates vary, fecundity depends on size and condition (Ansell and Loosmore 1963). Several studies have found that fecundity increased with shell length (Bricelj and Malouf 1980; Peterson 1983; Eversole et al. 1984; Peterson 1986a). Reproductive senescence is often common in long-lived species but there is no evidence that reproductive production declines with age in hard clams (Peterson 1983; Peterson 1986a). Hard clams occur in aggregations over a wide area, and close proximity of adults is important for successful reproduction to occur in organisms that spawn in the water column (Peterson 2002). Because hard clams have limited mobility, spawning efficiency could be reduced in areas where harvest has caused a significant decrease in number and size of hard clams within these aggregations. Reduced spawning efficiency could affect future recruitment in hard clam populations (Fegley 2001; Peterson 2002).

SIZE STRUCTURE, AGE, AND GROWTH

Hard clam populations exhibit a wide size range of individuals (Fegley 2001). Growth rates of hard clams are highly variable and depend on water temperature, habitat, food availability, and genetics (Ansell 1968; Pratt and Campbell 1956; Chanley 1958; Peterson et al. 1983; Peterson et al. 1985; Arnold et al. 1991). Shell growth is greatest during the first year after which growth decreases as age increases (Eversole et al. 1986; Eversole et al. 1987).

Age can be determined by direct examination of annual growth lines within the shell. Age frequency distributions differ widely among sites within and between regions (Fegley 2001). There is also variation in the age of similar-sized clams even within the same habitat (Peterson et al. 1984; Rice et al. 1989; Fegley 2001). The maximum age seen in

North Carolina is 46 years old (Peterson 1986a); however, the maximum life span of this species can exceed 100 years (Ridgway et al. 2011).

Shell growth patterns vary by latitude. North Carolina shell growth follows a southern growth pattern where light bands form during the winter months when animals are growing the fastest and dark band form during the late summer to fall months when growth is slowest, resulting in annual banding patterns (Peterson et al. 1983; Jones et al. 1990; Arnold et al. 1991, Goodwin et al. 2021). The opposite shell pattern growth is observed in northern latitudes (i.e., Connecticut to Massachusetts and England) where a dark band forms during the colder winter months, and a light band forms during the warmer months. At the middle part of the geographical range (i.e., New Jersey) shell pattern banding follows the “northern” banding pattern during the first several years of growth and then takes on a more “southern” banding pattern as they age (Fritz 2001). Unlike in other areas of their geographic range where growth ceases during certain times of the year, mature hard clams in North Carolina are capable of depositing shell material throughout the entire year, suggesting the species may serve as an important sclerochronological archive, documenting some of the most complete records of intra-annual environment conditions in their shells (Goodwin et al. 2021).

BIOLOGICAL STRESSORS

Little data is available on direct predation rates on larval hard clams (Kraeuter 2001), but high natural mortality in the larval stages suggest predation is probably high during this life stage. Newly set or juvenile hard clams (<1 mm shell length) are vulnerable to many predators. Primary predators of juvenile hard clams include snapping shrimp (*Alpheus heterochaelis*), mud crab (*Dyspanopeus sayi*), and blue crab (*Callinectes sapidus*; Beal 1983; Kraeuter 2001). Stone crabs (*Menippe mercenaria*) are effective predators of both juvenile and adult hard clams, capable of opening large hard clams (30-60 mm shell length) that typically cannot be preyed on by blue crabs, and the abundance of stone crabs in North Carolina has been increasing since the year 2000 (Wong et al. 2010). Several types of snails (*Urosalpinx* sp., *Polinices* sp.), whelks (*Busycon* sp.), cownose rays (*Rhinoptera bonasus*), and various birds feed on adult hard clams (Kraeuter and Castagna 1980; Kraeuter 2001). As hard clams grow the number of potential predators is reduced (Kraeuter 2001). Hard clam survival from predation is affected by sediment characteristics such as presence of shell fragments and seagrasses, and presence of other prey species (Peterson 1982; Peterson 1986b; Kraeuter 2001).

Infectious diseases can result in devastating losses of wild populations of some mollusks but hard clams appear to be relatively disease free and studies of captive populations show that non-predation losses are typically only 5% to 10% per year (Eldridge and Eversole 1982; Eversole et al. 1987; Bower et al. 1994). QPX (Quahog Parasite X = Unknown) is a parasite found in hard clams along the eastern coast of North American from Atlantic Canada to Virginia (Smolowitz et al. 1998; Dahl et al. 2011). QPX disease has not been identified in hard clams south of Virginia (Dahl et al. 2011) and a 2011 study confirmed QPX disease is a cold-water infection and not likely to occur in North Carolina because of warmer waters which impedes development of this disease in hard clams (Dahl et al. 2011).

Many large-scale hard clam mortalities along the northeastern United States and Canada are related to air exposure during extreme cold events and negative impacts from stress associated with parasites (Smolowitz et al. 1998). Diseases in larval and juvenile hard clams held in culture conditions are often caused by bacteria, fungi, and viruses that are common in the cultured bivalves and are associated with opportunistic invaders of animals under stress in high-density culture situations (Ford 2001).

Anthropogenic activities can also affect hard clam populations. Physical disturbances including bulkhead and dock construction, boat scarring, and dredging, can disrupt the sediment and increase turbidity (Bricelj et al. 2017) which can negatively impact hard clam feeding and growth. Additionally, extensive dredging can change bottom topography and flow patterns (Bricelj et al. 2017) which can alter food availability and larval distribution. Propeller wash from boat traffic may also displace sediment which can expose clams and increase their vulnerability to predators, and clam larvae that go through the propeller and engine cooling system are at risk of damage. Furthermore, toxic compounds from pressure-treated wood used to construct new docks, piers, and bulkheads leach into the water and accumulate in the sediment (Weis and Weis 1996). New construction often occurs in the spring, coinciding with hard clam spawning which can expose hard clam larvae to toxic leachates (Bricelj et al. 2017).

Stock Unit
The unit stock is considered all hard clams occurring within North Carolina coastal waters.

Assessment Methodology
Data are not available to perform a traditional assessment, so it was not possible to estimate population size or fishing mortality rates.

Stock Status
Data limitations prevent the NCDMF from conducting a hard clam stock assessment and calculating sustainable harvest metrics. Currently, the only data available for the stock in most areas are commercial landings, fishery dependent data, and the annual recreational harvest survey. Amendment 2 of the FMP recommends the status continue to be defined as unknown due to the continued lack of data needed to conduct a reliable assessment of the stock. The statutory obligation to manage hard clams according to sustainable harvest cannot be met until the appropriate data are collected.

DESCRIPTION OF THE FISHERY

Additional analyses and discussion of North Carolina’s commercial and recreational hard clam fisheries can be found in earlier versions of the Hard Clam FMP (NCDMF 2001, 2008, and 2017); all FMP documents are available on the NCDMF Fishery Management Plans website. Commercial and recreational landings can be found in the License and Statistics Annual Report (NCDMF 2022) on the NCDMF Fisheries Statistics website.

Discussion of socio-economic information (NCDMF 2022) describes the fishery as of 2021 and is not intended to be used to predict potential impacts from management changes. This and other information pertaining to the FMPs are included to help inform decision-making regarding the long-term viability of the state's commercially and recreationally significant species and fisheries. For a detailed explanation of the methodology used to estimate economic impacts, please refer to the NCDMF License and Statistics Section Annual Report (NCDMF 2022).

STATUS OF THE FISHERIES

Commercial Fishery

Since the inception of the Trip Ticket Program (TTP) in 1994, hard clam data collection has continuously improved. Hard clam landings come from both public harvest and private production, which are managed under different regulations, therefore trip numbers, landings, and effort cannot be compared between public harvest and private production. Since 2003, approximately 1% of the annual landings cannot be identified as either public harvest or private production. Much of the improvement has been from better recording and editing requirements, and from the new licensing system. In the following sections the different gear types in the fishery are separated into either public harvest or private production. Since there are some trips that could not be differentiated in the database, they were excluded from analyses.

The hard clam industry has provided a way to make a living and food for coastal communities along the entire Atlantic East Coast from the Canadian maritime region to Florida. Fluctuations in commercial landings are common along the Atlantic East Coast with a general trend of decline through time (Figure 1). A large part of the decline in Atlantic Coast landings occurred in the 1970's as a result of overfishing in New York and closure of shellfish beds due to bacterial pollution (MacKenzie et al. 2002). For more information on environmental pathogens, see Environmental Factors, Threats, and Alterations section.

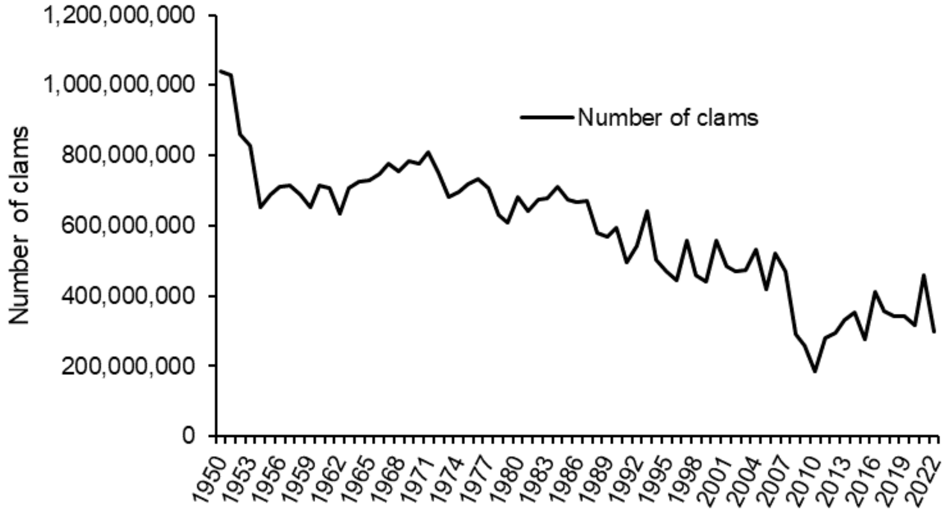


Figure 1. Commercial hard clam landings (number of clams, using a conversion factor of 0.32 oz per individual; ASFMC 1992) along the Atlantic East Coast (Maine south to Florida east coast), 1950-2022. Source: NMFS commercial fisheries landings database, except for NC landings from 1994 to 2022 using TTP.

Gear Types

HAND HARVEST

The hand harvest fishery for hard clams is year-round in North Carolina. Hand harvesting methods include signing (spotting siphon holes), treading, hand raking, hand tonging, and bull raking. Clams are taken by hand and rake in shallow water, up to 4 feet deep ($\leq$1.2 meters) while hand tongs and bull rakes are used in deeper water up to 20 feet deep (1.2 to 12.2 meters; Cunningham et al. 1992). Bull rakes have been used to exploit clam populations in New River, White Oak River, Bogue Sound, Newport River, North River, and the Intracoastal Waterway channel of Brunswick, New Hanover, Pender, and Onslow counties. Many subsistence fishermen use bull rakes in the southern area of the state.

MECHANICAL HARVEST

The two types of mechanical harvest gear currently used in North Carolina are the hydraulic escalator dredge and the clam trawl or “clam kicking” vessel. The hydraulic escalator dredge has an escalator or conveyor located on the side of the vessel. A sled is connected to the front end of the escalator. When the front end of the escalator is lowered to the bottom, the sled glides over the bottom. A blade on the sled penetrates the bottom to a depth of about four inches (10 cm) and collects the clams as they are forced from the bottom by water pressure (Cunningham et al. 1992). In clam trawling or “kicking”, clams are dislodged from the bottom with propeller backwash and a heavily chained trawl with a cage attached at the cod end towed behind the boat gathers the clams. Kick boats are generally 20 to 30 ft long and can operate in depths from 3 to 10 feet (1.0 m to 3.05 m). The propeller is usually positioned 12 to 15 inches above the bottom and extra weight can be added to the stern to improve the angle and height above the bottom. For better efficiency in varying water depths, boats include a winged rudder, which has two iron plates welded on either side of the rudder to deflect water downward (Cunningham et al. 1992). One person operates smaller kick boats, while larger boats may have a crew of two or three (Guthrie and Lewis 1982).

Historical Public Harvest Fishery
North Carolina hard clam harvest has fluctuated historically, often in response to changes in demand, improved harvesting techniques, and increases in polluted shellfish area closures. Hand harvest accounted for all recorded landings prior to the mid-1940s, when early forms of mechanical harvest were developed. Hand harvest is currently allowed year-round with daily harvest limits. A daily harvest limit of 6,250 clams per fishing operation from public waters was established in 1986 by proclamation and has remained in effect since (NCMFC Rule 15A NCAC 03K .0301 (a)).

The first mechanical method for harvesting hard clams was known as dredging. This gear allowed fishermen to remain on board and enabled them to work in poor weather (Guthrie and Lewis 1982). Trawls were first used to harvest clams in 1968 and remain in use today in a technique known as “kicking” (Guthrie and Lewis 1982). Increased market demand and more efficient gear soon led to increased landings around the 1970s (Figure 2). Another major development in the fishery occurred in 1968 with the advent of hydraulic dredges. This gear used jets of water from a high-pressure pump to displace bottom sediments covering the clams and a conveyor carried the catch up to the vessel. Hard clam landings remained stable through the 1960s and 1970s. Since the late 1980s, hard clam landings have declined. This decline may be the result of decreased abundance, increasing closures of shellfish waters from pollution, changing market demand, and storm events.

Allocation conflicts did not occur in the hard clam fishery until the late 1980’s as more management measures were put in place to reduce impacts to habitat causing harvesters to compete more for the limited resource. Mechanical harvest methods can negatively impact submerged aquatic vegetation (SAV) and oyster rocks (Peterson et al. 1987). Regulations to protect habitats from mechanical harvest methods have been in place since 1977 and mechanical harvest has largely been confined to deeper waters of the sounds and rivers. A rotation scheme for White Oak River and New River, including a portion of the Intracoastal Waterway (IWW) has been implemented annually by proclamation since the early 1980s. The intent was to prevent overharvesting of the clam stocks, discourage violations by mechanical harvesters who cross the lines in search of more lucrative clam quantities, and prevent the taking of undersized clams, or “buttons”. The NCDMF also allows harvest of clams by mechanical means in some navigational channels before maintenance dredging activities performed by the U.S. Army Corps of Engineers (USACE). For a thorough history of the hard clam fishery including overall history, historic landings and trends, management changes for mechanical commercial gear, length of seasons, and openings and closures of bays, please refer to Amendment 2 of the Clam FMP.

Present Public Harvest Fisheries

The current minimum size limit for clams is 1-inch thickness (width). The current daily hand harvest limit is 6,250 clams and the fishery is open year-round. Current public mechanical harvest limits vary by waterbody. In some instances, mechanical harvest areas are rotated (alternately open and closed) with other areas (Table 1). Since 2008, upon adoption of Amendment 2 to the Hard Clam FMP, Core Sound has been divided into two areas and the northern area is open every other year while the southern area is opened annually. In 2017 there were modifications to the areas in Core Sound and North River, and use of mechanical methods was prohibited in Bogue Sound due to SAV encroachment.

Table 1. Current daily mechanical hard clam harvest limits by waterbody.

Waterbody	Daily harvest limit (Number of clams)	Additional information
Northern Core Sound	5,000	Rotates one year open and one year closed opposite the open/close rotation of the New River
Southern Core Sound	5,000	Open annually
North River	3,750	Open annually
Newport River	3,750	Open annually
White Oak River	6,250	Rotates one year open and one year closed opposite the open/close rotation of the New River
New River	6,250	Rotates one year open and one year closed opposite the open/close rotation of Northern Core Sound, the White Oak River, and the IWW in the Onslow/Pender counties area
New River Inlet	6,250	Open annually from Marker 72A to the New River Inlet
IWW Onslow/Pender counties area	6,250	Intracoastal Waterway (maintained marked channel only) from Marker #65, south of Sallier's Bay, to Marker #49 at Morris Landing. All public bottoms within and 100 feet on either side of the Intracoastal Waterway from Marker #49 at Morris Landing to the "BC" Marker at Banks Channel. Open every other year when the New River is closed.

Annual Landings, Trips, Participation, And Market Grades

Separating hard clam landings data into public harvest and private production is inexact prior to 1994 because landings information was collected on a voluntary basis. Since 1994, about 88% (1994-2013 combined estimates) of the total commercial hard clam harvest came from public harvest areas in North Carolina. The annual number of hard clams from public bottom averaged 19.6 million from 1994 to 2022, but landings have steadily declined through time. Annual landings averaged 11.7 million from 2012-2022 (Figure 2).

There are year-to-year fluctuations in the number of trips harvesting hard clams. The annual number of trips has declined during the time series (1994-2022), with the highest number of trips in 1994 (Figure 3). Adverse weather conditions (e.g., hurricanes, and heavy rain events) can impact the annual landings. Freshwater runoff after storm events often causes shellfish harvest area closures and therefore reduces hard clam harvest effort for short time periods.

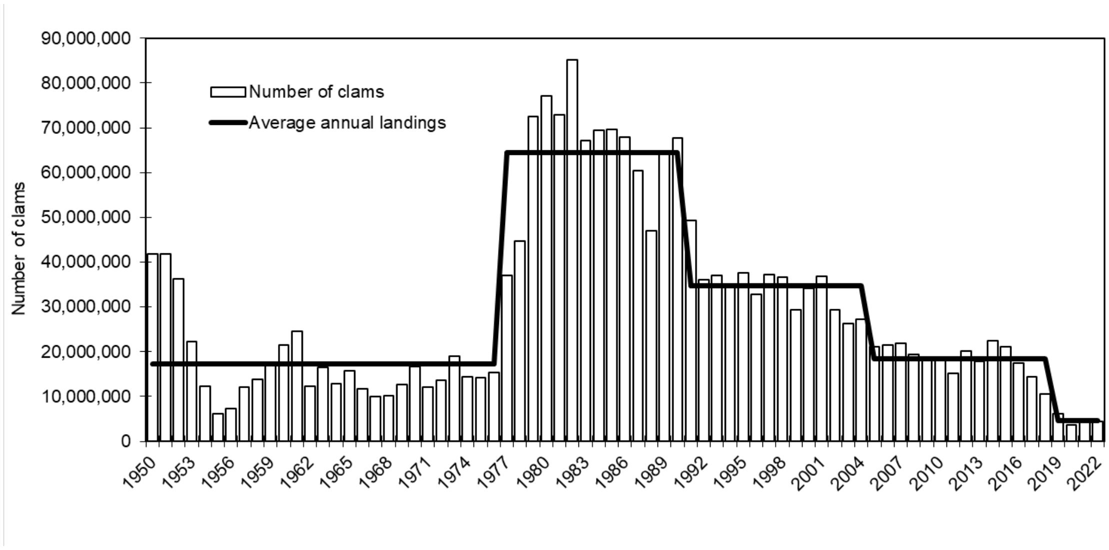


Figure 2. Hard clam landings (number of clams) from public harvest and private production showing the average annual landing trends (solid line) for specific time periods,1950-1976, 1977-1990, 1991-2004, 2005-2018, 2019-2022. TTP.

