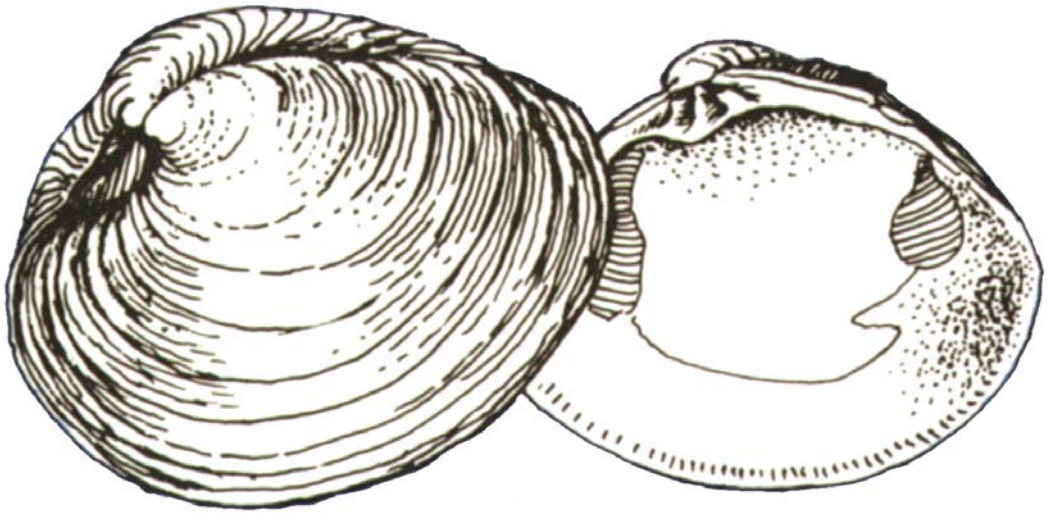
North Carolina
Fishery Management Plan

Hard Clam



North Carolina
MARINE
FISHERIES
Dept. of Environment and Natural Resources

August 2001

North Carolina
Hard Clam
Fishery Management Plan

By

The North Carolina Division of Marine Fisheries

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1.0 ACKNOWLEDGMENTS

The 2001 North Carolina Hard Clam Fishery Management Plan (FMP) was developed by the North Carolina Department of Environment and Natural Resources Division of Marine Fisheries (DMF) under the direction of the North Carolina Marine Fisheries Commission (MFC) with the advice of the Oyster/Hard Clam Advisory Committee (AC). Deserving special recognition are the members of the Oyster/Hard Clam Advisory Committee and the Plan Development Team who contributed their time and knowledge to this effort.

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3.0 EXECUTIVE SUMMARY

Hard Clam Stock Status: Unknown because of insufficient data.

Problem Areas: (A) Harvest issues – (1) Low harvests in Mechanical clam harvest fishery in Core Sound, (2) High potential for large number of harvesters in license system, (3) Need for more relay. (B) Private culture – (1) Insufficient industry support, (2) Opposition over water use concerns. (C) Insufficient data – (1) Cannot calculate optimum yield. (D) Environmental issues – (1) Increase efforts to restore water quality, (2) Increase production by habitat enhancement.

Goals and Objectives: The goal of the North Carolina Hard Clam FMP is to manage wildstock and cultured hard clams in North Carolina in a manner that conserves the stock and protects its ecological value so that it may achieve an optimal yield. To achieve this goal, it is recommended that the following objectives be met:

1. Protect and maintain the hard clam stock from overharvest and depletion, while maintaining levels of harvest at sustained production

2. Identify and promote research to improve the understanding of hard clam biology, ecology, population dynamics, and aquaculture requirements.

3. Initiate, enhance, and/or continue studies to collect and analyze economic, social, and fisheries data needed to effectively monitor and manage the hard clam fishery.

4. Identify, develop and promote clam-harvesting practices that reduce harvesting costs while protecting valuable habitat.

5. Investigate stock and bottom enhancement measures for both wild stock and cultured clams.

6. Develop a regulatory process that provides adequate resource protection, optimizes the harvest, and provides sufficient opportunity for recreational clamming, commercial clamming, and aquaculture.

7. Make recommendations on improvements to coastal water quality so that production of hard clams is optimized.

8. Consider the socio-economic concerns of all user-groups while providing for fair allocation of the resource.

9. Investigate methods of protecting spawning stock.

10. Investigate ways to develop more effective clam relay techniques

Public Fishery Aspects: The clam industry has existed since the 1880s when dealers from Virginia sent boats to the Ocracoke area to buy clams. Landings fluctuated over time because of changes in demand, processing plants, hurricanes and improved harvesting. Dredging clams began in the 1940s and evolved into "clam kicking," a very efficient method of harvesting clams. Hydraulic dredges came into the fishery in the 1960s. There are also several hand methods such as signing, treading, hand raking, hand tonging and bullraking. From 1994 -1999, landings have averaged approximately 57,660 bushels a year while average mechanical harvest landings are 17,877 bushels for the same time period. Number of hand harvest trips have fallen from 52,000 to 31,000 while number of mechanical harvests trips have risen from 985 to 1723 from 1994 to 1999.

Private Fishery Aspects: Although North Carolina law did not formally prescribe the methods for obtaining private shellfish bottom until 1858, laws existed giving private shellfish growers special privileges in harvesting and selling their shellfish as early as 1855. However, there is no evidence that clam culture existed before 1950 although several leases existed for holding surplus clams until market conditions improved. As the technology for spawning and rearing clams improved, more clam culture operations came to exist and over the next 15 to 20 years, experienced varying levels of success. Today, the DMF administers a shellfish lease program whereby State residents may apply to lease estuarine bottom and water column leases for commercial production. Now, hard clams are the principal species produced on leased bottom n North Carolina. Presently, there are 284 leases making up 2,121 acres in eight coastal counties that planted and harvested clams in 1999 with Carteret County being the number one producer of hard clams from leases.

Recreational Fishery: Hard clams are also harvested recreationally by hand and rakes. Little data are collected on the recreational harvest of shellfish in general and none are collected on the recreational harvest of hard clams specifically.

Economic Status: The value of hard clams harvested in North Carolina gradually increased from $163,000 in the early 1970s to a peak of $8.4 million in 1989. Th landed value of hard clams was approximate $3.8 million in 1999. Commercial hard clam fishermen are not fully dependent on hard clams and on average, hard clams account for 22% of the total reported fishing income during 1998-1999 for those fishermen reporting sales of hard clams. Aquaculture accounted for 22.5% of leaseholders total household income.

Management Options: Section 9.0 in the FMP provides background and discussion of the 28 issues considered by the staff and advisory committee in drafting the recommendations.

Optimum Yield: Because of lack of data, optimal yield (OY) cannot be estimated for hard clams at this time. However, based on stable harvest trends in trip ticket data, it is

recommended that the hard clam fishery be allowed to harvest at current catch/trip limits with the exception of Core Sound. It was recommended to lower the Core Sound mechanical harvest bag limit from 25 bags to 15 bags per vessel per day. This recommendation was made because trip ticket data indicates that mechanical harvest of Core Sound have declined in the past several years. However, the MFC was concerned with economics of a 15 bag limit and recommended lowering the bag limit to 20 bags.

3.1 MFC Selected Management Strategies

The MFC adopted the following as management strategies for the Draft Hard Clam Fishery Management Plan. Comments from the secretary of DENR have also been incorporated in this draft. Proposed rule and statute changes required to implement the management strategies may be found in the Appendix.

3.1.1 MFC Optimum Yield Recommendation

It is recommended that the hard clam fishery be allowed to harvest at current catch/trip limits with the exception of Core Sound. It is recommended to lower the Core Sound mechanical harvest bag limit from 25 bags to 20 bags per vessel per day.