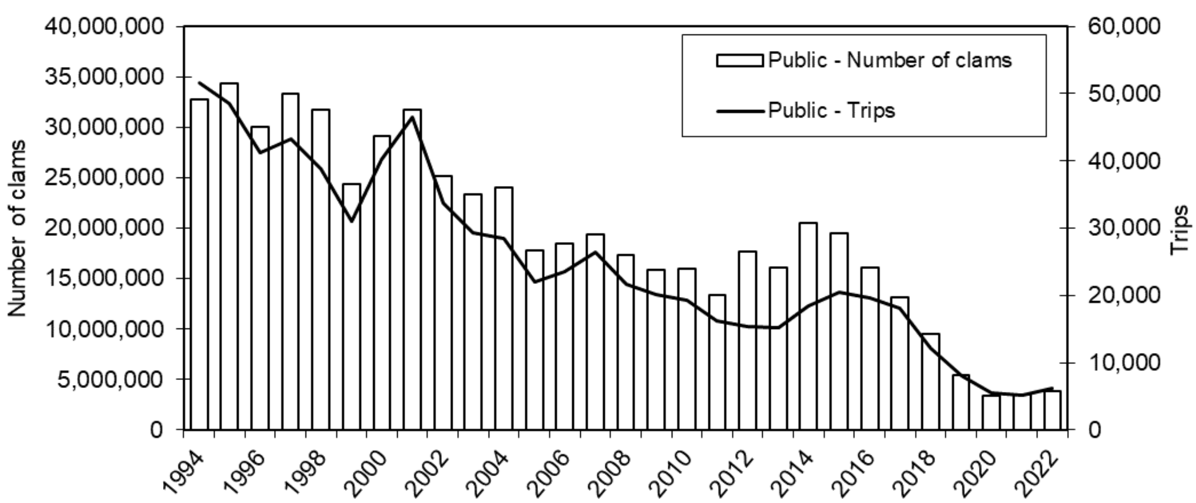


Figure 3. North Carolina annual commercial hard clam landings (number of clams) and trips from public harvest, 1994-2022. TTP.

New River and Core Sound are the top two waterbodies where hard clams are harvested from public harvest areas accounting for 50% of the landings from 1994 to 2022 (Figure 4). Landings in the southern part of the state, including the areas of Stump Sound, Lockwood Folly, Topsail Sound, Masonboro Sound, Cape Fear River, Shallotte River and the Inland Waterway accounted for an additional 25% of the public hard clam landings from 1994 to 2022.

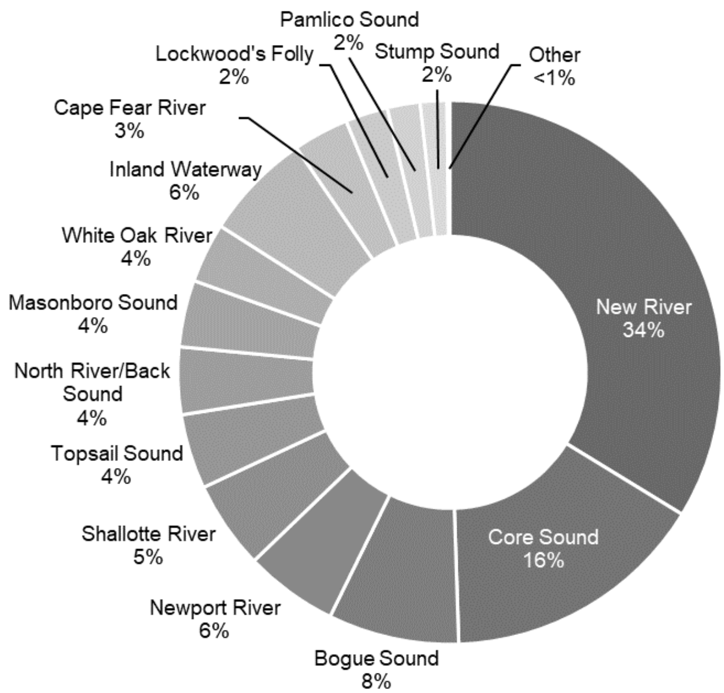


Figure 4. Commercial hard clam landings (percent of total landings) by waterbody from public harvest 1994 to 2022 combined. TTP.

Clam fishery participation has declined by about 82% over the last twenty years (Figure 5). There was an increase in participation in the hand harvest fishery from 2013-2015, then a decline from over 600 participants in 2015 to less than 280 participants in 2022 (Figure 5). Hand gears have had an order of magnitude of more participants across the entire time series (Figure 5).

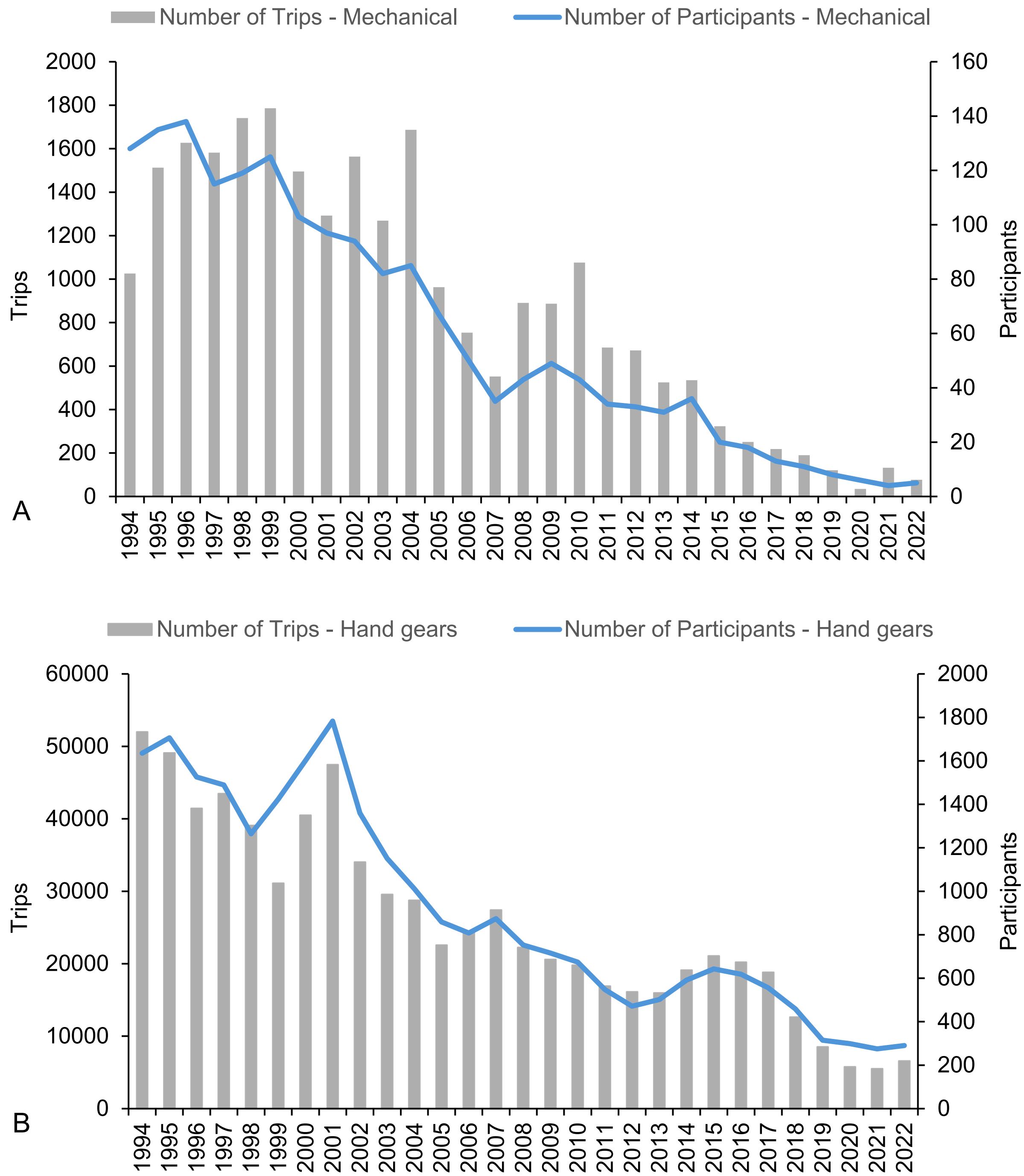
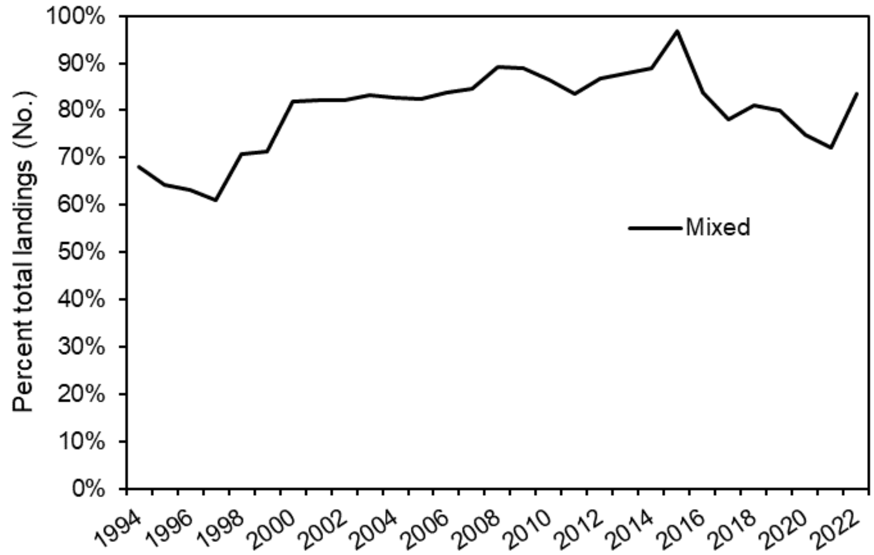


Figure 5. Participant and trip count by gear category for hard clam harvest, 1994-2022. (A) mechanical gear and (B) hand gears. Data provided by the NCDMF Trip Ticket Program.

Hard clam harvest is sorted by thickness (shell width) into various market grades when purchased by the seafood dealer. A mixed or unclassified market grade is the most common hard clam size category from public harvest and comprised 79% of the total landings from 1994 to 2022 (Figure 6a). Little neck, which consists of the smallest clams typically measuring between 1-inch (25 mm) to 1 ¼-inch (32 mm) in thickness, is the second most dominant market category of hard clam from public harvest (Figure 6b). Top neck is the next largest market category in size with individuals ranging from 1 ¼-inch (32 mm) to 1 ⅝-inch in thickness (41 mm). The proportion of hard clams graded as top necks from public harvest has remained about the same throughout the time series (6% on average; Figure 6b). Hard clams in the cherry and top cherry market grades have a shell thickness that ranges between 1 ⅝-inch (41 mm) to 2 ¼-inches (57 mm). These two market categories have not shown much change in proportion to the total hard clam public harvest from 1994 to 2022, although the cherry market grade began to see a slight increase in 2017 (Figure 6b). Chowder hard clams are the largest market category by size and are any hard clams greater than 2 ¼-inch shell thickness (Figure 6b).



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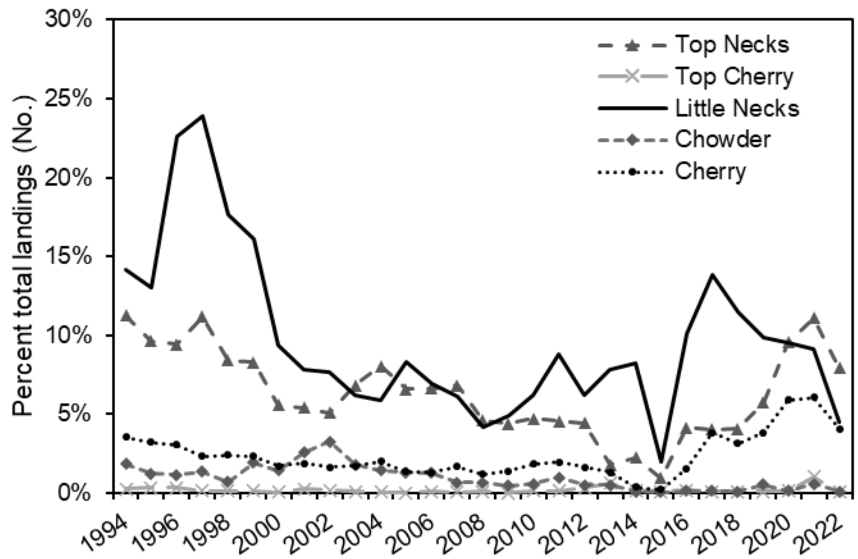

B.

Figure 6. Annual landings (percent of total annual landings) from public harvest by market grade, 1994-2022 combined. A. Mixed grade only; B. All other market grades. TTP.

HAND HARVEST

Hand harvest from public areas is a year-round fishery and has average landings of 16,274,336 clams per year (1994-2022). Most hand harvest occurs in the spring and summer when warm water is conducive to wading (Figure 7). Annual public harvest and the number of hand harvest trips per year for hard clams has declined overall from 1994 to 2022, except for a moderate increase from 2012 to 2014 (Figure 8). The annual catch per unit effort (CPUE; number of clams per trip) from public area hand harvest also reflects this increase from 2012 to 2014 but has subsequently dropped back down to around 600 clams per trip (Figure 9).

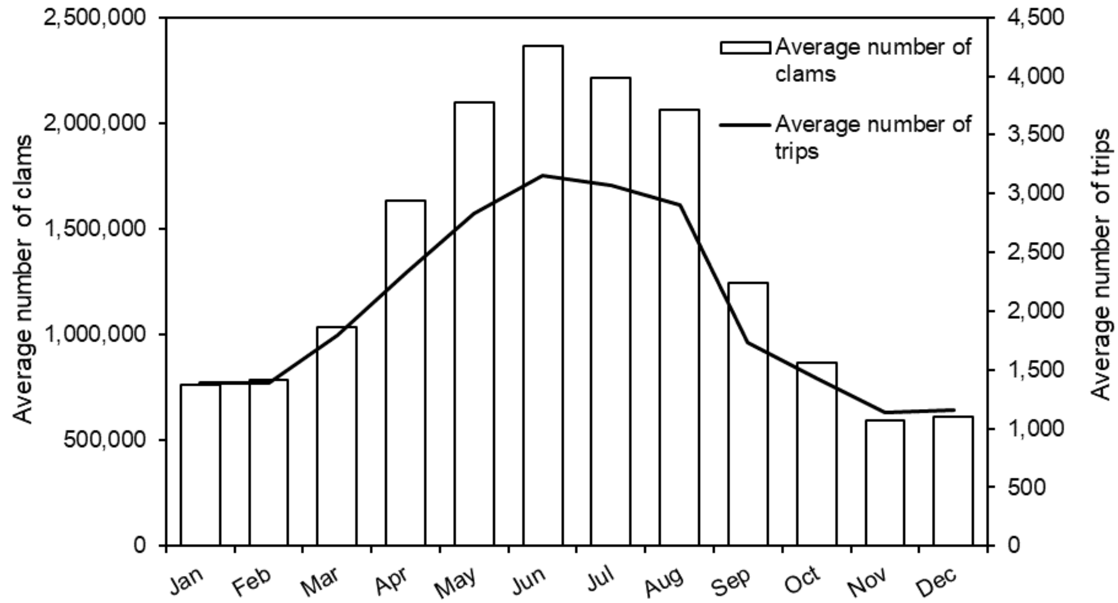

Figure 7. Average hard clam landings (number of clams) and average number of trips by month from public harvest using hand gears, 1994-2022. TTP.

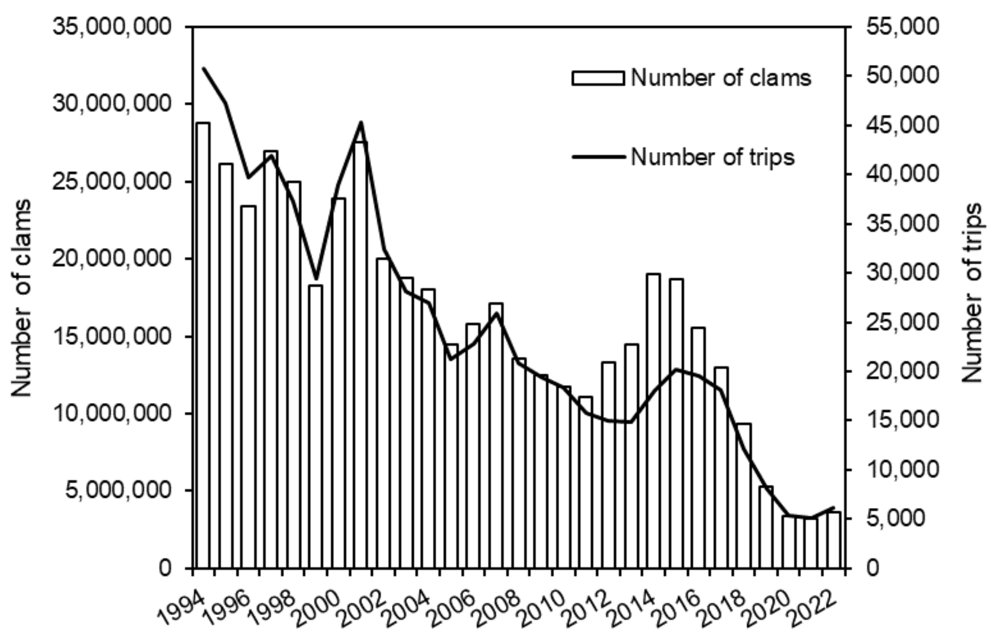

Figure 8. Annual hard clam landings (number of clams) and trips from public harvest using hand gears, 1994-2022. TTP.

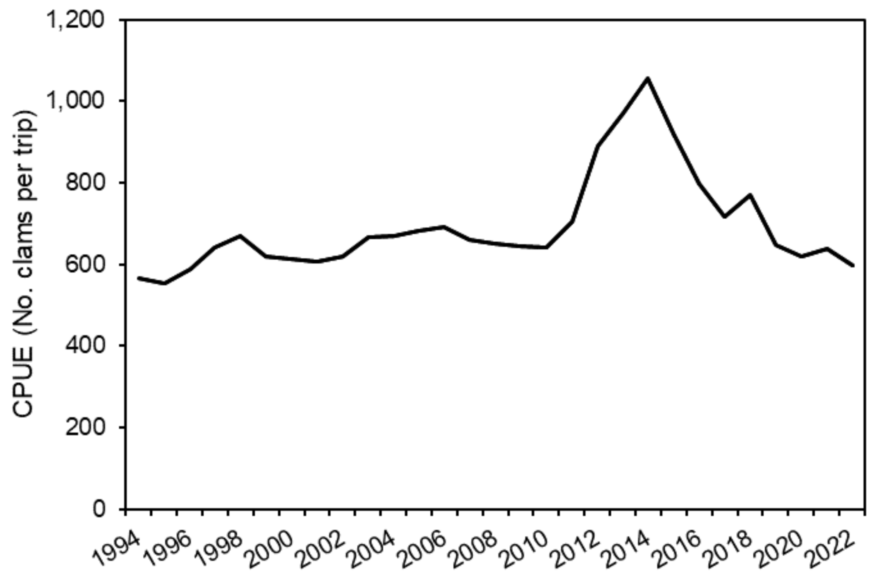

Figure 9. Annual catch per unit effort (CPUE; number of clams per trip) of hand harvest from public areas, 1994-2022. TTP.

MECHANICAL HARVEST

Mechanical harvest season usually begins the second Monday in December and extends through the week of March 31st. Harvest is allowed only from 7:30 a.m. to 4:00 p.m. on Monday through Friday until before the Christmas holiday and then Monday through Wednesday after December 25th for the remainder of the open harvest season.

Hard clam landings from public harvest, using mechanical methods, has average landings of 3,319,605 clams each fishing year (1994/95 to 2021/2022). The mechanical clam harvest season usually has the highest landings at the beginning of the fishing season in December and declines as the season progresses (Figure 10). Landings outside of the usual mechanical clam harvest season are from temporary openings for the maintenance of channels and temporary openings in Core Creek when bacteriological levels are at acceptable levels to harvest clams. Hard clam landings and trips fluctuate from fishing year to fishing year and appear to be greatly influenced by harvest from the New River mechanical harvest area (Figure 11). Mechanical clam landings have remained below 1,000,000 clams per season since 2016/2017.

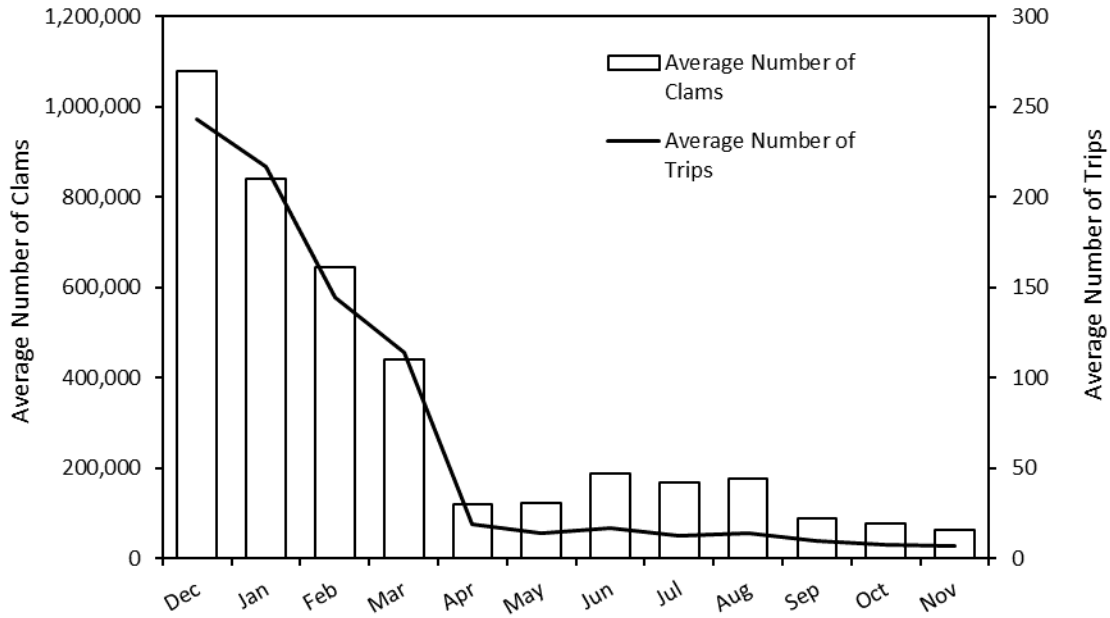

Figure 10. Average hard clam landings (number of clams) and average number of trips by month from public harvest using mechanical gears, 1994/95-2022/March 2023. TTP.

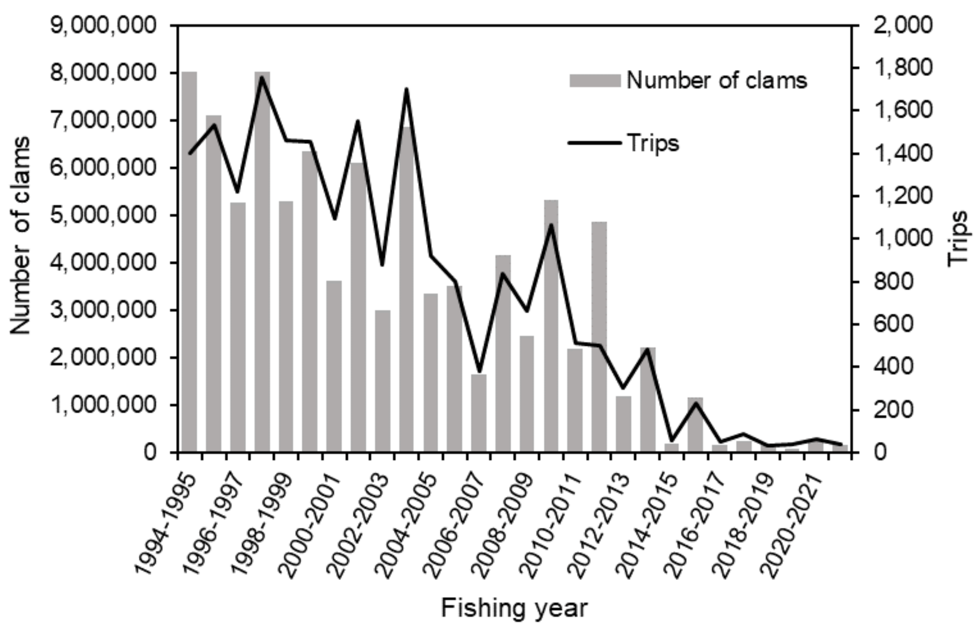

Figure 11. Hard clam landings (number of clams) and trips from public harvest using mechanical gears by fishing year (Dec-Nov), 1994/95-2021/2022. TTP.

Private Shellfish Culture: Shellfish Leases And Franchises

This plan does not focus on management of private shellfish culture through shellfish leases and franchises; however, detailed information on the history and management of private shellfish culture can be found in Amendment 2 of the Hard Clam FMP. It should also be noted that there is only one seed distributer in the state of North Carolina, which hinders the growth of private shellfish culture for clams in the state.

Recreational Fishery

Hard Clams are commonly harvested recreationally year-round in North Carolina by hand and rakes. The recreational bag limit is currently 100 clams per person per day with no more than 200 clams per vessel at a minimum size of 1-inch thick.

Recreational fishing data are collected by the Marine Recreational Information Program (MRIP), but the survey excludes recreational shellfish data. In addition, because any North Carolina resident can purchase a low cost commercial shellfish license to take shellfish in commercial quantities for recreational purposes, harvest from a commercial shellfish license used for recreational purposes does not get recorded because it is not sold to a seafood dealer.

NCDMF is required by the FRA to prepare an FMP for all commercially and recreationally significant species. Given North Carolina's shellfish fisheries are exclusively under state jurisdiction, a lack of recreational shellfish harvest data makes it difficult to address potential management issues such as harvest limits, size limits, and gear restrictions for this fishery.

The recreational harvest of hard clams in North Carolina does not require a fishing license, and due to this the total amount of recreational landings cannot be estimated and remains unknown. However, a mail survey has been used since 2010 to estimate harvest from Coastal Recreational Fishing License (CRFL) holders. This population of recreational harvesters makes up an unknown proportion of total recreational harvest, but still provides insight into catch rates, harvest trends, and scale of harvest by CRFL holders. In 2010, surveys were only mailed out in November and December, so harvest and effort estimates are very low (Table 2). Harvest and catch rate have been declining since 2013 (Figure 12). In 2022, recreational harvest was roughly one half of that in 2020 and only 30% of the time series average.

Recreational effort for clam harvest was reported from 60 waterbodies throughout coastal North Carolina. Overall survey results demonstrate a distinct seasonality for the recreational harvest of clams, with peak activity observed during the summer months. This, coupled with the highest concentrations of clamming activity being observed within Pamlico, Bogue, and Masonboro Sounds and during the summer months, suggests coastal tourism may significantly impact recreational clam harvest. More background and history on recreational shellfish harvest can be found in the Recreational Harvest Issue Paper.

Table 2. Estimated number of trips, number of clams harvested, and catch rate (clams per trip) per year of Coastal Recreational Fishing License holders, 2010–2022.

Year	Number Trips	Clam Harvest	Catch Rate
2010*	528	8,731	18.4
2011	6,350	127,597	22.9
2012	6,726	146,151	27.3
2013	8,644	191,842	26.2
2014	6,325	162,656	28.8
2015	7,637	166,419	27.4
2016	8,456	84,199	12.3
2017	3,435	75,171	21.8
2018	2,362	26,769	11.3
2019	5,088	114,042	22.4
2020	6,557	62,164	9.5
2021	1,765	15,471	8.8
2022	6,628	28,241	4.3

*Partial year of sampling

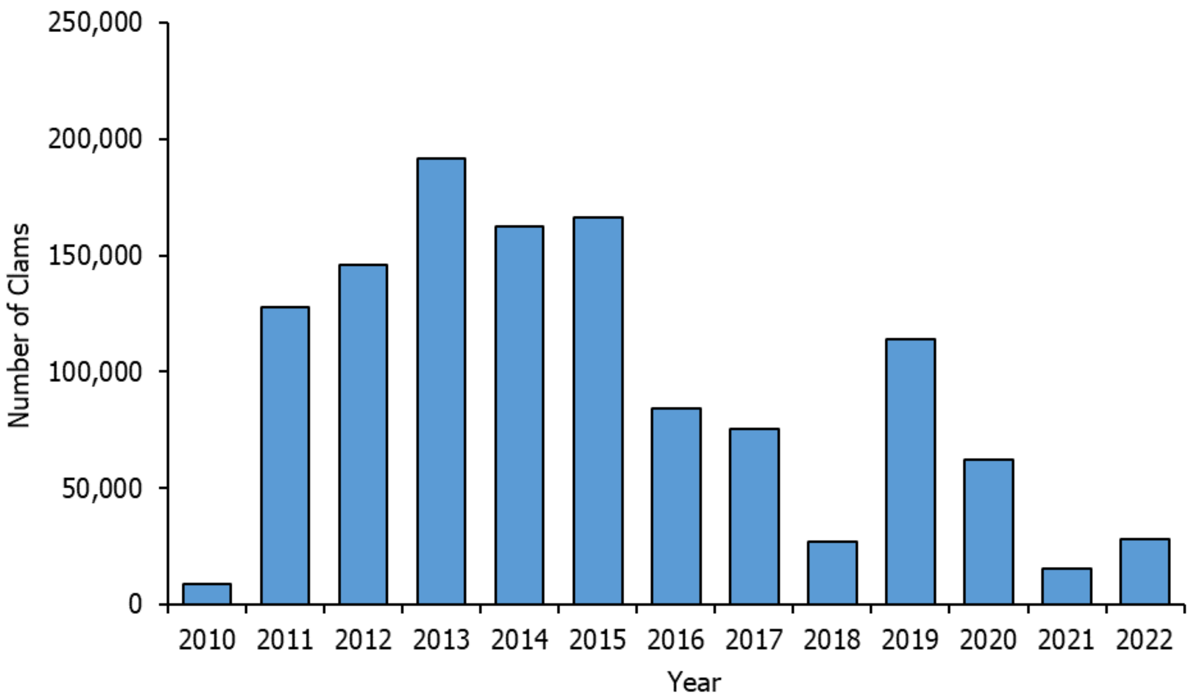

Figure 12. Annual recreational hard clam landings (number of clams) in North Carolina, 2010-2022. Data from 2010 represent a partial year of sampling.

SUMMARY OF ECONOMIC IMPACT

Economic Aspects Of The Fishery

EX-VESSEL VALUE AND PRICE

The value of hard clams to the North Carolina seafood industry has fluctuated over time. Before the mid-1970s, their economic contribution was relatively small, representing no more than 1-2% of the total value of landed seafood in the state. In 2013, clams were the sixth most economically important commercial seafood species in North Carolina. Landings of clams accounted for 4.7% of the total value of commercial non-finfish landings and 2.9% of the total value of all commercial seafood landings in the state.

The real value (the value that is adjusted for inflation) of North Carolina hard clam landings on public bottom has generally declined over the last twenty years peaking at just under $9 million in 1995 and declining until 2011 where ex-vessel value increased yearly until it peaked in 2015 at about $6 million before declining again in the last 7 years. When adjusted for the effects of inflation, 2021 saw the lowest landings value in the time series since 1994, then landings started increasing in 2014 and 2015, which then continued declining year over year to 2022 (Figure 13). The decline in total value is largely driven by a decrease in catch described in the previous section (Figure 11).

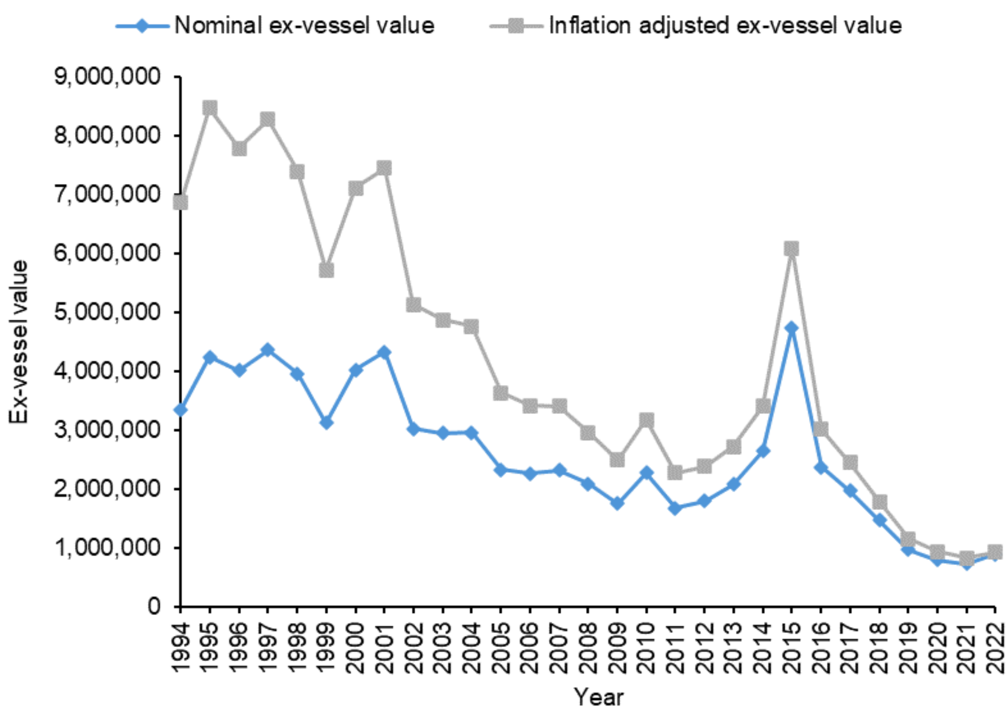

Figure 13. Annual ex-vessel value of clams in North Carolina, 1994-2022. Inflation adjusted values are in 2022 dollars. NCDMF Trip Ticket Program.

The average price per clam stayed constant from 1994-2014 before increasing dramatically in 2015, followed by a drop in 2016, and then a consistent increase from 2017-2022 (Figure 14). When adjusted for 2022 dollars, the average price per clam from 1994 to 2022 peaked in 2015 at $0.31 and had the lowest average value in 2012 at $0.14 In the last five years clam values have increased from $0.19 in 2018 to $0.21 in 2021 and $0.27 in 2022.

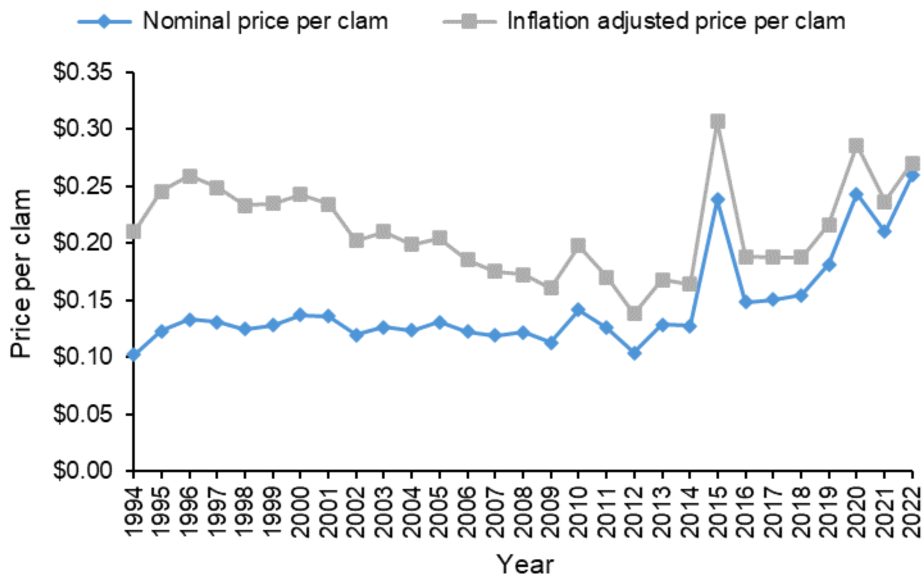

Figure 14. Annual average nominal and inflation adjusted price per clam harvested on public bottom in North Carolina 1994-2022. Data provided by the NCDMF Trip Ticket Program.

From 2004 to 2019 the value of all clam grades was stable and did not have much variation across grades. In 2020, there was a large spike in little neck prices and then a sharp decrease in 2021 before coming back up to $0.52 in 2022. This market volatility could have been influenced by outside market drivers such as the COVID-19 pandemic.