3.1.2 MFC Selected Management Strategies and Required Actions

The strategies listed below are grouped into those that can be accomplished with no increase in funding and no reallocation of personnel/funds (Tier 1); can be accomplished with no increase in funding but will require reallocation of personnel/funds at the division level (Tier 2); and can only be accomplished with additional funding (Tier 3). Since the management of clams is not subject to federal and regional management groups, funding is almost exclusively a state responsibility. Hard clam management has focused on mechanical harvesting practices and protection of sensitive habitats. Comprehensive management of the clam resource will require population assessments and habitat enhancement programs. The strategies developed to improve hard clam management were not limited to those not requiring funding, but included all strategies required to produce the best management plan possible. A prioritization of strategies requiring funding and consequences of failure to fund those strategies follows Tier 3.

Tier 1 – No additional funding or reallocation of funds/personnel required

STRATEGY	Required Action
Insufficient Data	
1. Support adoption of a mechanism that would provide data on recreational shellfish harvest and add “pleasure” category to the existing Shellfish License	**Statute Change**
Management Strategies	
1. Rotate southeast Pamlico Sound area with Core Sound.	**Rule Change**

2. Lower the bag limit in Core Sound to 20 bags. Pamlico Sound area bag limit would also be 20 bags.	Existing Authority
3. Continue to allow all NC residents to purchase a shellfish license.	Existing Authority
4. Status quo on nighttime unloading rule.	Existing Authority
Private Culture	
1. Change operational policy to increase use of marginal polluted areas for shellfish leases.	MOA with DEH
2. Inform public about Department of Agriculture and Department of Environment and Natural Resources roles concerning shellfish culture.	Department of Agriculture
3. Formalize and amplify current policy on transfers on out-of-state shellfish into NC waters.	Existing Authority
4. Recommend adoption of a statutory policy statement supporting shellfish culture insofar as it does not interfere with traditional fishing practices	**Statute Change**
5. Amend shellfish lease production rule to require harvest and sale of 10 bushels of shellfish per acre per year AND planting of 50 bushels of cultch or 25 bushels of seed per acre per year to maintain lease production.	**Rule Change**
6. Status quo on opportunities for riparian landowners to culture shellfish.	Existing Authority
7. Recommend water column lease fees change to an amount **ten** times the fee for bottom leases ($100 per acre according to current recommendations).	**Statute Change**
8. Continue to record clam production units as bushels.	Existing Authority
9. Recommend adoption of a statutory requirement for shellfish culture training certification for new applicants for shellfish leases. Training for existing leaseholders meeting production requirements would not be required.	**Statute Change**
10. Recommend shellfish lease fees be set as follows: application fee - $200 renewal application fee - $100, rental fee - $10 per acre per year. Also recommend a change in the term of the lease contract to expire July 1 to facilitate proper renewals.	**Statute Change**
11. Apply Fisheries Reform Act requirements to a revised, organized, upgraded permit system.	Existing Authority
Habitat and Water Quality	
1. Increase use of existing statutory authority (permit comments, CHPP development) to reverse the trends in closure of shellfish waters to harvest	Existing Authority
2. Develop strategies to restore water quality of Conditionally Approved harvest area and maintain water quality of Approved harvest areas by: - Classifying Conditionally Approved Open shellfish waters as Partially Supporting - Classifying Conditionally Approved Closed shellfish waters as Not Supporting - Adopting standards that limit total impervious cover immediately adjacent	Resolution to EMC

to SA waters to 10 percent - Requiring mitigation that results in water quality enhancements in permanently closed areas.	
3. Recommend specific changes to DWQ and EMC.	Existing Authority

Tier 2- Reallocation of personnel/funds required at Division level; no additional funding required

Management Strategies	
1. Continue to relay oysters as normal and increase the intensity of the recent clam relay schedule.	Existing Authority
Private Culture	
1. Continue the statutory shellfish lease program and increase relaying to public bottom to address concerns over use of public resources.	Existing Authority
2. Designate and plant cultch on managed seed beds for use on leases and franchises.	Existing Authority
Habitat and Water Quality	
1. Implement additional experimental closures of oyster areas based on habitat value for both oysters and clams.	Existing Authority
2. Enhance clam habitat by planting shell and other material.	Existing Authority
3. Examine methodologies to potentially enhance clam populations by planting seed clams in combination with habitat enhancement.	Existing Authority

Tier 3-Additional Funding Required

Priority 1- Required for management according to statutory standards

Priority 2- Needed to facilitate clam harvesting and support private culture

Insufficient Data	**Required Action**	**Priority**
1. Expand Shellfish mapping program.	Existing Authority	**1**
2. Expand catch/effort sampling of hard clam catches.	Existing Authority	**1**
3. Develop a fishery independent sampling program to determine population abundance.	Existing Authority	**1**
Private Culture		
1. Develop and utilize user coordination plans to assess areas for shellfish leasing.	**Rule Change**	**2**
2. Request funding research, disease, and education centers for shellfish culture.	Existing Authority	**2**
3. Recommend increased funding to Shellfish Sanitation.	Existing Authority	**2**

3.1.3 Consequences of and Alternatives for Failure to Fund the Tier 3 Clam FMP Strategies

Priority 1 Strategies

The first priority for additional funding is a shellfish population assessment staff to collect fishery dependent and independent data so that maximum sustainable yield (MSY) may be calculated. This would allow OY to be calculated in order to meet the standards of the Fishery Reform Act (FRA). Secondly, expansion of the shellfish mapping program is recommended so the program can provide timely results and baseline data for independent data collection for stock assessments. The funding of these two management actions is part of the first objective of protecting the hard clam stock from overharvest.

The best alternative to funding this priority is to establish a proxy MSY from landings data and the limited fishery dependent data that is available (1999-2000). However, using landings data as a means to calculate a proxy MSY would increase the risks of overestimating or underestimating the population so that an OY may be inaccurate.

Priority 2 Strategies

The third funding priority affects private shellfish culture and research. This priority includes funding for human use mapping of coastal waters. Human use mapping has already been completed in Core Sound where the majority of lease allocation issues occurs and can already be utilized in that area. This funding priority addresses several objectives in the clam plan (#3, #6, #8) such as user allocation and opportunities as well as providing economic and social data. Funding for research centers specifically for shellfish research is aimed at increasing private production of shellfish but has implications for wild harvest as well. By not funding additional human use mapping studies, user conflicts between wild harvesters and private culturists will be prolonged. Consequences of not funding the research centers will make it harder for private culturists to have cutting edge technology readily available to them and will deprive the Division of up to date shellfish research applicable to shellfish management as well.

It had been requested by the Clam and Oyster FMP Advisory Committee as well as the public that additional funding be made available to shellfish sanitation so that sampling time required for reopening of temporary closures can be reduced. By adding additional Shellfish Sanitation staff to sample areas and get quicker results, areas may be reopened in a more timely matter, shortening the time harvesters are out of work. However, increased sampling does not necessarily guarantee an area will reopen to harvest more quickly. Openings of areas are based on the results of the samples gathered

and must meet national standards for shellfish consumption, regardless of the timeliness of the sampling.

4.0 INTRODUCTION

4.1 Legal Authority for Management

Fisheries management includes all activities associated with maintenance, improvement, and utilization of the fisheries resources of the coastal area, including research, development, regulation, enhancement, and enforcement.

Many different state laws (General Statutes - G.S.) provide the necessary authority for fishery management in North Carolina. General authority for stewardship of the marine and estuarine resources by the North Carolina Department of Environment and Natural Resources (DENR) is provided in G.S. 113-131. The Division of Marine Fisheries (DMF) is the arm of the Department that carries out this responsibility. The North Carolina Marine Fisheries Commission (MFC) is charged to "manage, restore, develop, cultivate, conserve, protect, and regulate the marine and estuarine resources of the State of North Carolina" (G.S. 143B-289.51). The MFC can regulate fishing times, areas, fishing gear, seasons, size limits, and quantities of fish harvested and possessed (G.S. 113-182 and 143B-289.52). General Statute 143B-289.52 allows the MFC to delegate the authority to implement its regulations for fisheries "which may be affected by variable conditions" to the Director of DMF who may then issue public notices called "proclamations". Thus, North Carolina has a very powerful and flexible legal basis governing coastal fisheries management. The General Assembly has retained the authority to establish commercial fishing licenses, but has delegated authority to the MFC to set individual permit fees for various commercial fishing gears.