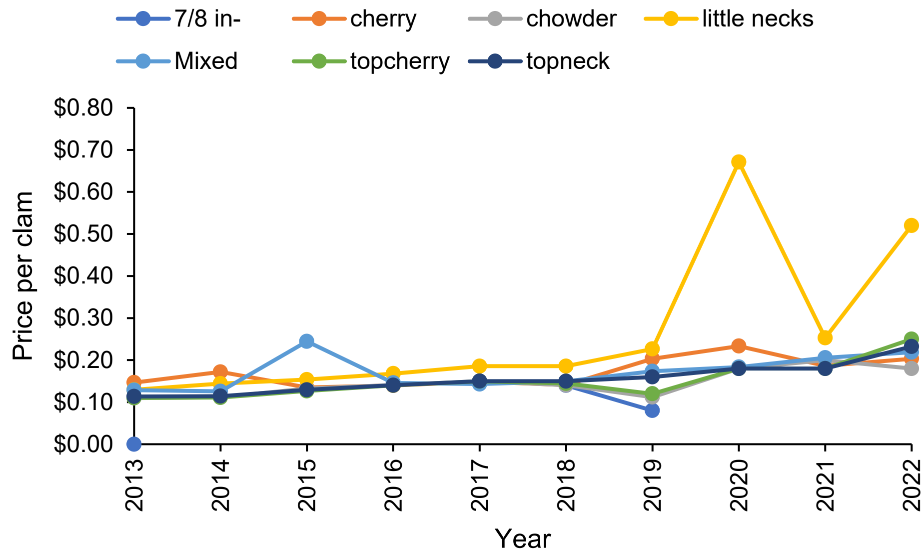

Figure 15. Annual average ex-vessel grade prices in North Carolina, 2013-2022. Data provided by the NCDMF Trip Ticket Program.

Most water bodies account for a constant amount of the clam harvest value over time (Figure 16). Notably, the New River has seen a decrease in the market share of landed clams in the last two years. Clam landings from public bottom in New River fell from 65% of the market share in 2014 to 9% in 2022. Core Sound and Bogue Sound have made up more of the landed clams in the last 5 years making up a combined 43% of clams landed from public bottom in 2022.

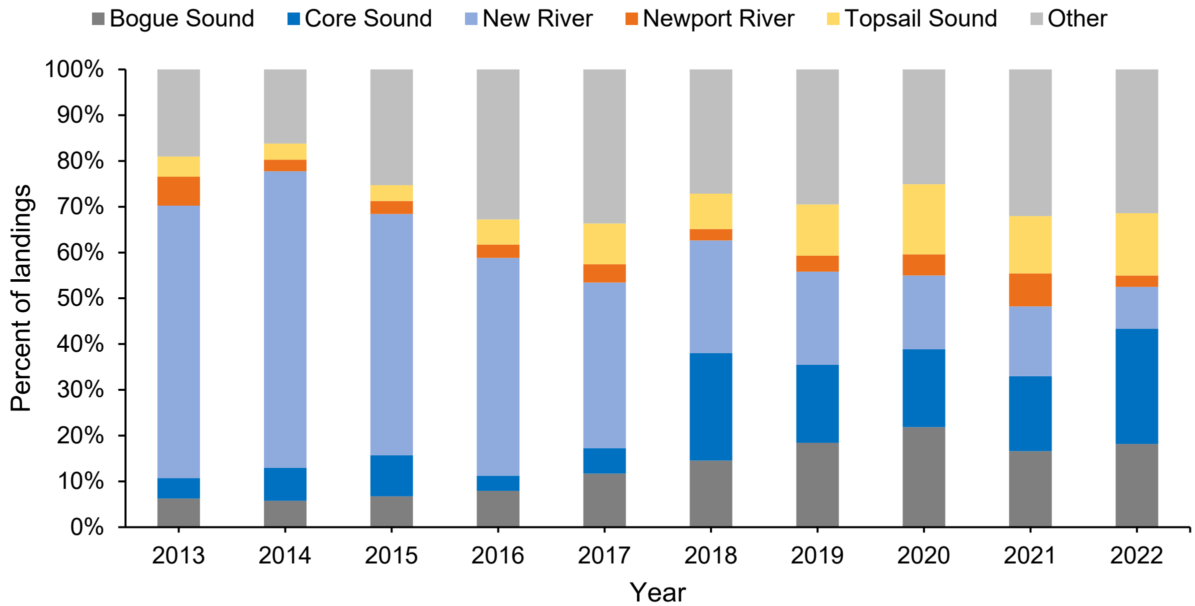

Figure 16. Percent of total annual commercial clam harvest value by waterbody, 2013-2022. Data provided by the NCDMF Trip Ticket Program

GEAR

From 2004 to 2022 hand harvest has dominated the percent of total ex-vessel value of clam landings. The percentage of mechanical harvest value saw a decrease over that period from a peak of 24% in 2003 to a low of 13% in 2015. As a proportion of clam harvest on public bottom, mechanical harvest has oscillated around 20% of market share for most of the time series with high yearly fluctuations from 2011-2016. From 2018 to 2022 hand harvest made up at least 86% of the harvest (Figure 17). Since 2016 mechanical harvest has accounted for between 20% and 24% of landings (Figure 17).

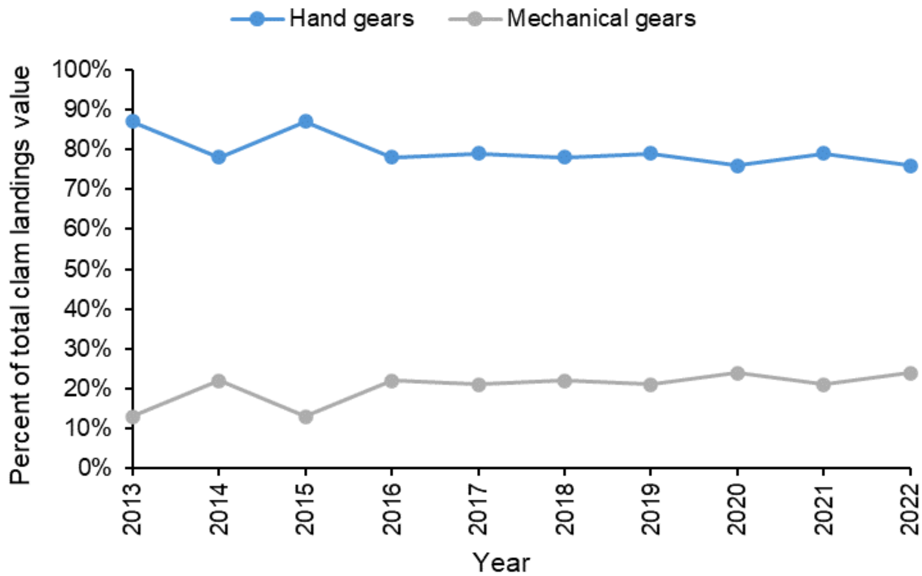

Figure 17. Annual percent of total landings value by gear type used to harvest hard clams. 2013-2022. Data provided by the NCDMF Trip Ticket Program.

PARTICIPATION AND TRIPS

The NCDMF tracks commercial landings of shellfish in the state through the Trip Ticket Program. Among the variables collected, number of participants, number of trips, gear types, location of landings and harvest, and number of dealers are categorized and summarized in this section.

In the last 20 years, 97% of clammers have recorded landings worth under $25,000 with 43% of clammers landing clams worth $500 or less a year. This indicates most participants use clamming as a supplement to their income.

Those participating in hand harvest were primarily in the 50-59 year old age group, with participation of individuals < 49 declining over time (Figure 18).

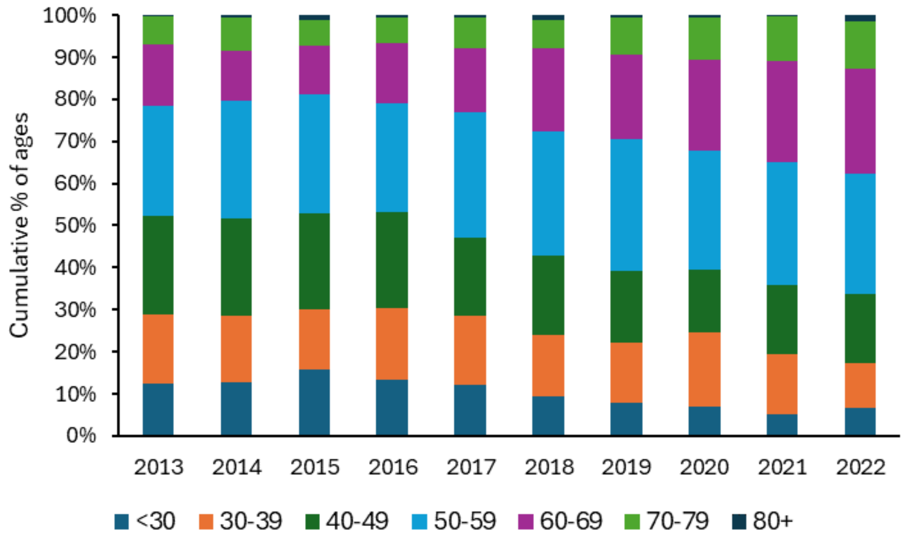

Figure 18. Age group demographics for hard calm hand harvest, 2013 – 2022 Data provided by the NCDMF Trip Ticket Program.

As is the case in all commercial fisheries in North Carolina, clam fishers may only sell their catch to licensed seafood dealers. The number of dealers reporting landings of clams has declined since a high of 94 in 2013. The number of dealers purchasing clams fell to 47 in 2019. Since 2019 the annual number of dealers participating in the purchase of clams and has been stable with 26 in 2022.

Economic Impact of The Commercial Fishery

The expenditures and income within the commercial fishing industry, as well as those by consumers of seafood produce ripple effects as the money is spent and re-spent in the state economy. Each dollar earned and spent generates additional economic impacts by stimulating further activity in other industries which fosters jobs, income, and business sales. These impacts are estimated using the NCDMF commercial fishing economic impact model which utilizes information from socioeconomic surveys of commercial fishermen and seafood dealers in North Carolina, economic multipliers found in *Fisheries Economics of the United States, 2020,* and IMPLAN economic impact modeling software. In 2022, the commercial clam fishery in North Carolina supported an estimated 326 full-time and part-time jobs, approximately $1.37 million in income, and approximately $3 million in sales impacts. In the last ten years the industry has contracted in landings, participants, and economic impacts.

Table 3. Economic impact of the commercial clam fishery in North Carolina, 2013-2022 reported in 2022 dollars. NCDMF Fisheries Economics Program.

				Estimated Economic Impacts			
Year	Participants[1]	Trips[1]	Clams landed (in thousands)[1]	Ex-vessel value (in thousands)[1]	Jobs[2,3]	Income impacts (in thousands)[3]	Sales impacts (in thousands)[3]
2022	276	6,194	3,828	$890	326	$1,370	$2,988
2021	268	5,140	3,557	$789	313	$1,399	$2,996
2020	292	5,438	3,430	$903	338	$1,389	$2,997
2019	311	8,151	5,428	$1,110	365	$1,793	$4,119
2018	452	12,211	9,492	$1,710	537	$2,667	$5,843
2017	544	18,189	13,156	$2,349	647	$3,490	$7,920
2016	599	19,612	16,047	$2,891	722	$4,247	$9,252
2015	627	20,413	19,529	$5,850	885	$8,400	$18,830
2014	581	18,372	20,538	$3,267	728	$4,883	$11,222
2013	491	15,241	16,061	$2,611	606	$4,124	$8,767

[1]As reported by the NCDMF trip ticket program.

[2]Represents both full-time and part-time jobs.

[3]Economic impacts calculated using the NCDMF commercial fishing economic impact model and reported in 2022 dollars.

Recreational Fishery Economics

The NCDMF has limited data on recreational clamming, including the number of participants and the effect of their effort on the economy. For more information on the Recreational Fishery, see the Recreational Harvest Issue Paper.

Social Importance of The Fishery

COMMERCIAL FISHERMEN

The NCDMF Fisheries Economics Program has been conducting a series of in-depth interview-style surveys with commercial fishermen along the coast since 1999. Data from these interviews are added to a growing database and used for fishery management plans, among other uses. The description of the clam fishery from these surveys can be found in Amendment 2.

ECOSYSTEM PROTECTION AND IMPACT

Coastal Habitat Protection Plan

In the 1990s, addressing habitat and water quality degradation was recognized by resource managers, fishermen, the public, and the legislature as a critical component for improving and sustaining fish stocks, as well as the coastal ecosystem. When the Fisheries Reform Act of 1997 (FRA; G.S. 143B-279.8) was passed, it required developing Coastal Habitat Protection Plans (CHPPs). The legislative goal of the CHPP is "…the long-term enhancement of coastal fisheries associated with coastal habitats." The FRA specifies that the CHPP will identify threats and recommend management actions to protect and restore coastal habitats critical to NC's coastal fishery resources. The plans are updated every five years and must be adopted by the NC Coastal Resources Commission (CRC), the NC Environmental Management Commission (EMC), and the NC Marine Fisheries Commission (MFC) to ensure consistency among commissions as well as their supporting NC Department of Environmental Quality (DEQ) agencies. The 2021 CHPP Amendment is the most recent update to the CHPP, building upon the 2016 CHPP source document.

The North Carolina Department of Environmental Quality's CHPP includes four overarching goals for the protection of coastal habitat: 1) improve effectiveness of existing rules and programs protecting coastal fish habitats; 2) identify and delineate strategic coastal habitats; 3) enhance habitat and protect it from physical impacts; and 4) enhance and protect water quality. The CHPP is an interagency plan with its goals and actions carried out by several state agencies. For instance, while NCDMF has the capacity to recommend management decisions towards meeting the goals described above pertaining to coastal habitat, the Division of Water Resources has the ability to enforce policies concerning water quality issues described in the CHPP. Overall, achieving the goals set by the CHPP to protect North Carolina's coastal resources involves managers and policy makers from several state agencies to make recommendations and ultimately enforce them as regulations.

Hard clams occur extensively in estuarine systems. Habitats for juvenile and adult hard clams include both intertidal and subtidal soft bottom (defined by Street et al. (2005) as "unconsolidated, unvegetated sediment that occurs in freshwater, estuarine, and marine systems" to include both deeper subtidal bottom and shallow intertidal flats), shell bottom (which can be commonly referred to as oyster beds, rocks, reefs, bars, and shell hash), and SAV. NCDMF's Estuarine Bottom Habitat Mapping (EBHM) Program mapped North Carolina's shellfish-growing bottom habitats between 1990 and 2021 and identified the top clam-producing bottom types across the state, as listed in Table 4.

Table 4. Average clam densities for the top five clam-producing bottom types as identified by the EBHM program.

EBHM bottom habitat category	Avg. clams per square meter	Habitat description
Intertidal Firm Non-vegetated Shell	2.03±0.03	Intertidal oyster reef/reef fringe on sandy or muddy sand bottom
Intertidal Hard Non-vegetated Shell	1.50±0.04	Intertidal oyster reef/reef fringe on sandy or shelly bottom
Subtidal Firm Non-vegetated Shell	0.86±0.03	Subtidal oyster reef/reef fringe on sandy or muddy sand bottom
Subtidal Hard Non-vegetated Shell	0.87±0.04	Subtidal oyster reef/reef fringe on sandy or shelly bottom
Subtidal Hard Vegetated w/o Shell	0.71±0.01	SAV beds on sandy bottom

By region, *Subtidal Hard Vegetated without Shell* (SAV on sandy bottom) was the most productive clam habitat in the Pamlico Sound region, but in regions south of Pamlico Sound, unvegetated intertidal and subtidal shelly bottom types both produced more clams than vegetated bottom (Table 4). Other unvegetated, non-shelly bottom types (identified in the CHPP as “soft bottom habitat”) also provide habitat for clams, but the EBHM program generally found clams at lower densities in those habitats than in shell bottom and SAV habitat. The EBHM program data support findings in the scientific literature that SAV (Peterson et al. 1984; Irlandi 1994; Carroll et al. 2008) and shell bottom (Peterson et al. 1995) provide superior habitat to unstructured soft bottom habitat. In addition to hosting lower densities of clams, soft bottom habitat is by far the most extensive estuarine habitat in North Carolina, and faces fewer threats than structured habitats. Therefore, the protection of SAV and shell bottom habitats from both physical impacts and water quality degradation are important when considering protecting clam habitats.

ENVIRONMENTAL FACTORS, THREATS, AND ALTERATIONS

Physical Threats

MOBILE BOTTOM DISTURBING FISHING GEAR

Goal 3 of the 2016 CHPP is to “enhance and protect habitats from adverse physical impacts,” which includes reducing the impacts of mobile bottom disturbing fishing gear, the negative effects of which are described in detail in Section 8.1.1 of the 2016 CHPP. Soft bottom habitat, because of its low structure and dynamic nature, has historically been considered the most appropriate location to use bottom disturbing gear. NCMFC rules restrict bottom disturbing gears in designated soft bottom habitat. Fishing gears with the greatest potential to damage soft bottom include dredges and trawls. Of the threats to structured clam habitat, physical disturbance from mechanical harvest of clams and oysters is the most obvious. Impacts of mechanical harvest on unstructured, soft bottom sediments are less studied, and the 2021 CHPP (NCDEQ 2021) highlights the need for increased monitoring of the condition of North Carolina's estuarine soft bottom habitat with regards to chemical and microbial contaminants and benthic macroinvertebrate communities. Recommended Action (RA) 8.6 in the 2021 CHPP (expansion of DWR's benthic macroinvertebrate sampling to estuaries) could directly contribute to a better understanding of the impacts of bottom disturbing gear on soft bottom habitats, and RA 8.1 (convene an expert workgroup to document data gaps and monitoring needs) and RA 8.2 (develop an ecosystem condition report) will provide a roadmap to better understanding impacts to hard clam habitats. For more in depth information on mobile bottom disturbing fishing gear, see the Mechanical Harvest Issue Paper.

HAND HARVEST METHODS

Intensive hand harvest methods can be destructive to oyster rocks. The harvest of clams or oysters by tonging or raking on intertidal oyster beds causes damage not only to living oysters but also to the cohesive shell structure of the reef (Lenihan and Peterson 1998). This destruction has been an issue where oysters and hard clams co-exist, primarily around the inlets in the northern part of the state and on intertidal oyster beds in the south (NCDMF 2001a). For more history on hand harvest methods, see Amendment 2 of the Hard Clam FMP.

Water Quality Threats

Marine bivalves, including oysters, have been shown to accumulate chemical contaminates, such as hydrocarbons and heavy metals, in high concentrations. Reductions in growth and increased mortality have been observed in soft-shelled clams (*M. arenaria*) following oil spill pollution events (Appeldoorn 1981). Impaired larval development, increased respiration, reduction in shell thickness, inhibition of shell growth, and general emaciation of tissues have been attributed to adult bivalve exposure to heavy metal contamination (Roesijadi 1996).

High concentrations of organic contaminates also result in impairment of physiological mechanisms, histopathological disorders, and loss of reproductive potential in bivalves (Capuzzo 1996). As shellfish can easily accumulate chemical pollutants in their tissues, consumption of impaired shellfish can create a health risk. Subsequently, shellfish closures occur due to chemical contamination, commonly associated with industry, marinas, and runoff.

Delivery of inorganic pollutants, organic contaminants, and harmful microbes to waterways occurs via both point and non-point sources. The accumulation of such harmful agents in the water column subjects oyster populations to the adverse effects listed above. Point sources have identifiable origins and include National Pollution Discharge Elimination System (NPDES) wastewater discharges. Although wastewater discharges are treated, mechanical failure can allow contaminated sewage to reach shellfish growing waters, thereby triggering an area to be closed to harvest.