The Fisheries Reform Act of 1997 (FRA) established a process for preparing coastal fisheries management plans in North Carolina. The FRA states that "the goal of the plans shall be to ensure the long-term viability of the State's commercially and recreationally significant species or fisheries. Each plan shall be designed to reflect fishing practices so that one plan may apply to a specific fishery, while other plans may be based on gear or geographic areas. Each plan shall:

a. Contain necessary information pertaining to the fishery or fisheries, includiing management goals and objectives, status of the relevant fish stocks, stock assessments for multi-year species, fishery habitat and water quality considerations consistent with Coastal Habitat Protection Plans (CHPP) adopted pursuant to G.S. 143B-279.8, social and economic impact of the fishery to the State, and user conflicts.

b. Recommend management actions pertaining to the fishery or fisheries.

c. Include conservation and management measures that prevent overfishing, while achieving, on a continuing basis, the optimal yield from each fishery."

Optimal yield is defined in the FRA as "The amount of fish that:

a. Will provide the greatest overall benefit to the State, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems;

b. Is prescribed on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and

c. In the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in the fishery."

The MFC decided the Hard Clam FMP would be written in conjunction with the Oyster FMP because of coincident fisheries, shared habitats and similar fishing practices. The Eastern Oyster was considered a priority species for the development of an FMP because the 1998 DMF Stock Status Report (SSR) designated the stock as depressed. DMF changed stock status designation in 1999 to "overfished" and later to "concern."

4.2 General Problem Statement

Issues that will be addressed in this Hard Clam FMP are: 1) insufficient data; 2) management strategies; 3) private culture; and 4) habitat and water quality.

4.2.1 Insufficient Data

Data limitations prevent DMF from conducting a hard clam stock assessment and calculating MSY and OY. Prior to 1994, hard clam data for North Carolina were limited to landings from the commercial fishery and a number of short-term surveys. **The statutory obligation to manage hard clams according to optimum yield cannot be met until the appropriate data are collected.** While landings records will reflect population abundance to some extent, the relationship is confounded by changes in harvest effort and efficiency. The trip ticket program, initiated in 1994, provides commercial landings as well as individual trip information. A fishery-dependent monitoring program was initiated in 1999 to collect biological data that will complement trip ticket landings information. A fishery-independent survey of hard clam is being developed to monitor population abundance. Unfortunately, no data are collected for the recreational harvest of hard clams.

4.2.2 Management Strategies

The hard clam fishery has been managed through harvest limits and size limits.

Mechanical harvest also has gear and area restrictions, and a relay program where clams are moved from certain polluted areas and placed on leases for depuration. No changes in management strategies have occurred because the status of the hard clam is currently listed as unknown. The management program needs to be assessed and modified as data become available. Other management strategies that are addressed include mitigating the effects of temporary closures due to stormwater runoff and resolution of conflicts over oyster rock between clammers and oystermen.

4.2.3 Private Culture

The current shellfish lease system in North Carolina needs to be evaluated and changes implemented in order to make the system productive. Improved allocation of lease areas may reduce conflict between culturists and other user groups, while better monitoring of leases and enforcement of lease requirements would greatly improve acceptance of the program by commercial fishermen. Leaseholder needs for technical support will also be assessed as a means of improving production through private culture.

4.2.4 Habitat and Water Quality Issues

Adequate habitat and suitable water quality are imperative to the hard clam. Recommendations to other agencies, such as the Coastal Resources Commission (CRC) and the Environmental Management Commission (EMC), to adopt rules to protect habitat and water quality critical to the hard clam must be pursued. The MFC and DMF will continue to comment on permit applications involving shoreline development that may impact shellfish areas. These recommendations should include ways to prevent or minimize potential impacts such as stormwater run-off, sedimentation, and pollutants. Other habitat issues that can be addressed by the Division, is habitat enhancement for hard clams, the effects of mechanical harvest on habitat, and the effects of clam harvest on oyster rock.

4.2.5 Goals and Objectives

The goal of the North Carolina Hard Clam FMP is to manage wildstock and cultured hard clams in North Carolina in a manner that conserves the stock and protects its ecological value so that it may achieve an optimal yield. To achieve this goal, it is recommended that the following objectives be met:

1. Protect and maintain the hard clam stock from overharvest and depletion, while maintaining levels of harvest at sustained production

2. Identify and promote research to improve the understanding of hard clam biology, ecology, population dynamics, and aquaculture requirements.

3. Initiate, enhance, and/or continue studies to collect and analyze economic, social, and fisheries data needed to effectively monitor and manage the hard clam fishery.

4. Identify, develop and promote clam-harvesting practices that reduce harvesting costs while protecting valuable habitat.

5. Investigate stock and bottom enhancement measures for both wild stock and cultured clams.

6. Develop a regulatory process that provides adequate resource protection, optimizes the harvest, and provides sufficient opportunity for recreational clamming, commercial clamming, and aquaculture.

7. Make recommendations on improvements to coastal water quality so that production of hard clams is optimized.

8. Consider the socio-economic concerns of all user-groups while providing for fair allocation of the resource.

9. Investigate methods of protecting spawning stock.

10. Investigate ways to develop more effective clam relay techniques

4.3 Definition of a Management Unit

The management unit includes the hard clam (*Mercenaria mercenaria*) and its fisheries in all waters of coastal North Carolina.

4.4 Existing Plans, Statutes, and Rules

4.4.1 Plans

There are no federal or interstate FMPs regulating hard clams in North Carolina. A state hard clam FMP was written in 1997 but was never finalized and did not address private culture issues.

4.4.2 Statutes

North Carolina General Statutes (G.S.) 113-134, 113-182, and 143B-289.54 give the North Carolina Marine Fisheries Commission broad authority to promulgate rules for the management of marine and estuarine resources, including clams, in coastal fishing waters. General Statute 113-201 also empowers the MFC to make rules and take all steps necessary to develop and improve the cultivation, harvesting, and marketing of shellfish

in North Carolina from public grounds and private beds. Propagation of shellfish by the DENR both for public or private beds is authorized under G.S. 113-204.

Aquaculture, including the aquaculture of estuarine shellfish, is under the jurisdiction of the North Carolina Department of Agriculture. That department and its Aquaculture Advisory Board are charged with reviewing and making recommendations on policies, laws, and regulations to facilitate aquaculture development. The powers and duties associated with this charge are contained in North Carolina General Statutes 106-756 through 106-760.

The MFC has jurisdiction, as provided in G.S. 113-132, over all activities connected with the conservation and regulation of marine and estuarine resources, including the regulation of aquaculture facilities (as defined in G.S. 106-758) which cultivate or rear marine and estuarine resources.

Other North Carolina General Statutes that address specific items relating to the hard clam fishery are listed as follows:

- Standard Commercial Fishing License (SCFL) $200.00 NC residents -This is an annual license available to all fishermen with a current/valid endorsement to sell license as of June 30, 1999. This license may be transferred or assigned. This license allows for the commercial harvest and sale of finfish, crabs, and shrimp except for menhaden and shellfish. A shellfish endorsement is available to NC residents only, at no charge (G.S. 113-168).
- Shellfish License (NC residents only) $25.00 - This is an annual license for NC residents only. This license allows for the commercial harvest of shellfish and the sale of shellfish to licensed seafood dealers. This license cannot be transferred. If a vessel is used in the harvest of shellfish, then a commercial fishing vessel registration is also required (G.S. 113-169.2).
- License for Fish Dealers $50.00 - This is an annual license for NC residents only. This allows the holder to buy clams from sellers who possess a current and valid standard commercial fishing license with a shellfish endorsement or a shellfish license (G.S. 113-169.3).
- Commercial Fishing Vessel Registration - This is a requirement for commercial fishermen who use boats to harvest seafood. The fee is based on boat length; fees range from $1.00 to $6.00 per foot (G.S.113-152).
- Fisheries Management Plans. This requires the DENR to prepare and the MFC to adopt fishery management plans for commercially or recreationally significant species (G.S. 113-182.1).
- Penalties for violations - Penalties for shellfishing in a area closed because of suspected pollution is guilty of a class A1 misdemeanor (G.S. 113-187).
- New and renewal leases for shellfish cultivation - Shellfish leases meeting certain standards are granted in coastal fishing waters with the exception of Brunswick County and Eastern Core Sound (G.S. 113-202).