Non-point sources of microbial contamination include runoff from animal agriculture operations and urban development. Animal agriculture produces waste with fecal bacteria, runoff from pastures, concentrated animal feeding operations (CAFOs), and land where CAFO waste has been applied as manure, all of which can be transported to surface waters and subsequently lead to shellfish restrictions (Wolfson and Harrigan 2010; Burkholder et al. 2007; Hribar 2010). Impervious surfaces (e.g., roads, roofs, parking lots) facilitate runoff and microbe transportation, facilitating significant water quality degradation in neighboring watersheds (Holland et al. 2004). For instance, in New Hanover County, an analysis of the impact of urban development showed that just 10-20% impervious cover in an area impairs water quality (Malin et al. 2000). In North Carolina, most CAFOs primarily house swine and poultry with a majority located in the coastal plain portions of the Cape Fear and Neuse river basins; however, both occur in all basins across the coastal plain (DWR 2024; Off 2022).

HYPOXIA

Point and non-point sources (developed and agricultural lands) are also sources of increased nutrient loads, which fuel phytoplankton growth and increase the strength and frequency of algal blooms. The eventual bacterial decomposition of these blooms results in a depletion of dissolved oxygen levels that can be dangerous to shellfish, particularly in warm, deep waters. Increased eutrophication leads to decreased oxygen levels (hypoxia and anoxia), which North Carolina’s estuaries can already be prone to because of salinity stratification and high summertime water temperatures (Buzzelli et al. 2002). These low-oxygen events degrade the usability of subtidal oyster reef habitats for fish (Eby and Crowder 2002) and cause high rates of oyster mortality in the deeper (4-6 m) waters of the estuaries (Lenihan and Peterson 1998; Powers et al. 2009; Johnson et al. 2009). Increased state action to limit nutrient loading from urban and agricultural lands is critical for reducing hypoxia impacts to estuarine habitat and resources, including oysters and the reefs they create (DWR 2024).

CLIMATE CHANGE

According to North Carolina’s 2020 Climate Science Report (Kunkel et al. 2020), the intensity of hurricanes is likely to increase with warming temperatures, which will result in increased heavy precipitation from hurricanes. Additionally, it is likely the frequency of severe thunderstorms and the annual total precipitation in NC will increase. The expected increase in heavy precipitation events will lead to increased runoff, which will result in an increase in chemical and microbial pollutants transferred to clam habitats. Recent research has provided evidence that negative impacts from increased precipitation and pollutant delivery to estuaries have already begun in North Carolina (Kunkel et al. 2020; Paerl et al. 2019).

For instance, Paerl et al. (2020) investigated the impact of tropical cyclones on nutrient delivery and algal bloom occurrences in the Neuse River Estuary and Pamlico Sound. They found high-discharge storm events, such as high-rainfall tropical cyclones, can double annual nutrient loadings to the estuary, leading to increased nutrients and dissolved organic carbon. Phytoplankton response to moderate storm events is immediate, while during high-rainfall events like Floyd (1999), Matthew (2016), Florence (2018), and Dorian (2019) phytoplankton growth is diverted downstream to Pamlico

Sound, where it can persist for weeks. Additionally, increased organic matter and phytoplankton biomass from heavy rainfall events contribute to oxygen depletion, exacerbating hypoxic and anoxic conditions in the Neuse River and Pamlico Sound.

Additionally, warming water temperatures caused by climate change may benefit growth rates for pathogens that can negatively impact resources. For instance, increased water temperatures have been linked to increasing abundance of *Vibrio* over the past 60 years (Vezzulli et al. 2016). This is a significant public health issue and can disrupt shellfish markets, as *Vibrio* species get taken up by filter-feeding shellfish and can cause life-threatening illness when consumed. Common wisdom in North Carolina has advised against consuming raw shellfish in the warm-water months for this reason, and rising water temperatures threaten to increase this risk, potentially through longer periods of the year.

In addition to causing hypoxia, the enhanced phytoplankton growth resulting from increased rainfall and nutrient delivery to estuaries will also result in negative impacts to SAV habitat. The majority of SAV loss in North Carolina has been attributed to decreases in light availability due to increased eutrophication (nutrient enrichment) and suspended sediments, and those losses are expected to increase as eutrophication increases due to climate change (NCDEQ 2021). Further, North Carolina's dominant high-salinity SAV species, eelgrass (*Zostera marina*), is already growing at the warmest edge of its thermal tolerance in NC, regularly experiencing stressful temperatures that affect growth and reproduction. While the response of eelgrass to increased water temperatures is complex, and the species may be more resilient in North Carolina than other states (Bartenfelder et al. 2022), projections of shifts in the range of eelgrass due to warming waters indicate that the species' southern limit is likely to move northward and potentially out of North Carolina altogether by 2100 (Wilson and Lotze, 2019).

To reduce the negative impacts of climate change on the hard clam fishery, it will be important for state agencies to implement policies that encourage the use of agriculture, forestry, and urban stormwater best management practices (BMPs) to reduce the amount of runoff reaching North Carolina's estuaries. This need, among others, has been emphasized in the CHPP as recommended actions to improve water quality. While the MFC has little direct control over such actions to mitigate the impacts of increased runoff, it can continue to support them through its role in developing and approving the CHPP, coordinating the efforts of the Environmental Management Commission, the Coastal Resources Commissions, and their respective state agencies to continue trying to improve water quality for fish habitats.

WATER QUALITY MANAGEMENT THROUGH THE CHPP

Improved water quality has been a component of all editions of the CHPP, and the 2021 CHPP included a specific focus on improving water quality to protect SAV habitat, which will directly benefit the clam fishery. The 2021 CHPP proposed to follow the successful examples of management in Chesapeake Bay and Tampa Bay with a five-element strategy that includes 1) supporting efforts to improve water quality; 2) protecting and restoring SAV; 3) enhancing SAV research and monitoring; 4) improving collaboration through citizen involvement, education and outreach; and 5) addressing other contributing factors such as physical disturbance and climate change.

The 2021 CHPP's SAV protection recommendations heavily emphasize the first element, and Division of Water Resources (DWR) staff have led the Nutrient Criteria Development Process (NCDP), with collaboration from other DEQ divisions, including DMF habitat and enhancement staff. Because the EMC's current chlorophyll and turbidity standards are not enough to protect SAV from light limitation, the 2021 CHPP placed increased emphasis on developing new standards and updating current but deficient standards to improve water quality to protect and restore SAV. To address that, the NCDP team has developed a water clarity standard, as poor clarity is what prevents light from reaching SAV beds, and DWR staff are beginning the process of bringing the proposed standard to the EMC within the next year. There are many potential pitfalls along the way, but if the approval process is successful, it will take approximately a year.

From there, it will take until the 2030 biennial update to the North Carolina Integrated Report (303d list), which identifies which water quality parameters are exceeded in which of the state's waterbodies, to have enough data to assess waterbodies as impaired for clarity. An impairment listing on the 303d list triggers the need to develop a Total Maximum Daily Load, or TMDL, (or another approved alternative). TMDL development also identified sources and causes of water quality degradation so that restoration efforts can target the appropriate issues (common causes are detailed in the 2021 CHPP, but include increased freshwater input and nutrient delivery from impervious surfaces, agriculture, and wastewater, among others).

Following TMDL development, then on-the-ground restoration work would begin to start improving water clarity, so the earliest potential improvements from this effort may occur in the early 2030s. The timeline of this effort is not short, but it represents the best opportunity for statewide restoration of SAV habitat through improving water quality, which will also reduce the frequency of shellfish harvest closures and provide benefits to other habitats like oyster reefs by reducing nutrient pollution and the severity of hypoxic events.

The 2026 update to the CHPP will consider progress made in this process and provide further recommendations to advance this process and other avenues for improving water quality in North Carolina's estuaries through collaboration with DWR, DCM, and other state agencies with direct jurisdiction over issues driving water quality degradation.

ENVIRONMENTAL PATHOGENS

There are various environmental pathogens that can impact shellfish and those that consume shellfish. These pathogens include Neurotoxic Shellfish Poisoning (NSP), Vibrios, and Green Gill.

Neurotoxic Shellfish Poisoning is a disease caused by consumption of molluscan shellfish contaminated with brevetoxins primarily produced by the dinoflagellate, *Karenia brevis*.

Blooms of *K. brevis*, called Florida red tide, occur frequently along the Gulf of Mexico (Watkins et al. 2008).

Vibrios are salt loving bacteria that inhabit coastal waters throughout the world, and with the exception of toxigenic *Vibrio cholera* 01, are not usually associated with pollution that triggers shellfish closures and can be ubiquitous in open shellfish growing areas. Vibrios are more common during the warmer summer months and are found throughout the coastal waters of North Carolina (Blackwell and Oliver 2008; Pfeffer et al. 2003).

Green gill in clams comes from the single-celled alga called *Haslea ostrearia.* This is a blue-green diatom found in the coastal waters of North Carolina. For more detailed information on these environmental pathogens, see Amendment 2 of the Hard Clam FMP.

Shellfish Sanitation

The NCDMF has a contingency plan in place as required by the FDA, including a monitoring program (National Shellfish Sanitation Program, NSSP) and management plan. The purpose is to ensure quick response of any harmful algal species within State waters that may threaten the health and safety of shellfish consumers. The plan also details the system to provide early warning of any potential issues, actions to be taken to protect public health and steps to reopen areas to harvest. (Shellfish Sanitation and Recreational Water Quality Section Marine Biotoxin Contingency Plan 2022). Shellfish Sanitation and Marine Patrol are the primary Sections of NCDMF responsible for North Carolina's compliance with the NSSP.

The Shellfish Sanitation Section classifies shellfish growing areas and recommends closures and re-openings to the Director that are implemented by proclamation. The entire North Carolina coast is divided into a series of management units that are referred to as Growing Areas. Each of these Growing Areas is individually managed to determine which portions of the area are suitable for shellfish harvest, and which need to be closed to harvest. Data collected and used in classifying Growing Areas include actual and potential pollution sources, rainfall and runoff impacts, physical hydrodynamic patterns, and bacteriological water quality.

Shellfish growing waters can be classified as "Approved", "Conditionally Approved", "Restricted", or "Prohibited". Approved areas are consistently open to harvest, while Prohibited areas are off limits for shellfish harvest. Conditionally Approved areas can be open to harvest under certain conditions, such as dry weather when stormwater runoff is not having an impact on surrounding water quality, and Restricted waters can be used for harvest at certain times as long as the shellfish are subjected to further cleansing before they are made available for consumption. For a map of both temporary and permanent closures, please visit the Interactive Shellfish Closure Map on NCDMF's Shellfish Sanitation website. Additional information can be found under Current Polluted Area Proclamations.

Enhancement Activities

NCDMF has not identified a need to target restoration efforts towards increasing hard clam populations; however, NCDMF supports enhancement programs which benefit native shellfish species through a variety of initiatives. In recognition of the eastern oyster as a keystone species in estuarine habitat, these initiatives focus on oyster restoration, while indirectly and simultaneously providing enhancement to hard clam habitat.

Habitat Enhancement Programs

Cultch Planting

The objective of the North Carolina Division of Marine Fisheries cultch planting program is to provide shellfish habitat on public bottom grounds open to commercial harvest. While cultch planting is traditionally viewed as an oyster restoration measure, it may also serve as a restoration tool for other shellfish species, including hard clams. A comprehensive overview of the cultch planting program is available in the Eastern Oyster FMP Amendment 5, Appendix 4.

Oyster Sanctuaries

Oyster Sanctuaries in North Carolina are designed in such a way that enhanced habitat complexity may provide habitat for both oysters and other species typically found on or near oyster reefs. At many of these sites, soft bottom habitat between hard substrate patches may provide ideal habitat for clam colonization and also offer refuge from predation (Castagna 1970).

Hard clams, as with oysters, in harvest-protected sanctuaries can serve as broodstock populations, providing subsidies to harvestable areas (Gobler et al. 2022). While a monitoring protocol is in place for oyster sanctuaries, there is currently no provision for addressing hard clam ecology associated with these protected areas.

A comprehensive overview of the Oyster Sanctuary Program is available in the Eastern Oyster FMP Amendment 5, Appendix 4.

Shellfish Aquaculture

Aquaculture of hard clams has ecosystem service value similar to wild stocks. Hard clams maintain the capacity to filter large volumes of water. Depending on the ploidy of hard clams in culture, environmental conditions, and the duration of grow out, shellfish aquaculture may provide an additional source of larvae for habitat enhancement. However, currently there are limited seed producers in North Carolina, potentially hindering the growth of clam aquaculture.

Clam Restoration Efforts In Other States

Although a majority of shellfish restoration efforts have focused on oysters, a few recent projects have looked at effective strategies for enhancing depleted clam populations along the east coast. The cost-effectiveness of various methods has been investigated, including the use of spawner sanctuaries, planting seeded shell, and larval release in shallow lagoons of New York and Florida (Arnold et al. 2002; Doall et al. 2009; Gobler et al. 2022). Among these strategies, spawner sanctuaries appear to have had the most success. This strategy, as suggested by Peterson (2002), takes advantage of the long lifespan and sustained reproductive output of *M. mercenaria*.

A study conducted in Shinnecock Bay, along Long Island, New York observed the 9-year impact of transplanting 3.2 million adult hard clams and placing them in high-density no-take spawner sanctuaries (Gobler et al. 2022). Compared to neighboring lagoons during the same time period, Shinnecock Bay saw a 16-fold increase in landings of clams, in addition to significant decreases in harmful algae density and chlorophyll a concentration and a significant net gain in seagrass habitat (Gobler et al. 2022). While other projects testing the spawner sanctuary strategy had mixed results, their takeaways highlighted the importance of suitable environmental conditions using healthy adult clams. For instance, shallow water (< 2 m), higher DO, higher temperatures, and higher salinity (> 20 psu) likely all play a significant role in both the ability of adult clams to recondition between spawning years, as well as survivability and recruitment of larvae (Castagna & Chanley 1973; Doall et al. 2009; Arnold et al. 2002; Gobler et al. 2022).

Therefore, careful consideration of environmental variables must occur during site selection for any possible clam restoration projects. While both oysters and clams have similar ecological roles as filter feeders in shallow water estuaries, each has specific physiological tolerances and environmental needs. Oysters can survive a wide range of environmental conditions, while clams have a narrower tolerance of environmental variables and are not constrained to the tidal column upper limits (Galimany et al., 2017). Furthermore, researchers have placed considerable emphasis on the necessity of long-term monitoring surveys (similar to protocols used for NC's Oyster Sanctuary Program) following any restoration efforts involving *M. mercenaria* (Simpson et al. 2022).

Protected Resources

A "protected species" is defined as any organism whose population is protected by federal or state statute due to the risk of extinction. In North Carolina, these species are primarily protected by the following federal statues: the Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), and the Migratory Bird Treaty Act (MBTA). As mentioned in other sections of this document, hard clams are primarily harvested in North Carolina estuarine waters by hand rakes and bull rakes. Additional lesser used gears include clam trawls and escalator dredges.

For the purpose of the MMPA, the NMFS splits this fishery into two distinct Category III fisheries: the Atlantic Shellfish Bottom Trawl fishery and the Atlantic Ocean, Gulf of Mexico, Caribbean shellfish dive, hand/mechanical collection fishery. As reflected by the Category III designations, neither section of the fishery has had any known interactions with marine mammals. Additionally, in either fishery there is only a remote likelihood that any incidental interactions may occur. More information on the MMPA List of Fisheries and fisheries categorizations can be found here: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries.

North Carolina estuaries are also home to multiple ESA-listed species including green sea turtles (*Chelonia mydas*), Kemp's ridley sea turtles (*Lepidochelys kempii*), loggerhead sea turtles (*Caretta caretta*), leatherback sea turtles (*Dermochelys coriacea*), hawksbill sea turtles (*Eretmochelys imbricata)*, Atlantic sturgeon (*Acipenser oxyrinchus*), and shortnose sturgeon (*Acipenser brevirostrum*). No ESA-listed species interactions have been recorded within this fishery. Furthermore, the timing of this season (December through March) generally precludes any potential interactions as estuarine abundance of sea turtles during these months is typically low (Epperly et al. 1995). As such, it can be assumed that any potential impacts of hard clam harvest on protected species populations would be primarily indirect and at the ecosystem-level.

North Carolina is home to a diverse array of migratory bird species (Potter et al. 2006). It is unlikely that species of MBTA-protected birds are directly impacted by clam harvest and some research suggests that hand and rake harvest of clams has a negligible effect on certain species of shorebirds (Navedo and Masero 2008). Overall, there is little evidence to suggest that any hard clam harvest method impacts MBTA-protected species.

FINAL AMENDMENT THREE MANAGEMENT STRATEGY

****Section will be completed when the MFC selects preferred management and prior to DEQ secretary and legislative committees review****

RESEARCH NEEDS

The research recommendations listed below are offered by the division to improve future management strategies of the hard clam fishery. They are considered high priority as they will help to better understand the hard clam fishery and meet the goal and objectives of the FMP. This list of research recommendations is also provided in the Annual FMP Review and NCDMF Research Priorities documents.

- Develop hard clam sampling methodology to monitor regional adult abundance
- Map and characterize hard clam habitat use by bottom type
- Develop a survey to better quantify recreational harvest
- Determine natural morality estimates
- Investigate causes of recent clam-kills and overall decline in hard clam abundance in the New River

MANAGEMENT FROM PREVIOUS PLANS

Discontinue rotation of Pamlico Sound with northern Core Sound.

Institute a resting period within the mechanical clam harvest area in the northern part of Core Sound.

Modify mechanical harvest lines to exclude areas currently open to mechanical harvest where oyster habitat and SAV habitat exist based on all available information.

Implement shading requirements for clams on a vessel, during transport to a dealer, or storage on a dock during June through September. These requirements would be implemented as a public health protection measure under 15A NCAC 03K .0110.

Leave current management practices in place for Ward Creek.

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APPENDICES

Appendix 1: Clam Mechanical Harvest Issue

ISSUE

The number of participants and trips in the mechanical clam fishery on public bottom have steadily declined since the 1990s to the lowest levels on record. This, along with habitat concerns associated with bottom disturbing gears, as well as significant cost to the state for management of this fishery, has led the division to re-examine if this fishery should still be allowed to operate.

ORIGINATION

The North Carolina Division of Marine Fisheries (NCDMF)

BACKGROUND

Historical Importance

Historically, harvest of hard clams by mechanical methods from public bottom made up a significant portion of the commercial hard clam landing on public bottom from its advent in the mid-1940s all the way through the early-2010's. As detailed in the Status Of The Fishery section, mechanical harvest of hard clams began as a rudimentary version of dredging where boat propellers were used to blow sediment away and expose hard clams for hand harvest. This evolved through time into the modern methods of escalator dredging and clam trawling we see today (see Mechanical Harvest subsection of the Status Of The Fishery section).