- Water column leases for aquaculture - This authorizes the Secretary to allow leasing of water columns (G.S. 113-202.1).
- Water column leases for perpetual franchises - This authorizes the Secretary to allow leasing of water columns to franchises (G.S. 113-202.2).
- Transplanting of oysters and clams - This establishes rules for transplanting shellfish to private beds (G.S. 113-203).
- Propagation of shellfish - This authorizes the Department to close areas of public bottom as necessary in any program of propagation of shellfish (G.S. 113-204).
- Registration of grants in navigable waters - This establishes authority for the MFC to make rules governing utilization of private shellfish bottom arising out of shellfish franchises (G.S. 113-205).
- Chart of grants, leases and fishery rights; overlapping leases and right; contest or condemnation of claims; damages for taking of property - This statute provides for resolution of submerged lands conflicts (G.S. 113-206).
- Clamming on posted oyster rocks forbidden; penalty - It is unlawful to take clams from posted oyster rocks by use of rakes or tongs. A violation is a class 3 misdemeanor (G.S. 113-207).
- Protection of private shellfish rights - This statute makes it unlawful to remove shellfish from a lease by anyone other than the owner. Violation of this is a class 2 misdemeanor (G.S. 113-208).
- Taking polluted shellfish at night or with prior conviction forbidden; penalty - This statute establishes the act of taking polluted shellfish at night is a Class I felony.
- Robbing or injuring hatcheries and other aquaculture operations - Fines and punishment for robbing or injuring aquaculture operations are set forth in this statute.
- Coastal Habitat Protection Plans - The Plans shall provide for the long term enhancement of coastal fisheries associated with coastal habitats including shellfish beds (G.S. 143B-279.8).

4.4.3 Marine Fisheries Commission Rules

General:

- Dredge is defined as a device towed by engine power consisting of a frame, tooth bar or smooth bar, and catchbag used in the harvest of shellfish and crabs (15A NCAC 3I.0101(b)(12)).
- Mechanical methods of clamming is defined as including but not limiting to dredges, hydraulic clam dredges, stick rakes and other rakes when towed by engine power, patent tongs, kicking with propellers or deflector plates with or without trawls, and any other method that utilizes mechanical means to harvest clams (15A NCAC 3I.0101(b)(13)).
- Depuration is defined as the purification or the removal of adulteration from live oysters, clams and mussels by any natural or artificially controlled means (15A

NCAC 3I.0101(b)(14)).

- Aquaculture operation is defined as an operation that produces artificially propagated stocks of marine or estuarine resources or obtains such stocks from authorized sources for the purpose of rearing in a controlled environment (15A NCAC 3I.0101(b)(19)).
- Shellfish producing habitats is defined as a critical habitat where economically important shellfish historically or currently reproduce and survive (15A NCAC 3I.0101(b)(20)(B)).
- Intertidal Oyster Bed is defined as a formation of shell and live oysters of varying density (15A NCAC 3I.0101(b)(21)).
- Shellfish production on leases and franchises is defined as the culture and/or transplanting of shellfish on leases and franchises (15A NCAC 3I.0101(b)(26)(A)(B)).
- Shellfish marketing from leases and franchises are defined as the harvest of shellfish from privately held shellfish bottoms and lawful sale of those shellfish to the public at large or to a licensed shellfish dealer (15A NCAC 3I.0101(b)(27)).
- Shellfish planting effort on leases and franchises is defined as the process of obtaining authorized cultch materials, seed shellfish, and polluted shellfish stocks and the placement of those materials on privately held shellfish bottoms for increased shellfish production (15A NCAC 3I.0101(b)(28)).
- It is unlawful to introduce, transfer or hold any live aquatic animals or plants not native to the state without first obtaining a permit from the Fisheries Director (15A NCAC 3I.0104 (a)(1)(2)(3)(b)(c)).
- It is unlawful to conduct aquaculture operations without a permit and to take fisheries resources during a closed season without a permit. It is unlawful to sell or use fisheries resources for non-aquacultural operations, taken during a closed season under a permit (15A NCAC 3I.0111 (a)(b)(1)(2)).
- It is unlawful to not submit an annual report specifying the amount and disposition of fishery resources and to refuse to allow fisheries agents to inspect aquaculture operations (15A NCAC 3I.0111 (3)(4)).

Shellfish general

- Harvesting of clams from polluted public bottom may only occur between April 1 through It is unlawful to possess, sell, or take oysters, clams or mussels from prohibited (polluted) areas in or out of North Carolina. The fisheries director may close areas to the taking of oysters, clams, scallops and mussels in order to protect shellfish populations for management purposes or for public health purposes (15A NCAC 3K .0101 (a) (b) (c)).
- It is unlawful to possess or sell oysters, clams, or mussels without a harvest tag affixed to each container. Tags should be durable for at least 90 days, and should be securely fastened to the outside of each container. Tags should have legible information including the harvester s name, address, and license number, harvest date, harvest location, type, and quantity (15A NCAC 3K .0101 (d)).

- The Fisheries Director may designate Shellfish Management areas based on certain criteria such as bottom type, salinity, cover, and the ability to produce commercial shellfish populations (15A NCAC 3K.0103 (a)(1)(2)(3)).
- It is unlawful to use a trawl net, long haul seine, or swipe net in a Shellfish/Seed Management area. It is unlawful to take oysters or clams from a closed Shellfish/Seed Management area. A permit is required to take oysters or clams from a Seed Management area for planting on private bottom (15A NCAC 3K.0103 (b) (c) (d)).
- Harvesting of clams from polluted public bottom may only occur between April 1 through May 15 and only with a permit (15A NCAC 3K.0104 (a) (1) (2)).
- The Fisheries Director shall close and reopen any private shellfish bed for which the owner has obtained a permit to relay oysters and clams from polluted public bottom (15A NCAC 3K.0104 (b)).
- The recreational harvest limit for clams is one hundred clams per person per day, not to exceed two hundred clams per vessel per day (15A NCAC 3K.0105 (b)).
- It is unlawful to take clams on Sundays except in recreational quantities (15A NCAC 3K.0105 (c)(1)(2)).
- It is unlawful to take oysters or clams, unload oysters or clams, or remove any vessel containing oysters or clams between the hours of sunset and sunrise on any day. Oysters and clams taken in New Hanover, Pender and Brunswick Counties may be unloaded two hours after sunset (15A NCAC 3K.0106 (a) (b)).
- It is unlawful to take clams, oysters, or mussels from polluted waters for depuration except when the harvest utilizes shellfish that would be destroyed in maintenance dredging operations. The fisheries director may impose restrictions on harvest. A permit is required to harvest clams, oysters or mussels from polluted waters for depuration (15A NCAC 3K.0107 (a) (b)(1)(2)(3)(4)(5)(6)(7)(c)(1)(2)(3)).
- Oysters, clams, or mussels harvested from polluted areas for depuration shall be transported under the supervision of the Division of Marine Fisheries only to facilities located in North Carolina unless the facility is in compliance with the applicable rules and laws of the shellfish control agency of that state (15A NCAC 3K.0107 (d) (1) (2) (e)).

Hard clams

- It is unlawful to take, land, or possess aboard a vessel more than 6,250 clams per fishing operation from public bottom. It is unlawful to take, possess, sell or purchase any clams less than one inch thick, except for hatchery/aquaculture clams (15A NCAC 3K.0301 (a) (b) (1) (2)(3)).
- It is unlawful to take buy, sell, or possess any clams taken by mechanical methods from public bottom except when the Fisheries Director may open and close the season in the ocean and between December 1 through March 31 in internal waters. Areas that may be open are Core and Bogue Sounds, Newport, North, White Oak and New Rivers (15A NCAC 3K.0302 (a) (1) (2) (3) (4) (5) (b)).

- Permits are required to harvest hard clams by mechanical methods from public or private bottom (15A NCAC 3K.0303 (a) (b) (1) (2) (3) (4)).
- It is unlawful to take clams by any method, other than by hand tongs, hand rakes 12 inches or less, or by hand in an oyster bed. Only hand rakes 12 inches or less and by hand are allowed in submerged aquatic vegetation and salt water cordgrass (15A NCAC 3K.0304 (a) (1) (2)).
- It is unlawful to have mechanical harvest gear aboard a vessel at any time except during mechanical harvest season (15A NCAC 3K.0304 (b)).
- Possession and sale of hatchery/aquaculture clams are exempted from bag and size limit (15A NCAC 3K.0305).

Nursery areas

- It is unlawful to use mechanical methods for the harvest of clams in a primary nursery area (15A NCAC 3N.0104).

Leases and franchises

- All areas of public bottoms must meet certain criteria in order to be deemed suitable for leasing for shellfish purposes (15A NCAC 3N.0201 (a) (1) (A)(B)(C)(I)(ii)(iii)).
- All leases must produce 25 bushels of clams per acre per year or plant 25 bushels of cultch or seed clams per acre per year (15A NCAC 3N.0201 (2)(A)(B)(C)(D)(I)(ii)(E)(F)).
- Water columns must meet certain criteria in order to be deemed suitable for leasing for aquaculture purposes. purposes. (15A NCAC 3N.0201 (b)(c)).
- All water column leases must produce 100 bushels of clams per acre per year or plant 100 bushels of cultch or seed clams per acre per year (15A NCAC 3N.0201(d)).
- Applications for leases are available from Division of Marine Fisheries and must be submitted along with a management plan, map or diagram of proposed lease area and a filing fee of one hundred dollars (15A NCAC 3N.0202(a)(b)(1)(2)(3)(4)(5)(c)(d)).
- Agents of the Division shall inspect accepted applications of a proposed lease area. After the proposed lease is deemed consistent with applicable requirements, the applicant will be notified and notices of intention published. The Secretary shall consider the lease application, the Division's lease area analysis and public comment and may lease or decline to lease all or any part of the proposed lease. The Secretary may also impose special conditions so that leases may be issued (15A NCAC 3N.0203(a)(b)(c)).
- Approved bottom leases and water column leases must be marked (15A NCAC3N.0204 (a)(1)(A)(B)(C)(2)(b)(c)(d)).

- It is unlawful to exclude or attempt to exclude the public from allowable public trust use of navigable waters on shellfish leases and franchises (15A NCAC 3N.0204(e)).
- Shellfish bottom lease renewals shall be provided in January of the year of expiration and water column lease renewals shall be provided at least 90 days prior to expiration. Lease renewals shall be accompanied by management plans. Fifty dollars is required with renewal application of bottom leases (15A NCAC 3N.0205 (a)(1)(2)(b)).
- A survey for renewals shall be required when the Division determines the area leased is inconsistent with the survey on file. When it is determined that the lessee has not complied with requirements or is inconsistent, the Secretary may decline to renew any shellfish bottom or water column lease. The Secretary is not authorized to recommend approval of renewal of a lease in an area closed to shellfishing because of pollution (15A NCAC 3N.0205 (c)(d)(e)).
- Any member of the public has the right to protest issuance of a leaser and shall be allowed an opportunity to comment on any lease application (15A NCAC 3N.0206(a)(b)).
- Owners of shellfish leases and franchises shall provide annual production reports to the Division. Failure to furnish production reports can constitute grounds for termination (15A NCAC 3N.0207 (a)(b)).
- The Secretary shall begin action to terminate leases and franchises for failure to produce and market shellfish, or for failure to maintain a planting effort at 25 bushels per acre per year on bottom leases and 100 bushels per acre per year for water column leases (15A NCAC 3N.0208(a)(1)(2)(b)(c)(d)(e)).
- A new owner must notify the Division and must provide the number of the lease, location, and a management plan prepared by the new owner within 30 days of transfer of ownership of all or part of a shellfish lease or franchise (15A NCAC 3N.0209(a)(b)).
- Water column leases are not transferable except when the Secretary approves a transfer (15A NCAC 3N.0209(c)).
- It is unlawful to use any bottom disturbing fishing gear on any shellfish lease or franchise unless it has been duly authorized by the Fisheries Director (15A NCAC 3N.0211).

4.4.4 Other Jurisdictions

The Department of Health and Human Services Commission for Health Services is responsible for regulation of human health concerns related to harvest of shellfish for raw consumption by humans. The State Health Director is responsible for North Carolina's compliance with the National Shellfish Sanitation Program (NSSP) of the US Food and Drug Administration. Based on data from his staff (Shellfish Sanitation Section of the Division of Environmental Health), the State Health Director recommends closures of coastal waters to shellfish harvest; the DMF implements closures by proclamation, and enforcement of those closures is conducted by DMF Marine Patrol.

Other than the Food, Drug and Cosmetic Act, under which the NSSP operates, the Lacey Act of 1981 probably has the most authority over shellfish. The National Marine Fisheries Services enforces the Lacey Act, which prohibits import, export, and the interstate transport of illegally taken fish and wildlife, which includes illegally- possessed clams.

The ASMFC approved a plan in 1989 to control the transfer and introduction of shellfish, although it has no authority over shellfish in the states. The plan supports state regulation. A key provision of the plan is the training of state biologists in detection and management of shellfish diseases. The intent is to reduce introductions of diseases and pests from contaminated areas into waters free of such organisms.

5.0 STATUS OF STOCK

5.1 General Life History

The hard clam, *Mercenaria mercenaria*, is distributed from the Gulf of St. Lawrence, Canada to Texas (Abbott 1974) and occurs throughout the south Atlantic region in estuaries from the intertidal zone to depths exceeding 15m (Eversole 1987). Hard clams in North Carolina are most abundant in higher salinity waters inside the barrier islands from Ocracoke southward to the North Carolina/South Carolina border (NC DMF Shellfish bottom mapping data unpublished). They also have been harvested by hand methods in the immediate vicinity of Oregon Inlet and trawlers occasionally take a few while trawling for shrimp or oyster dredging in western Pamlico Sound.

Spawning occurs in North Carolina from spring through fall, when water temperatures reach 20 ^{o}C (68 ^{o}F) (Loosanoff and Davis 1950; Porter 1964). Spawning clams release eggs and sperm through the exhalent siphon into the water, where fertilization occurs and eggs begin rapid development. 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 differentials in water current occur (Carriker 1959). 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). Primary predators of juvenile hard clams are the snapping shrimp, *(Alpheus heterochaelis)*, (Beal 1983), mud crabs (*Neopanope sayi*), blue crabs (*Callinectes sapidus)* (Kraeuter 2001). Several types of snails (*Urosalpinx* sp., *Polinices* sp.), whelks, (*Busycon* sp.), and various waterfowl feed on adult hard clams (Kraeuter 2001).

Although estimates vary widely, fecundity depends on clam size and condition.

Peterson (1986) found that gonad mass increased significantly ($p<0.05$) with shell length and internal volume. There was no evidence of reproductive senility in hard clams up to 46 years of age. However, it was assumed that gamete viability did not vary with size or age and that all gametes were released. Belding (1931) reported that hard clams averaging 63.5mm shell length produced about two million eggs in a spawning season.

Both male and female sex cells are found in the gonad of hard clam juveniles. During the juvenile stage, gonadal cells differentiate and clams become predominately male, then become either male or female as adults. Sexual maturity in hard clams tends to be a function of size not age, and is therefore dependent on growth rates. Sexual maturity is usually reached during the second year of life at a shell length of 1.3 inches (33 mm), but faster growing clams may mature at an earlier age. (Eversole 1987). The legally harvestable size of one inch thick is typically reached by age two to five with three as a reasonable average expectation (C.H. Peterson, UNC Institute of Marine Science, pers. com.).

Growth rates of hard clams are highly variable and depend on water temperature (Ansell 1968), available food supply (Pratt and Campbell 1956), and to some extent, genetics (Chanley 1958). Peterson et al. (1983) reported that annually deposited growth lines could be used for aging clams.