Historical mechanical harvest data are sparse until 1950 when commercial reporting became more regular. The mechanical harvest in the early 1950s was massive compared to recent decades, exceeding 35 million hard clams in 1951 (Figure 19). This period of high landings was followed by a steep decline in landings that lasted until the late 1960s. An increase in demand for North Carolina hard clams was created during the 1976-1977 season, when hard clam beds in the northeastern states became inaccessible due to abnormally thick ice. This period marked another large increase in mechanical harvest that would last into the mid-1980s. Since the late 1980s, hard clam landings have declined. This decline is likely the result of a decrease in abundance, increased closures of shellfish waters from pollution, changing market demand, several major storms, and a red tide event in 1987.

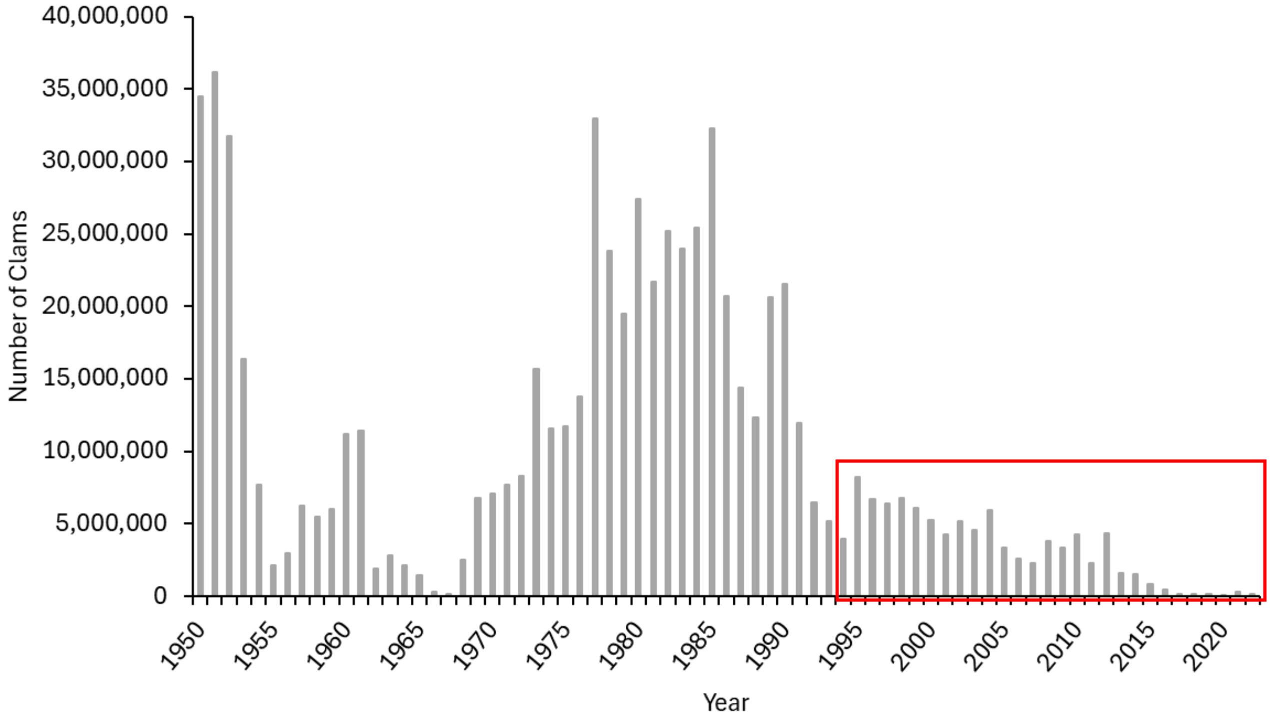

Figure 19. Hard clam landings (number of clams) using mechanical gears on public bottom by year, 1950-2022. TTP data is presented in the red box.

Since 1994, the mechanical hard clam fishery has seen a steady decline in landings and participation to its lowest levels since clam trawls were first used in the late 1960s (Figure 19). Landings from this fishery have declined from a maximum harvest of over 8.7 million hard clams in 1995, to a level that has remained below 100,000 hard clams per year from 2017 to 2022. The precipitous decline in landings is mirrored by a similar decline in participation over the same period (Figure 20). In 1996, the fishery maxed out at 138 participants. Over the next two and a half decades, participation quickly waned until less than 10 participants per year were active in the fishery from 2019 to 2022.

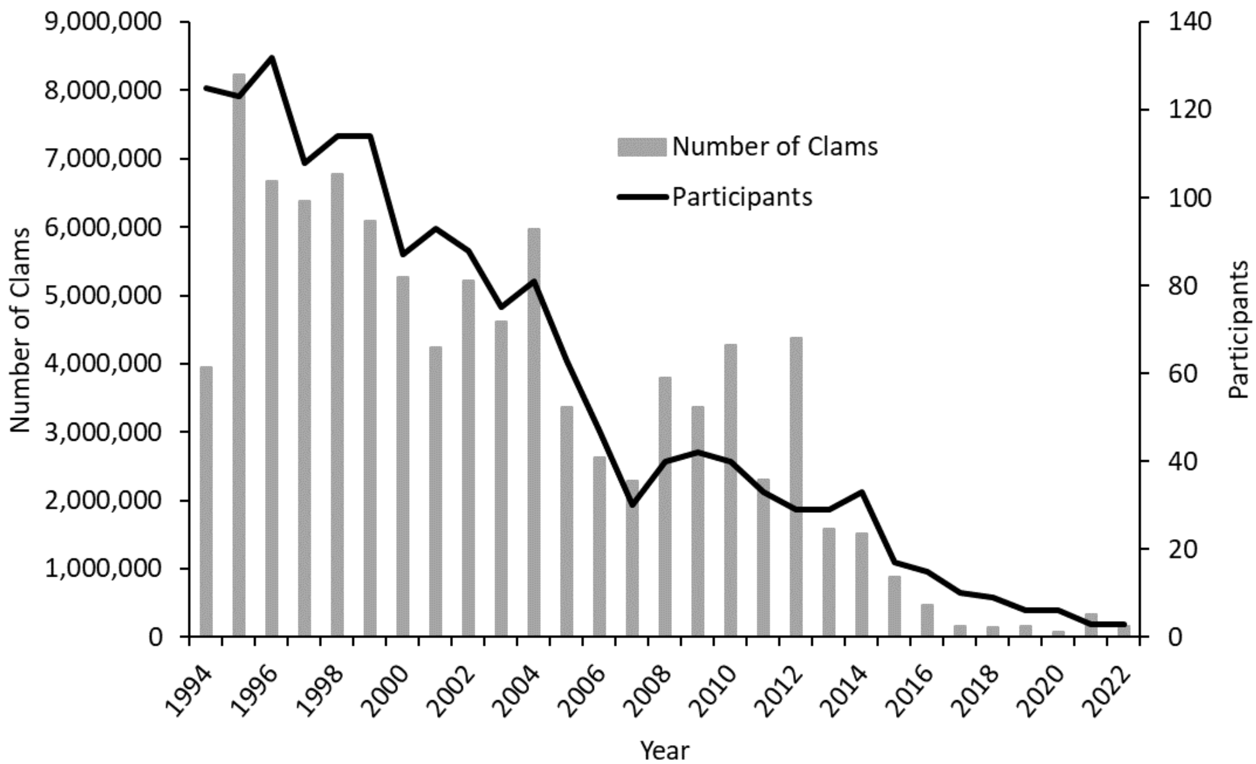

Figure 20. Hard clam landings (number of clams) and number of participants using mechanical gears on public bottom by year, 1994-2022.

As detailed in the Status Of The Fishery section, the mechanical hard clam harvest season can occur from December 1 through March 31 and is opened by proclamation in specific areas. These areas are limited to what is defined in Amendment 2. These areas include portions of Core Sound, North River, Newport River, Bogue Sound, White Oak River, New River, New River inlet, and the IWW in Onslow and Pender Counties. These areas can be reduced but cannot be expanded beyond what is outlined in Amendment 2. Since 1994, the New River and Core Sound have accounted for over 80% of the total mechanical hard clam harvest from 1994-2022 (Figure 21). The New River was the most important waterbody for mechanical harvest from 2000 to 2016, before being overtaken by Core Sound. The New River has seen a consistent decline in overall contribution to the landings since 2012, except for 2020 which had extremely low landings overall because of the COVID-19 pandemic. The consistent decline is primarily due to a series of clam kill events that occurred in the 2010s, which decimated the population within New River, and caused fishermen to move to new waterbodies or transition to other fisheries.

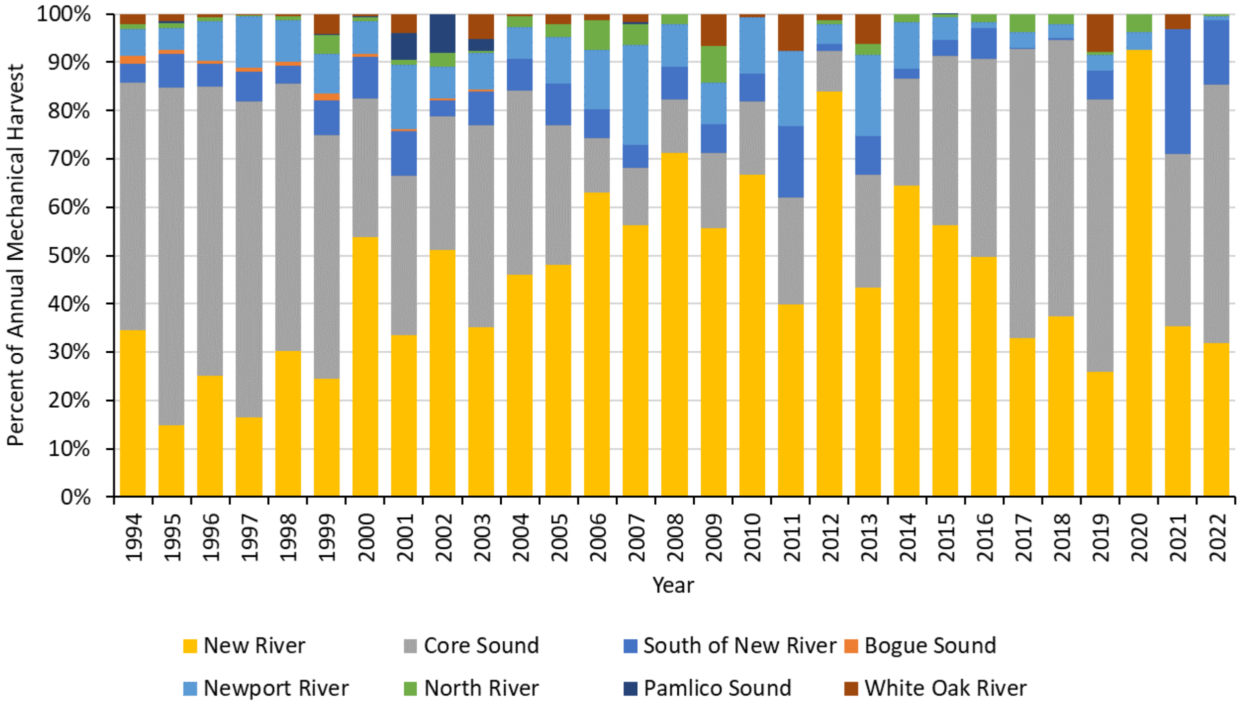

Figure 21. Percentage of annual mechanical hard clam harvest in NC on public bottom by waterbody and year, 1994-2022.

Enforcement

Each year the Division marks all the mechanical clam harvest area boundaries with posts and signs (except for the New River) to ensure enforceability of these boundaries. The staff must replace all missing or damaged posts and signs affected by weather or vandalism. The loss of posts and signs can be significant in years with major weather events such as hurricanes.

In addition to the significant cost and staff time associated with marking the mechanical harvest areas, a large force of Marine Patrol officers is required to monitor and enforce these areas. Normally, each harvest area will have several officers watching the lines with a couple on standby with vessels in case there is a violation. Then when the vessels start returning to the docks, it takes several officers to complete an inspection (i.e., count the hard clams, check licenses, and maintain security while counting the hard clams). The large volume of hard clams caught from these operations requires a good deal of Marine Patrol manpower, especially when several vessels return to the docks at the same time. In Core Sound, the vast area encompassed by the mechanical clam harvest area, along with its zig-zagging boundary makes enforcement difficult and resource intensive.

Maintenance Dredging

The NCDMF also allows the harvest of hard clams by mechanical means before maintenance dredging occurs in some navigational channels through NCMFC Rule 15A

NCAC 03K .0301 (b). The purpose of this is to allow commercial fishermen access to a resource that would otherwise be destroyed during the maintenance dredging process. The execution of opening an area prior to maintenance dredging requires communication and collaboration between the division, Army Corps of Engineers (ACE), and the fishermen requesting access to mechanically harvest within the proposed dredge area. Late notice by fishermen, difficulty in communication with ACE, and the time to prepare and process proclamations to open areas have been major obstacles to this program since its inception in 1991. Due to the complicated process and limited interest from mechanical harvesters, no openings for mechanical harvest in proposed maintenance dredging areas have occurred since 2007.

AUTHORITY

N.C. General Statutes

113-134	Rules.
113-182	Regulation of fishing and fisheries.
113-182.1	Fishery Management Plans.
113-201	Legislative findings and declaration of policy; authority of Marine Fisheries Commission.
113-221.1	Proclamation; emergency review.
143B-289.52	Marine Fisheries Commission – powers and duties.

N.C. Marine Fisheries Commission Rules (15A NCAC)
03K .0302 Mechanical Harvest of Clams from Public Bottom

DISCUSSION

The division believes it may be appropriate to further reduce, phase out, or eliminate the mechanical clam harvest fishery due to habitat concerns with mechanical gears, declining participation in a fishery that lands just 0.1% of its historical catch, and significant cost to the state for monitoring and enforcement.

Habitat Concerns

Goal 3 of the 2016 CHPP is to “enhance and protect habitats from adverse physical impacts,” which includes reducing the impacts of mobile bottom disturbing fishing gear, the negative effects of which are described in detail in Section 8.1.1 of the 2016 CHPP. Under Goal 3, the primary relevant recommended actions are 3.3 “Protect habitat from adverse fishing gear effects through improved compliance” and 3.8 “Develop coordinated policies including management adaptations and guidelines to increase resiliency of fish habitat to ecosystem changes." The management options presented in this issue paper support those recommended actions by simplifying compliance and contributing to the CHPP’s comprehensive management strategy of managing both physical and water quality impacts to improve habitat resilience.

Summarizing information compiled in the 2016 CHPP, impacts from mobile bottom-disturbing fishing gear range from changes in community composition from removal of species to physical disruption of the habitat (Barnette 2001). Corbett et al (2004), found an increase in total suspended sediment 1.5 – 3 times above background concentrations for less than a day, and minor impacts on nutrient and chlorophyll a concentrations. Wind played a greater role in mixing the water column and altering its nutrient and sediment characteristics. Bottom trawls, dredges, and other mobile gears can cause rapid and extensive physical damage to hard bottom habitat (e.g. Auster and Langton 1999; SAFMC 1998). Habitat complexity is reduced through flattening of mounds, filling of depressions, dispersing shell hash, and removing small biotic cover such as hydrozoans and sponges (Auster et al. 1996; Løkkenborg 2005). Auster and Langton (1999), ASMFC (2000), and Collie et al. (2000) discussed impacts of fishing gears on SAV. Belowground effects, such as those from toothed dredges, heavy trawls, and boat propellers, may cause total loss of SAV, requiring months to years to recover. Excessive sedimentation from bottom disturbing fishing gear and propeller wash can bury SAV. Because of the severe bottom impacts, the MFC restricts use of this gear to open sand and mud bottoms, including areas frequently dredged for navigation, such as the AIWW, disallowing it in SAV and oyster habitats. Clam trawling, or kicking, began in Core Sound as a method involving the scouring of bottom sediment with a prop wash while towing a trawl. Anecdotal accounts indicate significant negative impacts occurred to oyster rocks prior to marking and closing areas to mechanical harvest of clams. As part of CHPP implementation, the area allowed for clam kicking was modified by proclamation to clearly avoid all SAV and oyster beds and to establish a buffer of 50-100 feet between the gear and structured habitats.

Fishing related impacts to habitat have been reviewed and compiled in fishery management plans and have been summarized in documents produced by the South Atlantic Fisheries Management Council (SAFMC), Mid-Atlantic Fisheries Management Council (MAFMC), N.C. Moratorium Steering Committee (MSC 1996), Auster and Langton (1999), NCDMF (1999), and Collie et al. (2000). Gears with the greatest potential for damage to soft bottom include dredges and trawls. However, research suggests that neither activity has a significant effect on clam recruitment (Auster and Langton 1999; NCDMF 1999; Collie et al. 2000). Dredges and trawls have a greater impact on structured habitat where clams are more abundant. Oyster rocks and cultch plantings provide excellent habitat for hard clam settlement and growth in areas where salinity regimes and water flow are suitable for survival. Hard clam harvesting in oyster rocks involves overturning or sifting through shells and oysters overlying clams, possibly damaging the oysters. For this reason, oyster rocks are protected from mechanical harvest of clams and bull rakes by rule (Marine Fisheries Commission Rules 15A NCAC 03K .0304 and 03K .0102). Most harvesting of clams in relation to oysters occurs around the base of the beds where they are most abundant (Noble 1996). Clams are also harvested by mechanical methods using either hydraulic escalator dredge or clam trawl. Current fisheries regulations prohibit the use of mechanical gear in SAV beds and live oyster beds because of the destructive capacity of the gear. Mechanical harvest of clams is now only allowed in designated harvest areas that do not contain significant SAV or oyster resources. In the 20-year period analyzed in the 2016 CHPP, trips for mechanical harvest of clams made up 18% of all trips using mobile bottom-disturbing fishing gears; however, that percentage had decreased to 6% of all trips by the terminal year of the analysis (2013), largely attributed to changes in regulations regarding gear restriction areas for mechanical harvesting of clams.

In accordance with the CHPP (e.g. 2016 CHPP action 3.3: protect habitat from adverse fishing gear effects through improved compliance), the division has already reduced the allowable mechanical clam harvest areas in the state due to concerns over encroachment with oysters and overlap with SAV beds. Beginning in 2008, the division discontinued the Pamlico Sound area in rotation with the northern Core Sound area and instituted an annual resting period between northern Core Sound and the southern Core Sound areas due to limited harvest and concerns over impacts to the crab fishery in the area (NCDMF 2017). From 2019-2020 (north of Bogue Inlet; APNEP 2022) and 2021 (south of Bogue Inlet; NCDMF 2022), a comprehensive study was conducted to map SAV beds across the state. The SAV maps generated from this study were overlayed onto the mechanical clam harvest area maps to look for areas of overlap. Significant overlap was identified in four of the harvest areas including Core Sound, North River, Bogue Sound, and New River. The mechanical clam harvest areas were then adjusted to eliminate overlap and provide a suitable buffer. An example of this overlap and subsequent area modification can be seen in Figure 22. Due to the large extent of overlap with SAV, the entire mechanical clam harvest area in Bogue Sound was eliminated (Figure 23).