5.2 Stock Status

The status of the hard clam stock in North Carolina is currently listed as unknown because there are no data available to assess the population. Data are now being collected to evaluate the population and estimate maximum sustainable yield (MSY) for the hard clam fishery. Landings data have been recorded since the 1880s but additional effort and survey data necessary to assess the stock are lacking. While landings records will reflect population abundance to some extent, the relationship is confounded by changes in effort, gear technology, aquaculture contributions and market demand.

The apparent sustainability of current harvest levels in a given water body may be detected by examining trends in landings and effort data from the trip ticket program. Additionally, localized trends in mechanical or hand harvest can be analyzed separately in order to assess whether trends are likely to be gear specific or extend to the entire water body.

The average catch per trip for the period 1994-1999 for either hand harvest or mechanical harvest was calculated in each of the major water bodies from which clams are harvested. In order to compare water bodies, the mean catch/trip was expressed as a percentage of the trip limit. In other words, if the average catch per trip was 12.5 bags and the trip limit was 25 bags, then the average catch was 50% of the trip limit. By looking at catch per trip instead of just landings, the problem of varying closure periods across years and water bodies is avoided. Since the confounding effect of variable effort per trip cannot be avoided, it is assumed that effort per trip did not increase or decrease

steadily over the time period.

Based on examination of trip ticket data, mean percent of limit landed per trip remained constant for most water bodies in North Carolina. Hand harvest of clams appeared to be particularly stable (Figure 1). Hand harvesters are limited to a 25-bag trip limit in all water bodies and typically land 5-10% (1.25-2.5 bags) of the trip limit per trip. Mechanical harvest of clams was slightly more variable, however, most water bodies appeared to be stable. An exception was Core Sound (Figure 1) where the percent of the limit landed per trip declined from around 80% in 1994-1995 to about 30% in 1996-1999. During the latter period (1996-1999), mechanical harvest in Core Sound appeared relatively stable. Based on this trend, clam abundance in the area of Core Sound open to mechanical harvest is likely to have declined from 1994-1999. Because of the historical importance of the Core Sound hard clam fishery it is recommended that the mechanical harvest of hard clams from Core Sound be prevented from exceeding current levels (8,320 bushels/year) until data indicate that abundance can support higher take. Based on the average number of trips for the period 1996-1999, a trip limit that would reach the target harvest of 8320 bushels, would be about 15-bags/ trip. In all other water bodies, the apparent stability of current harvest levels suggests that change in harvest policy is not warranted at this time.

DMF optimum yield recommendation

Lower mechanical harvest limit in Core Sound from 25 bags to 15 bags. Continue to harvest in other areas at current levels.

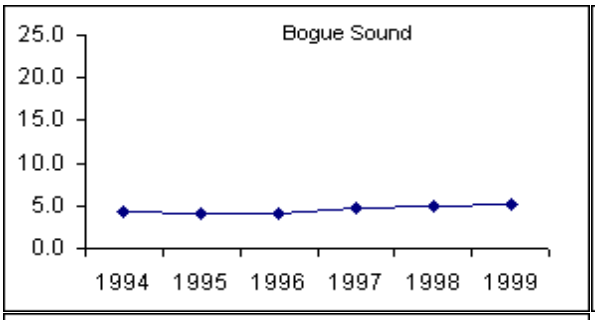
AC optimum yield recommendation

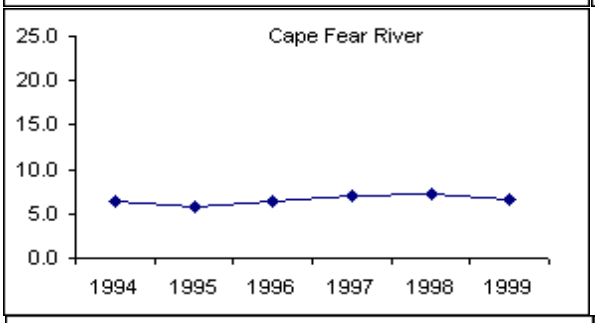
Agreed with DMF

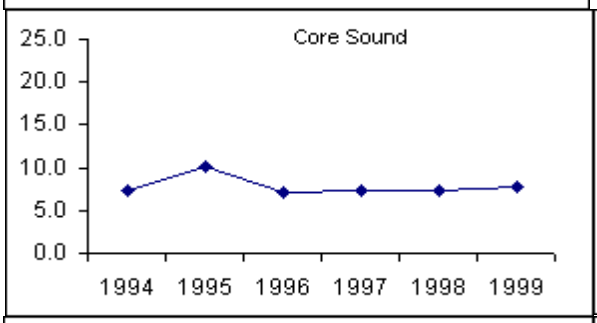
MFC recommended optimum yield management strategies

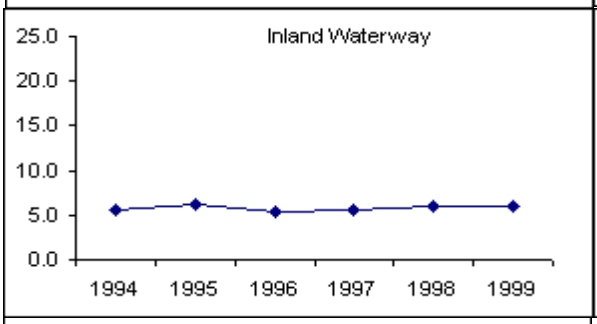
Lower mechanical harvest limit in Core Sound from 25 bags to 20 bags. Continue to harvest in other areas at current levels.

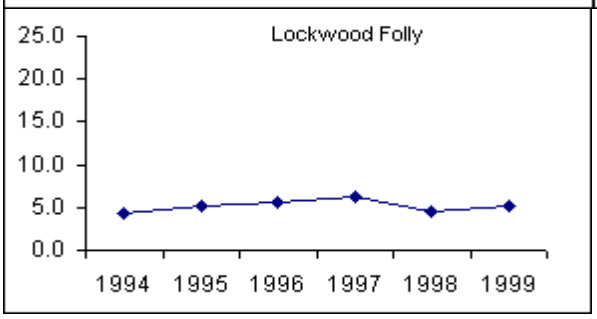
Hand Harvest



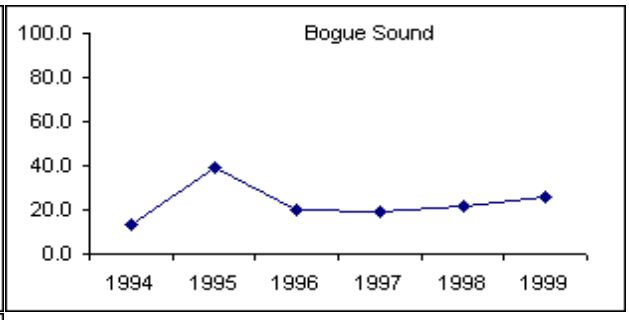


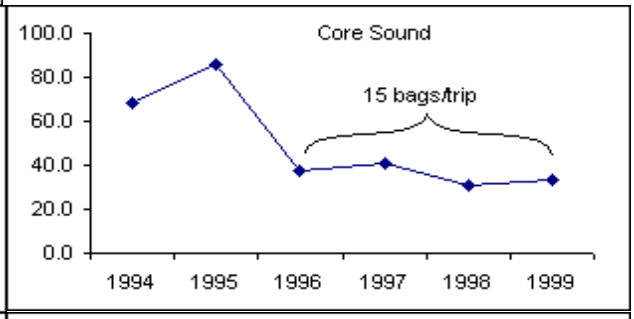






Mechanical Harvest





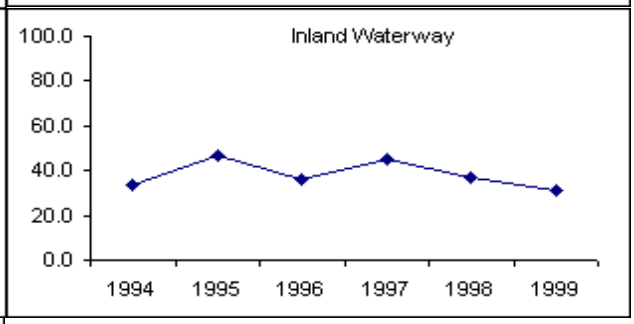
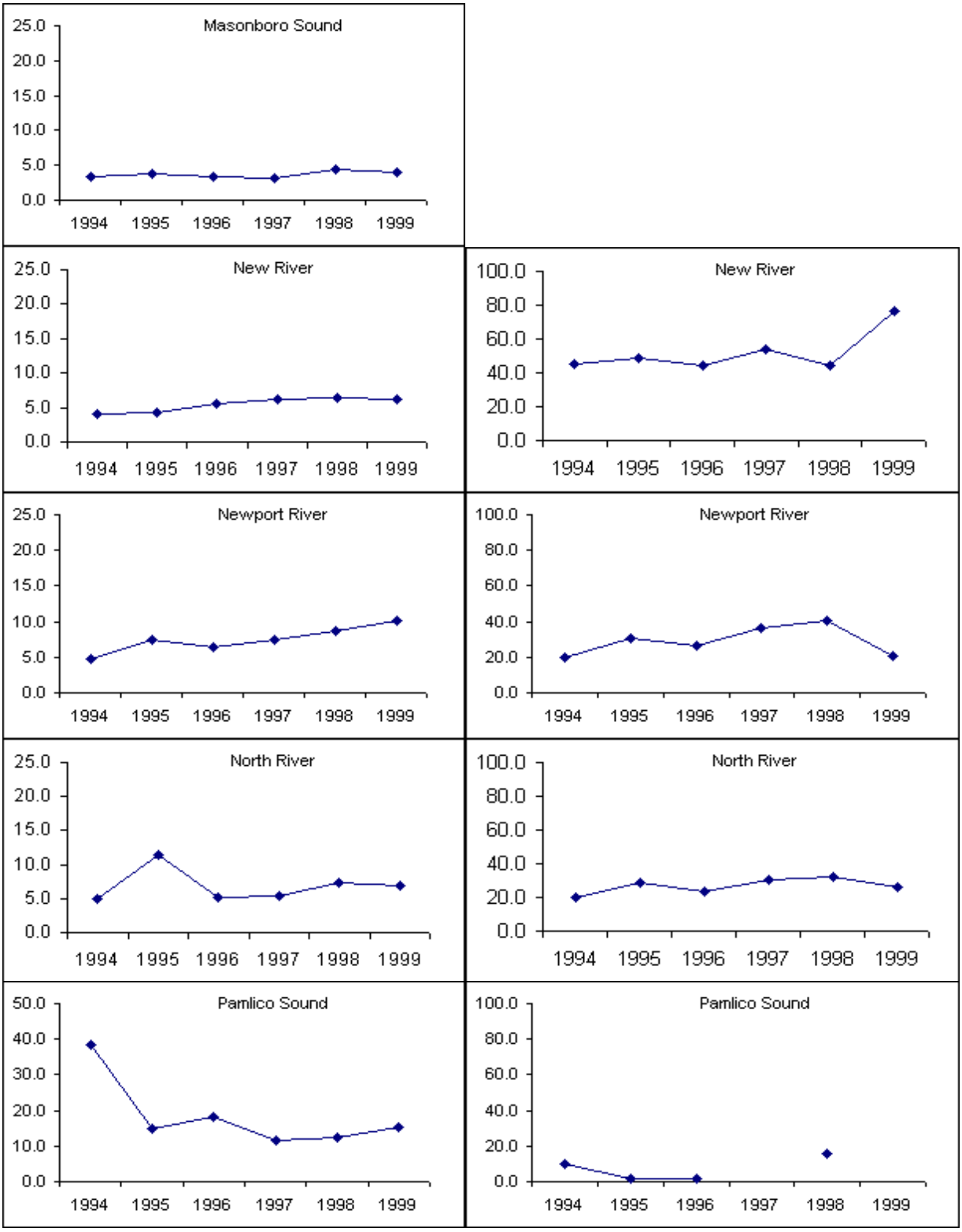


Figure 1. Mean percent of hard clam trip limits

Hand Harvest | Mechanical Harvest



Hand Harvest Mechanical Harvest

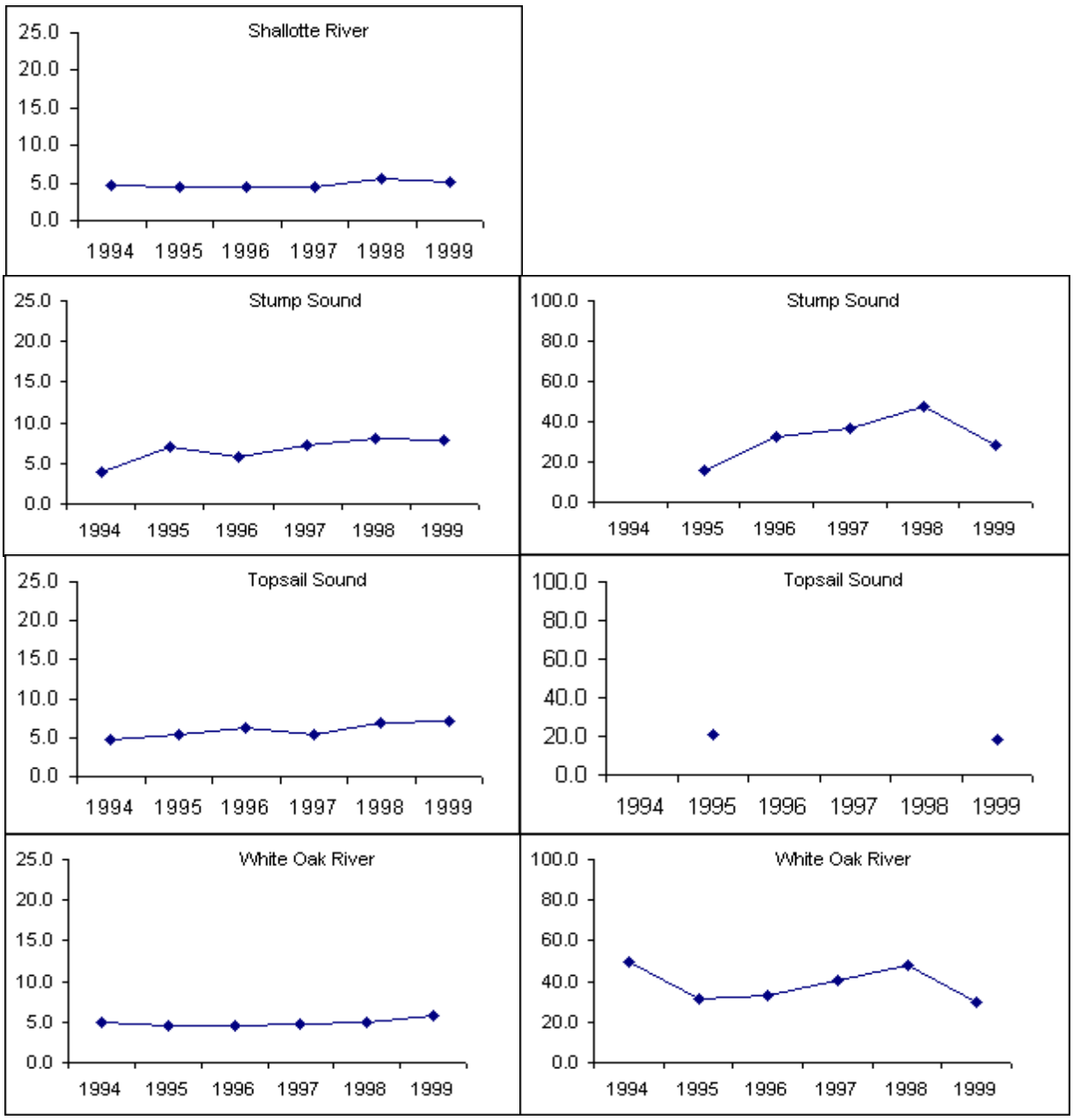


Figure 1. Continued

5.3 Determination of Optimum Yield

Since data collection is currently in its early stages, every effort should be made to evaluate the costs and benefits associated with available data collection methods and choose one that will allow adequate evaluation of the stock. The biological program we

choose will need to be in place for several years.