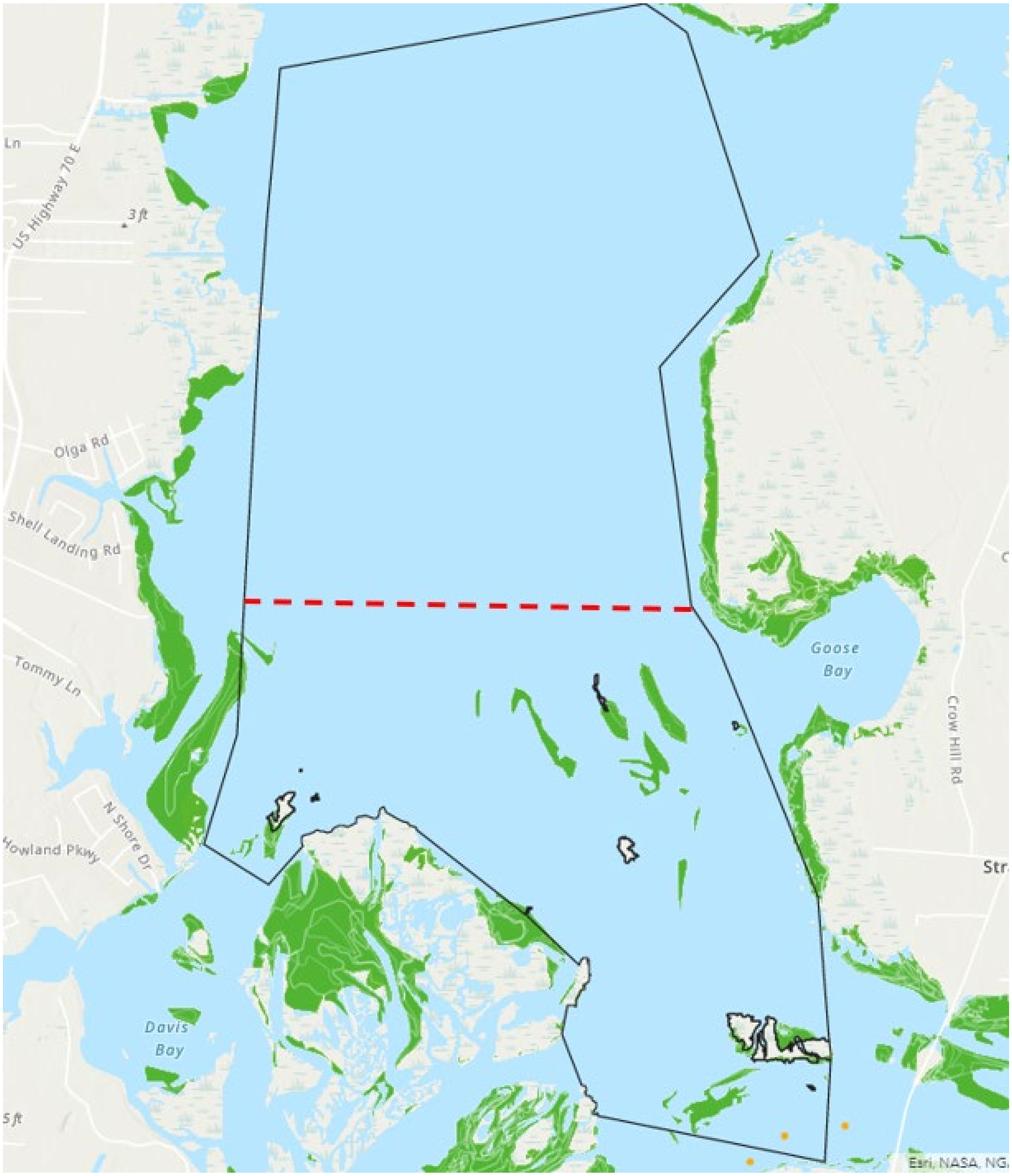

Figure 22. Map of North River mechanical clam harvest area (black line) overlaid with SAV mosaic (in green; APNEP 2022) to show SAV overlap. The dotted red line is where the new area boundary was established.

Figure 23. Map of Bogue Sound mechanical clam harvest area (black line) overlaid with SAV mosaic (in green; APNEP 2022) to show SAV overlap.

Organisms in soft bottom habitat are adapted to shifting and changing sediments. However, when sedimentation is excessive, there can be negative impacts. In addition to direct physical damage to the shell mound structure, bottom disturbing fishing gear, including hydraulic clam dredges, clam trawls (kickers), and shrimp and crab trawls can impact clam beds and oyster reefs indirectly by re-suspending sediment. High levels of suspended sediment in an estuarine or marine habitat can reduce successful settlement of larval clams and oysters and can smother other benthic invertebrates (Coen et al. 1999; AFS 2003). Excessive sedimentation can also harm shellfish by clogging gills, increasing survival time of pathogenic bacteria, or increasing ingestion of non-food particles (SAFMC 1998). Water column sediments can increase survival of fecal coliform bacteria in waterways (Schueler 1999), and while fecal coliform bacteria do not affect the viability of clams or oysters, pathogenic bacteria can make shellfish unfit for human consumption.

Socioeconomic Analysis

Commercial landings and effort data collected through the DMF trip ticket program are used to estimate the economic impact of the commercial fishing industry. For commercial fishing output, total impacts are estimated by incorporating modifiers from NOAA's Fisheries Economics of the United States reports from 2012-2020 (National Marine Fisheries Service 2023), which account for proportional expenditures and spillover impacts from related industries. By assuming the mechanical clam harvest commercial fishery's economic contribution is a proportion equal to its contribution to total commercial ex-vessel values, we can generate an estimate of the economic contribution of the clam mechanical harvest fishery statewide.

From 2012 to 2022, clam mechanical harvest on public bottom economic sales contributions have varied from a high of $960,000 in 2012 to a low of approximately $62,000 in 2020 and supported between 41 and 4 jobs annually (Table 5). Annual sales impacts and number of trips have consistently declined over the past decade, notably dropping sharply in 2017 and again in 2020. The industry expanded in 2021, and to a lesser extent in 2022, but has not returned to pre-2016 landings or participation which has steadily declined over the period.

Table 5. Annual economic contributions from the clam mechanical harvest commercial fishery to the state of North Carolina from 2012-2022 reported in 2022 dollars. * Indicates confidential data

Year	Trips	Participants	Ex-Vessel Value	Job Impacts	Income Impacts	Value Added Impacts	Sales Impacts
2022	41	3	< $75,000*	4	$44,522	$92,392	$105,235
2021	72	3	< $75,000*	5	$32,630	$149,882	$175,563
2020	32	6	$18,891	7	$29,053	$53,201	$62,685
2019	40	6	$32,992	8	$53,273	$83,219	$122,346
2018	56	9	$24,752	10	$38,595	$69,255	$84,564
2017	59	10	$27,570	11	$40,962	$67,218	$92,955
2016	106	15	$83,951	19	$123,316	$214,598	$268,630
2015	178	17	$257,687	28	$369,966	$649,341	$829,340
2014	360	33	$226,378	43	$338,399	$554,643	$777,574
2013	348	29	$252,269	40	$365,723	$636,974	$826,304
2012	414	29	$284,867	41	$423,831	$701,532	$960,031

Each year the division uses a large number of staff, primarily marine patrol officers, and financial resources to monitor, manage, and enforce this fishery. These costs are difficult to justify for a fishery with low participation and diminished value. The cost to the state to facilitate the execution of this fishery may be better used to fund projects more beneficial to the clam fishery as a whole, or at least one that benefits more users.

Maintenance Dredging

If the mechanical clam harvest fishery on public bottom were to be discontinued, it may be necessary to end the exception for mechanical harvest prior to maintenance dredging described in rule 15A NCAC 03K .0301 (b). If the primary mechanical clam fishery is closed, fishermen that currently participate in the fishery would likely get rid of their gear, leaving no one to participate in pre-maintenance dredging openings. This would further benefit the habitat by reducing the extent of turbidity issues associated with mechanical gears. This program has not been utilized since 2007, and with declines in the mechanical clam harvest fishery as whole, it is unlikely to be used much in the future.

Management options

Due to dwindling participation and landings, significant cost to demarcate, maintain, and enforce the fishery, concerns about physical disturbance of SAV and oyster habitat by the gear, and concerns about turbidity and sedimentation, the division believes it is necessary to examine the validity of this fishery.

Due to the requirements of G.S. 113 221 (d), the division does not think the mechanical clam harvest fishery can be ended abruptly upon adoption of this amendment. An immediate closure of this fishery could “result in severe curtailment of the usefulness or value of equipment in which fishermen have any substantial investment” as outlined in statute. This would require “a future effective date so as to minimize undue potential economic loss to fishermen”. Possible management options include, but are not limited to; status quo, ending the allowance for mechanical clam harvest in conjunction with maintenance dredging activities, further limiting mechanical clam harvest areas, phasing out the fishery, and ending the fishery immediately. These management options would only affect mechanical clam harvest from public bottom and would not affect their use on private bottom.

Status quo would allow the fishery to continue to operate as it currently does. The fishermen currently operating in the fishery could continue, and new harvesters could join. The cost to the state for demarcation and enforcement would remain the same, making up a significant cost compared to the total value of the fishery. Concerns about effects of bottom disturbing gears on structured habitats would not be addressed.

Discontinuing the allowance for mechanical clam harvest in conjunction with maintenance dredging could also be considered. This would end a program that has not been utilized since 2007. This option could be pursued on its own, or in conjunction with a closure or phase out of the whole fishery. This would require a change to rule 15A NCAC 03K .0301 (b).

Mechanical clam harvest areas could be further limited to create boundaries that are more easily enforceable that also create buffers around critical habitat to protect them from sedimentation associated with bottom disturbing gears, as was done in the North River (Figure 4). To improve enforceability the boundaries would be based on permanent structures or known geographic features, be rectangular or rhomboid in shape without zig-zagging lines and have complete line of sight visibility. This would be implemented through proclamation after adoption of Amendment 3. As with status quo, The fishermen currently operating in the fishery could continue, and new harvesters could join. The cost to the state for demarcation would be reduced, but the resources required for enforcement would likely remain the same, making up a significant cost compared to the total value of the fishery. This would help address habitat concerns, but sedimentation would still occur from mechanical harvesting operations.

The mechanical clam harvest fishery could be phased out over a set timeframe, as was done with the shellfish relay program. This option would allow fishermen currently operating in the fishery to continue during the phase out period, but would discourage new participants. The phase out period would allow current mechanical harvesters time to get rid of gear and transition to other clam harvesting methods or fisheries. This option would address the division’s cost concerns with demarcation and enforcement, as well as the habitat concerns. This option is consistent with G.S. 113-221 (d), as it gives “a future effective date so as to minimize undue potential economic loss to fishermen”.

After hearing concerns from the FMP Advisory Committee about participants wanting the ability to re-enter the fishery, the division recommends a phase out timeframe of three years from adoption of this amendment unless minimum landings and participation increases occur in the fishery in any year prior to 2027. This increase in landings and participation would show the fishery is no longer diminishing and is valuable enough to maintain. The division recommends the minimum threshold for participants in the mechanical clam harvest fishery on public bottom be set at 10. Ten participants have not been active in a single year in the fishery since 2017 and is over three times the number of active participants in 2022 (three participants), but still less than a tenth of the peak participation in 1996 (132 participants). The division recommends the minimum threshold for landings in the mechanical clam harvest fishery on public bottom be set to one-million clams. The fishery last landed at least one million clams in 2014 (1.5 million clams) and one million clams is over six times the number caught in 2022 (less than 200,000 clams), but still less than an eighth of the peak landings in 1995 (8.2 million clams). If both thresholds are met in any single year prior to 2027, the issue would be brought back to the MFC for consideration at their May 2027 business meeting, or the next meeting that participation and harvest estimates are available from 2026, where they would decide whether to move forward with phase out of the fishery. This timing ensures that if following May 2027, the phase out continues as planned, fishermen would still have had three years to sell their gear and exit the fishery before the phase out is complete and the fishery closes in 2028, which would be consistent with G.S. 113-221 (d) (Figure 24).

Figure 24. Proposed timeline for the phase out of the Mechanical Clam Harvest Fishery on public bottom.

MANAGEMENT OPTIONS

- Status quo
- Immediately discontinue allowance for mechanical clam harvest in conjunction with maintenance dredging
- Further limit mechanical clam harvest areas to improve enforceability and protect habitat
    - Make mechanical areas rectangular with straight lines for enforcement like was done in North River.
    - There are only a small number of overlaps with current SAV mosaics. Most of which is on the western banks of Core Sound
    - Could look into overlap with oysters or other SHAs and critical habitat

- Phase out mechanical clam harvest
    - The only option to end mechanical clam harvest that is consistent with G.S. 113-221 (d)
    - Would allow fishermen to plan ahead and sell gear, transition to other fisheries
    - Three years from the adoption of the plan unless landings in the mechanical clam harvest fishery on public bottom increase to at least 1 million clams and participation increases to at least 10 participants in any year prior to 2027. If the thresholds are met, the MFC would meet in May 2027, or the next meeting that participation and harvest estimates are available from

2026, to consider whether to complete the phase out with fishery closure in 2028.

RECOMMENDATIONS

The Division recommends a phase out to be completed three years from the adoption of this plan unless fishery participation increases to 10 participants and landings increase to 1 million clams in any year prior to 2027. If these increases are met, the issue would be reconsidered by the MFC at their May 2027 business meeting, or the next meeting that participation and harvest estimates are available from 2026. The PDT also recommends the immediate end to the allowance for mechanical clam harvest in conjunction with maintenance dredging.

Appendix 2: Recreational Shellfish Harvest Issue Paper

ISSUE

The number of recreational shellfish harvesters in North Carolina is currently unknown which makes estimating the total recreational harvest of shellfish difficult. Additionally, commercial harvesters are provided with human health and safety information regarding shellfish harvest when acquiring their license; however, there is currently no mechanism for reaching and educating recreational harvesters.

ORIGINATION

The North Carolina Division of Marine Fisheries (NCDMF).

BACKGROUND

Despite the importance of the commercial shellfish fisheries (molluscan and crustacean) to the state, limited data exist on recreational shellfish harvest. Currently, the NCDMF has limited data on recreational shellfish harvesting, including the number of participants and the extent of their economic activity. Collection of recreational shellfish harvest data, in addition to existing commercial landings data available through the North Carolina Trip Ticket Program (NCTTP) would provide a better estimate of total fishing mortality, relative abundance, and improve our knowledge of variation in abundance caused by a combination of fishing effort and environmental changes. A more accurate account of landings allows mangers to examine the proportional harvest of recreational and commercial fisheries to make better decisions on management strategies for both harvest sectors. It is imperative to collect high quality recreational harvest data to address potential management issues such as harvest limits, size limits, and gear restrictions.

Efforts to accurately quantify the impact of recreational fishing on shellfish (mollusks and crustaceans) have had limited success in North Carolina. The NCDMF collects data on recreational fishing in conjunction with the federal government's Marine Recreational Information Program (MRIP). However, MRIP collects information on finfish only.

Participation in recreational shellfishing in North Carolina has not been assessed for over 30 years. In 1991, a phone survey was conducted by the Marine Recreational Fisheries Statistics Survey (MRFSS), precursor to the MRIP, and it indicated that 3% of households in coastal North Carolina participated in recreational shellfishing, compared to an average of approximately 7% for finfish at that time (D. Mumford, NCDMF, personal communication). In 1991, MRFSS reported that in the state more than one million recreational fishing trips targeted shellfish. However, data on actual shellfish harvest estimates were not reported. The current extent of coastal households in North Carolina which recreationally harvest shellfish is unknown at this time.

The Hard Clam Fisheries Management Plan FMP (NCDMF 2001a) and Oyster FMP (NCDMF 2001b) supported adoption of a mechanism to provide data on recreational shellfish harvest. As a result of the recommendation by the Oyster and Hard Clam FMPs in 2001, House Bill 1427 was introduced before the general assembly in 2003 to establish a recreational shellfish license. This license would have been for shellfish only and would have been instituted on a trial basis for three years. However, the bill was never passed. In 2004, House Bill 831 did pass a saltwater fishing license mandating those individuals recreationally fishing for both finfish and shellfish to obtain a license. However, the state legislature revisited the issue in 2005 and replaced the saltwater fishing license with the Coastal Recreational Fishing License (CRFL). The Marine Fisheries Commission in the Bay Scallop FMP, Hard Clam FMP, and Oyster FMP recommended developing a mechanism to obtain data on recreational harvest of shellfish (DMF 2007). The need for a mechanism to be able to accurately quantify recreational effort and harvest has been a consistent area of concern in all North Carolina shellfish and crustacean FMPs.

The CRFL, which was implemented January 1, 2007, is only required when targeting finfish. When the CRFL legislation was originally drafted in 2007, it included shellfish. However, that language was removed before it was finally legislated. To fill this data gap, a survey of shellfish harvesting participation was added to the CRFL in November 2010 to collect monthly data on the harvest of crabs, oysters, clams, and scallops from the CRFL pool. The survey sample is made up of approximately 650 randomly selected CRFL holders that hold a valid license for at least one day during the survey period and answer “yes” to the harvest of at least one of the following species: crabs, oysters, clams, or scallops. In September 2014, the sample size was doubled to approximately 1,300 CRFL holders to increase the number of responses and precision of estimates. The selected CRFL holders are sent a letter explaining the survey along with the survey itself. Those that have not responded by the end of the month are sent a second copy of the survey. This survey obtains information on the number of trips taken during the survey period, average length of the trip, average party size, number of species kept and discarded, gear used, location information (water access), waterbody, and county of harvest. The mail survey estimates are a useful representation of shellfish harvest by CRFL holders but are limited in that they do not cover the entire population of potential recreational shellfish harvesters and probably represent a minimum estimate of effort and harvest. Despite good response rates, few responses contain oyster and clam activity.

The Fisheries Reform Act of 1997 (FRA) created a Recreational Commercial Gear License (RCGL) to allow recreational fisherman to use limited amounts of commercial gear to harvest recreational limits of seafood for personal consumption; however, shellfish gear (including hand, rakes, and tongs) was not authorized under this license. Since these gears are not covered by RCGL, recreational shellfishers can use these gears to harvest recreational bag limits of oysters and clams without a license. Therefore, recreational harvest data are not captured by past RCGL surveys.

Some recreational fishermen may purchase a commercial shellfish license rather than a CRFL because the license is easy to obtain (available to any NC resident), is relatively inexpensive ($50.00), and allows fishermen to harvest more shellfish than allowed under recreational limits. The Trip Ticket Program only captures landings from fishermen who sell their catch to certified seafood dealers. Identifying and surveying individuals who purchase a commercial shellfish license but do not have any record of landings within the

North Carolina Trip Ticket Program could be used to determine if the license is indeed being used for recreational purposes. This is also true for fishermen who buy a Standard Commercial Fishing License (SCFL) with a shellfish endorsement but do not have any reported landings of shellfish. Even though this approach limits the sampling universe to only recreational fishermen who bought a commercial license, it would provide some information on recreational shellfish harvest occurring that is not constrained by recreational limits. The shellfish harvest survey provides the ability to characterize recreational shellfish harvest, but still has limitations for estimating the total recreational harvest of shellfish.

With the limited data collected from the optional CRFL survey, some pieces of information about recreational effort have been captured. For instance, recreational oyster harvest was reported from 92 waterbodies throughout coastal North Carolina, with Topsail, Pamlico, Bogue, and Masonboro sounds all boasting more than 100 reported trips. The same survey revealed 70% of recreational oyster harvest effort originated from private residences, private boat ramps, or from shore. Given only 28% of reported effort originated at public access locations, intercept-oriented surveys are less than ideal. Recreational oyster harvest effort and catch were concentrated between October and March, accounting for over 84% of reported trips. Conversely, some individuals reported recreational harvest of oysters during the summer months despite state-imposed restrictions on harvest during this time. This suggests unfamiliarity with state regulations such as season and area closures.

Another concern of not having a license requirement for recreational shellfish harvest is the inability to easily communicate health and safety concerns of this harvest to recreational participants. The Shellfish Sanitation and Recreational Water Quality Section (SSRWQ) within the Division is responsible for ensuring all shellfish (oysters, clams, mussels) harvested or processed within North Carolina are safe for human consumption. To ensure shellfish are being harvested from areas free of contaminants, SSRWQ conducts pollution source assessments around shellfish growing areas, direct water quality sampling, hydrographic studies at point source discharges of pollution, and studies of the impacts of stormwater runoff on water quality. SSRWQ also conducts inspections and certifications of shellfish dealer facilities, as well as providing training for commercial harvesters and dealers, to ensure that shellfish are handled, stored, processed, and transported in a manner that keeps them safe for consumption.

To help keep the public informed of safe harvest areas and safe harvesting and handling practices, SSRWQ produces several publicly available informational resources, including:

Prohibited Shellfish Harvest Boundaries – SSRWQ establishes permanent closure boundaries that prohibit the harvest of shellfish in areas where there may be consistent contamination exceeding the standards for safe human consumption. These permanently closed areas are described and established via proclamation.

Polluted Area Proclamations and Temporary Closure Maps – In addition to the permanently closed areas described above, studies have found that water quality in certain areas can be negatively impacted by stormwater runoff, and shellfish can become temporarily unsafe for harvest under certain conditions. SSRWQ has developed management plans describing rainfall thresholds that can generate negative impacts and require temporary closures of these impacted areas. Temporary closures are put in place via proclamation and shown visually on the Division website through a web map updated as closed areas change.

Articles and Fact Sheets on Safe Handling Practices – Temperature abuse or improper handling practices can render shellfish unsafe to eat. To provide the public with information on how to safely store and handle shellfish, SSRWQ has prepared articles, fact sheets, and pamphlets available through the Division website.

Information on *Vibrio* Bacteria – *Vibrio* bacteria are naturally occurring bacteria that can be found in North Carolina waters and can cause severe illness in certain susceptible populations if consumed or through exposure to open wounds. Notably, these bacteria can proliferate within harvested shellfish even after they've been removed from the water, if the shellfish are held in warm/hot temperatures for extended periods of time. Proper handling/cooling of harvested shellfish is a critical step towards avoiding illness. SSRWQ has made available pamphlets and articles describing risks associated with these types of bacteria, and best practices for shellfish handling.

Although commercial harvesters, dealers, and shellfish lease/franchise holders, are provided with all this information when acquiring their license, getting their dealer certification, or acquiring/renewing their lease, there is no mechanism for reaching and educating recreational harvesters unless they actively seek out information.

AUTHORITY

N.C. General Statute

113-134	Rules.
113-169.2	Shellfish license for NC residents without a SCFL,
113-174.2	Coastal Recreational Fishing License.
113-182	Regulation of fishing and fisheries.
113-182.1	Fishery Management Plans.
113-201	Legislative findings and declaration of policy; authority of Marine Fisheries Commission.
113-221.1	Proclamation; emergency review.
143B-289.52	Marine Fisheries Commission – powers and duties.

Session Law 2023-137

N.C. Marine Fisheries Commission Rule (15A NCAC)

03O.0101	PROCEDURES AND REQUIREMENTS TO OBTAIN LICENSES, ENDORSEMENTS AND COMMERCIAL FISHING VESSEL REGISTRATION

03O.0107 LISENCE REPLACEMENT AND FEES
03O.0501 PROCEDURES AND REQUIREMENTS TO OBTAIN PERMITS
03O.0502 PERMIT CONDITIONS; GENERAL
03O.0506 SPECIAL PERMIT REQUIRED FOR SPECIFIC MANAGEMENT PURPOSES

DISCUSSION

Given North Carolina's shellfish fisheries are exclusively under state jurisdiction, lack of recreational shellfish harvest data makes addressing potential management issues such as harvest limits, size limits, and gear restrictions difficult. There are no data on demographics, perceptions, or expenditures of recreational shellfish harvesters in the state. Consequently, there is no data available to conduct an economic impact assessment of recreational oyster harvesting. Due to widespread accessibility of intertidal oysters and clams along North Carolina's coast, the potential impact of recreational harvest could be significant.

Table 6. Recreational shellfish harvest license requirements for east coast states.

State	License Requirements
Maine	No state license, towns have local restrictions and permits
New Hampshire	State license
Massachusetts	No state license, towns have local restrictions and permits
Rhode Island	Required for non-residents
Connecticut	No state license, towns have local restrictions and permits
New York	No state license, towns have local restrictions and permits, also has residency requirements
New Jersey	State license
Delaware	State license
Maryland	None, must be state resident
Virginia	None
North Carolina	None
South Carolina	State license
Georgia	State license and free permit
Florida	State license

License requirements for recreational shellfish harvesting varies by state along the United States east coast (Table 6). Most states require some type of license while in Maine, Massachusetts, New York, and Connecticut individual towns and cities require a license to recreationally harvest shellfish. North Carolina and Virginia are the only states without some form of license, local permitting, or residency requirements.

There are multiple avenues the NCDMF and MFC could pursue to better assess population of recreational shellfish harvesters. One solution is to include shellfish as part of the CRFL. This can be accomplished by three different methods. The first is to require the existing CRFL to recreationally harvest both finfish and shellfish. The second would be to create a separate shellfish only CRFL. This license would only give a recreational angler access to the allowed shellfish species and would exclude finfish harvest. This would allow fishery access to recreational anglers who are only interested in harvesting shellfish, and the cost could be set at a lower price than a standard CRFL. The third option would be to require the existing CRFL and create an additional recreational shellfish endorsement. The endorsement would be applied to the CRFL and would indicate the angler is licensed to recreationally harvest both finfish and shellfish. One drawback to these three options is it would require legislation to change the CRFL.

Another solution is to develop a recreational shellfish permit. The MFC has the authority to implement a permit to help manage estuarine and coastal resources and can set a maximum fee of up to $100 (although most permits are free of charge). A permit could function similar to a license. Recreational anglers would be required to have the permit to participate in the recreational shellfish fishery. A nominal fee for the permit would discourage participants from only obtaining the permit because it was free, helping to constrain the sampling universe.

Creating a specific CRFL, as outlined above, or a recreational shellfish permit would provide NCDMF with a complete pool of recreational shellfish harvesters. That list could then be used as a survey frame to help estimate effort and harvest in the fishery. Having a list of the population of recreational shellfish harvesters is useful for distributing shellfish area closure proclamations and maps. If shellfish species are added to the existing CRFL, the activity survey conducted during CRFL sale would still be needed to identify fishers who are involved in recreational shellfishing. These fishers would then receive additional surveys to estimate effort and harvest in the recreational shellfish fishery.

Although creating a specific type of CRFL, adding shellfish under the existing CRFL, or developing a recreational shellfish permit would be the most efficient mechanisms to determine effort in the fishery, another way to obtain these data would be to capture this activity in MRIP. MRIP does capture some non-finfish activity, but those data are broad and not available to shellfish at the species level and MRIP agents rarely encounter those types of recreational fishing trips. Most recreational shellfishing effort is by coastal residents using private docks and access points as opposed to public access points. Because MRIP is a nation-wide program, any changes to methodology designed to intercept more recreational shellfishing activity would need to undergo extensive review process and if implemented could take away from intercepts in other target fisheries.

Personal consumption by participants holding commercial fishing licenses (either a SCFL with a shellfish endorsement or a Shellfish license without a SCFL) would not be covered under any type of recreational shellfish license or permit. In the fall of 2023, the North Carolina General Assembly passed Session Law 2023-137. Section 6 of this legislation requires anyone holding a commercial fishing license who is engaged in a commercial fishing operation to report all fish (including shellfish) harvested to NCDMF, regardless of if the fish are sold or kept for personal consumption. Currently, this legislation is effective December 1, 2025. NCDMF is working on draft rules to implement this law and to develop the reporting mechanism for these participants. Implementation of this law should fill this data gap.

Implementing a licensing or permitting requirement for recreational shellfish harvesters would give the Division the opportunity to inform participants of where to find information on harvest closure boundaries, where to sign up to receive polluted area proclamations or to access temporary closure maps, and where to find information on safe handling practices, particularly as it relates to Vibrio bacteria.

To pursue any of these solutions, significant time and effort will be needed to assess internal program and resource capabilities and limitations. Any legislative changes require a specific process and are ultimately out of NCDMF or MFC control. Given these constraints, NCDMF recommends exploring potential options and solutions outside of the FMP process.

MANAGEMENT OPTIONS

- Status Quo
  - Does not provide reliable estimates of recreational shellfish harvest or effort.
  - Does not provide a mechanism to ensure recreational shellfish harvesters are provided with SSRWQ health and safety information and links to harvest area closures.
- Support the NCDMF to further explore potential options and develop a solution to estimate recreational shellfish participation and landings, and to establish a mechanism to provide all recreational shellfish harvesters with SSRWQ health and safety information outside of the FMP process.

RECOMMENDATIONS

DMF RECOMMENDATION: Support the NCDMF to further explore potential options and develop a solution to quantify recreational shellfish participation and landings, and to establish a mechanism to provide all recreational shellfish harvesters with SSRWQ health and safety information outside of the FMP process.

LITERATURE CITED

NCDMF. 2001a. North Carolina Hard Clam Fishery Management Plan. North Carolina Department of Environment and Natural Resources. North Carolina Division of Marine Fisheries, PO Box 769, Morehead City, NC.

NCDMF. 2001b. North Carolina Oyster Fishery Management Plan. North Carolina Department of Environment and Natural Resources. North Carolina Division of Marine Fisheries, PO Box 769, Morehead City, NC.

Appendix 3: Hard Clam Management in Other States

State	Fishery	License Requirements	Trip Limit	Size Limit	Gear Limit	Open Season Area
Maine	Recreational	No state license. License by town.	1 peck per person/day (peck is 1/4 of a bushel)	1 inch hinge width	Limited to hand rakes and tongs	-
	Commercial	State license	-	-	-	
New Hampshire	Recreational	State license	No open season for *Mercenaria mercenaria*. Regs for other clam species	No limit	-	No open season
	Commercial	-	-	-		-
Massachusetts	Recreational	No state license, towns have local restrictions & permits	Consult town regs	1 inch shell thickness	-	-
	Commercial	Town permit and shellfish ID card issued by Mass DMF	40 Bu/Day	1 inch thickness (wild)		
Rhode Island	Recreational	Required only for non-residents	(Shellfish management areas)Resident limit: 1 peck/person. Non resident: 1/2 peck/person. (Non-management areas) Resident: 1/2 BU/person. Non resident: 1 peck/person	1 inch hinge width	-	-
	Commercial	-	Bay Quahog: Shellfish management areas: 3 BU/person/day with exceptions. Non management areas: 12 BU/person/day	-	Bay Quahog: No person shall dig and/or take any bay quahogs from the waters of this State by dredge(s), rakes, or other apparatus operated by mechanical power or hauled by power boats, unless otherwise provided for in these regulations.	

Connecticut	Recreational	No State, towns have local restrictions and permits	1/4 - 1/2 BU variable by town	1.5-2 inches variable by town	-	-
	Commercial	State license	-	-		
New York	Recreational	No State, towns have local restrictions on permits, and residency requirements	100 clams/day	1 inch thickness	Only rakes and tongs allowed	Open areas - year round
	Commercial	Shellfish digger permit required	No limit	-	No mechanical	-
New Jersey	Recreational	State license	150 clams	1.5 inches length	Hand implements only	No harvest on Sundays
	Commercial	State license + training course	-	1- 1.5 inches length	No mechanical or motive power	-
Delaware	Recreational	State license. For >100 but <500 clams need a non-commercial clamming permit.	Residents: 100 clams/day. Non Residents: 50 clams/day	1.5 inches or larger	Hand held rake only	Clamming prohibited 30 min before sunrise and after sunset.
	Commercial	Commercial clam tong/rake license	2,500 clams/day	-	-	-
		Commercial dredge clam license	no limit			
Maryland	Recreational	None, must be state resident.	250 clams/day	1 inch transverse measurement	Hand operated gear only. No mechanical harvesting.	-
	Commercial	State license	No limit	1 inch transverse measurement	Hydraulic Dredge: sunrise to 4pm. Other gear: sunrise to sunset	Harvest only in Pocomoke and Tangier Sound. 1/1 - 5/31 & 9/15 - 12/31
Virginia	Recreational	None	250 clams/day by hand or tongs from open areas	-	Hand or ordinary tongs	-
	Commercial	State license	-		-	
North Carolina	Recreational	None	100 clams/person/day	1 inch thick	Hand or rake	Year round
	Commercial	State license	Hand harvest 6,250 clams/ trip. Mechanical harvest limits vary by open water body	1 inch thick	Hand or mechanical implements	Hand harvest open year-round. Mechanical harvest is second Monday in Dec – March 31

South Carolina	Recreational	State license	1/2 BU clams/person/day	1 inch think	Hand operated gear	No harvest from 5/15 - 9/1
	Commercial	State license	No limit	-	-	-
Georgia	Recreational	State license and free permit	1 BU clams/person/day	3/4-inch depth (perpendicular to hinge)	Hand or handheld implements	Clamming prohibited 30 min before sunrise and after sunset. Approved locations
	Commercial	State license	No limit			
Florida	Recreational	State license	One 5-gallon bucket/person/day	1 inch think across the hinge	-	Year round
	Commercial	Aquaculture license	-	-		-

Appendix 4: Hard Clam Fishery Management Plan Advisory Committee Workshop Summary

ISSUE

Summarize stakeholder input received during the Oyster & Clam Fishery Management Plans Advisory Committee Workshop.

ORIGINATION

The North Carolina Division of Marine Fisheries (DMF).

BACKGROUND

The Oyster-Clam Fishery Management Plans (FMPs) Advisory Committee (AC) met for a three-day workshop July 15, 16, and 27 at Craven Community College in New Bern. As these two fisheries share considerable overlap in their ecology and management, these FMPs are revised simultaneously though written separately. The purpose of the workshop was for the AC to assist DMF staff in evaluating management issues and options included in the draft documents of Amendment 5 for the Eastern Oyster FMP and Amendment 3 for the Hard Clam FMP. Specifically, DMF sought to solicit feedback and input on the impacts of management options on the oyster and clam resources and user groups. It is important to note the aim of the AC workshop was to receive input from committee members based on their experiences, expertise, and sector relationships, not to build a consensus among AC members or to recommend specific management strategies.

For the Hard Clam FMP, DMF staff presented overviews of the base plan (life history, stock status, description of the fisheries, habitat impacts, and environmental threats), mechanical clam harvest issue paper, and the recreational shellfish harvest issue paper. Each presentation was followed by an opportunity for the AC to ask clarifying questions and discuss the content and management options included in each paper or section of the draft. Below is a summary of the input and subsequent discussions for the base plan and issue papers of Amendment 3. These ideas represent options the AC suggested the Division explore. Division staff explored these options and discussed where they could be incorporated into the base plan and issue papers.

DISCUSSION

Base Plan

Members of the AC suggested adding more demographic information in the mechanical and hand harvest fishery. The AC also suggested more graphs comparing private harvest and commercial harvest. They noted clam aquaculture has been slow to grow due to limited seed supply in NC.

Similar to oyster, the AC emphasized the importance of water quality and its importance to SAV. Since water quality issues are explored extensively in the Coastal Habitat Protection Plan and enforced by the Division of Water Resources, the AC suggested strengthening ties to the CHPP in the base plans.

Mechanical Clam Harvest

The division brought forward several options to AC members to address the mechanical clam harvest issue. Options included phase out of the fishery and further reducing the mechanical clam harvest areas to make enforcement easier. The division also presented an option to end the allowance for mechanical clam harvest in conjunction with maintenance dredging operations.

Members of the AC expressed concerns with discontinuing the mechanical clam harvest fishery. They noted this fishery is an important source of supplemental income for a small group of mostly retired people. Members also stated the fishery has an important historical significance to the state and to their heritage and should, therefore, be preserved. They also stated many of the participants in this fishery are aging out and hope to pass the tradition and equipment on to their children to continue the practice.

Members of the AC expressed support for changing the boundaries of the mechanical clam harvest areas to be more easily enforced. They were open to areas being reduced in size if input from fishermen was considered when defining the new boundaries.

AC members did not believe the mechanical clam harvest fishery was a major source of turbidity, SAV degradation, or any other water quality concerns. They felt protecting these habitats should not come at the cost of the clam fishery. There was broad support for further protections and research on SAV, but the focus should be on large-scale threats, such as prop scarring from recreational vessels.

Recreational Shellfish Harvest

AC members recognized the potential widespread impact of recreational shellfish harvest, particularly with high tourism occurring along the coast and harvest effort being largely undocumented. The AC workshop further highlighted the importance of understanding this impact as estimating recreational harvest would be necessary for a future stock assessment. Members of the AC recognized the potential scale of recreational harvest and the importance of filling the current data gap. As such, the AC voiced support for taking steps to collect this data, either through survey or temporary permit, until a recreational license could be put in place. Additionally, the AC identified the importance of a system in place to improve public education for safe harvest practices and reduce consumption during warm months. Listing public health as a concern furthered the discussion to the potential economic impact Vibrio cases might have on North Carolina’s shellfish fisheries. Ultimately, the AC agreed that a nominal permit would be a great step before a license to promote education and to collect recreational data.