Table 1. Summary of assessment methodology to estimate MSY

	Advantages	Disadvantages	Data Demands
Age-Based Analysis	provides detailed information about population structure state-of-the-art	age data not validated several years before data can be used to estimate MSY expansion of current biological program	-catch at age matrix -natural mortality estimate
Biomass-Based Analysis	simplicity	sufficient contrast often lacking if stock has not been both overfished and underfished several years before data can be used to estimate MSY expansion of current biological program	-total catch -effort
Standing Stock Survey	intuitively understandable results results may be immediately useful for estimating MSY	expansion of current biological program	-hard clam density estimates for fished and unfished areas collected annually

Table 1 summarizes the advantages, disadvantages, and data requirements for several assessment methodologies that could be used to estimate MSY for hard clams in the future. Although age-based analysis is commonly used in finfish stock assessments, this method should probably be considered inappropriate for our purposes because ages have not been validated in all sediment types across a geographic range.

Biomass-based analysis should be considered as a possible assessment method for hard clams because the necessary catch and effort data could be collected fairly easily. A noteworthy disadvantage to this approach (that is not unique to hard clams) is that estimating MSY is often difficult unless the data include periods when the stock was overfished and periods when the stock was underfished. For both age-based and biomass-based approaches, several years of data must be collected before analysis can begin. A standing stock survey, or density estimate, is consistent with current approaches

by other management agencies and could give results that are both immediately useful and easy to understand.

Integration of GIS technology into the management of hard clams in North Carolina should be examined since it would allow coordination of population monitoring, habitat management, and shellfish sanitation harvest closures. GIS data are currently being gathered through the ongoing Shellfish Mapping Program.

Regardless of how we collect and analyze hard clam data, an important issue that will need to be settled is that of stock identification. A stock, for assessment purposes, consists of a population (of a single species) for which population processes (recruitment, survival) are independent of processes of other populations. It is quite probable that multiple unit stocks exist in North Carolina waters and, therefore, responsible management of hard clams should include their identification (C.H. Peterson, UNC Institute of Marine Science, pers.com.). If multiple unit stocks are ignored and managed based on a statewide assessment, we run the risk of over- or under-harvesting clams in regions where conditions differ from the statewide trend.

Given that current data are inadequate for calculation of MSY, it may be prudent to examine methods for calculating a proxy MSY. Federal and other state management agencies often use information from logbooks, fishery independent surveys, and other sources to establish MSY proxies. In North Carolina, the data that could be used currently consist of landings data and trip ticket data. Landings data for hard clams go back as far as 1887, although considerable gaps occur in the data set. The trip ticket data base covers a much shorter time frame (1994-present), however, if the total number of trips/year is used as an index of annual harvest effort, the apparent sustainability of current harvest levels may be examined. Under this approach, with the exception of Core Sound (Section 5.3), recent harvest levels appear to be sustainable since total catch does not decrease while assumed effort is fairly constant. The error involved in this approach is potentially quite large, however, since the amount of effort expended in an average trip may differ from year to year and because we do not know the magnitude of the unreported (recreational) take. Regional quotas may be more appropriate because of the possibility of multiple unit stocks. Harvest ranges for regional water bodies are given in Table 2.

Table 2. Landings (bushels) for major clam-producing regions in North Carolina

	1994	**1995**	**1996**	**1997**	**1998**	**1999**
Bogue Sound	4,891	5,381	3,188	3,749	3,641	2,527
Cape Fear River	3,674	5,075	4,845	2,909	1,761	1,047
Core Sound	22,027	38,178	18,561	21,299	17,522	15,465
Inland Waterway	5,309	6,615	3,279	3,011	2,955	2,854
Lockwood Folly	2,501	2,808	2,800	3,527	1,609	1,425
Masonboro Sound	2,004	3,122	2,345	2,726	3,300	1,817
New River	12,157	9,778	14,666	19,392	21,649	12,641

Newport River	5,150	8,480	8,692	9,712	10,377	6,901
North River	3,887	10,157	2,632	1,821	3,013	2,183
Pamlico Sound	2,578	864	1,822	1,071	1,808	2,483
Shallotte River	6,669	4,745	4,606	5,650	4,723	2,963
Stump Sound	947	1,963	1,261	1,722	1,531	1,045
Topsail Sound	1,866	2,005	1,883	1,517	2,741	2,100
White Oak River	4,118	3,892	2,542	2,430	2,172	2,310
Statewide Total	80,479	103,062	73,093	80,534	78,801	57,760

Table 2 continued

6.0 STATUS OF FISHERIES

6.1 Historical Commercial Fishery

The clam industry has existed since the 1880s when dealers from Virginia sent boats to the sounds of North Carolina to buy clams. These boats came mostly to the Ocracoke area. J.H. Doxy of Long Island, NY established a clam processing plant in 1898 at the entrance of Silver Lake. Clams were processed as whole clams, clam chowder, and clam juice. Most of these clams were labeled as quahogs from Islip, Long Island, NY. Clam landings increased noticeably as a result of this processing operation and peaked at 134,286 bushels in 1902 (Figure 2). Three years later, the plant was moved to Atlantic, NC, because of diminished clam resources in the Silver Lake area and later moved to Florida. Following the demise of the processing plant, production slowly dropped to below 45,714 bushels in 1918 and remained low until 1934 (Figure 2).

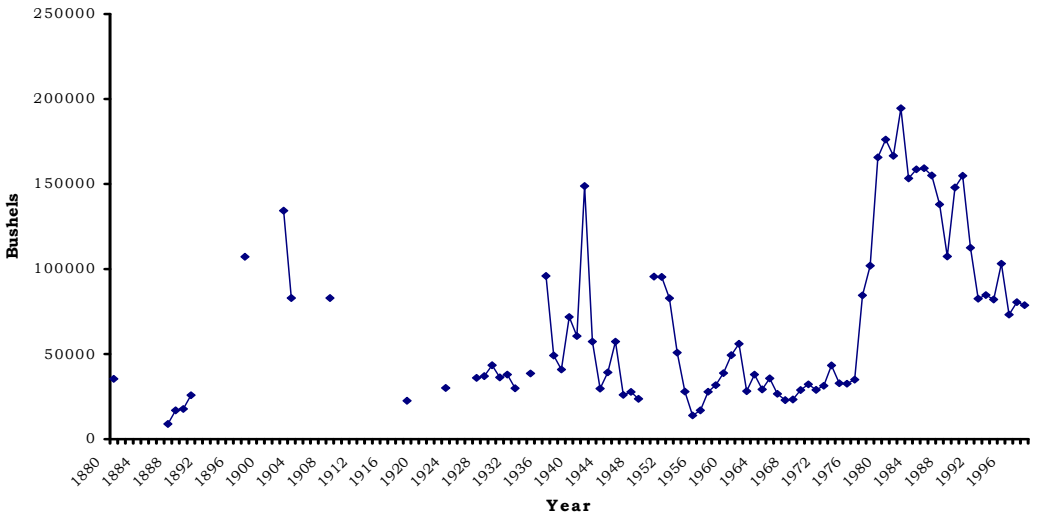


Figure 2. Commercial landings of hard clams

Increased clam abundance in upper Core Sound is attributable to a hurricane that opened of several inlets in 1933 (Chestnut, 1951). High landings of hard clams from 1935 to 1942 are attributed to the opening of a processing plant in Morehead City, NC which processed clams and also shipped whole clams to Virginia (Figure 2). Landings dropped during World War II and reached a low in 1949.

Clam harvest has fluctuated over the last 60 years, often in response to changes in demand and improved harvesting. A new method of harvest, dredging clams, began in the 1940s. Dredging initially evolved from the anchor method, where an anchor was put out behind a boat with a weighted stern to stop forward motion and cause the vessel to swing

in an arc. Prop wash was then used to expose clams. The fishermen then picked up these exposed clams with a rake. Over time, the bedstead method was developed, in which a wide, low profile sled-like gear called a bedstead was placed behind the anchored boat. A bunt with a heavy lead line was attached to the bedstead and used to scoop up clams exposed by the prop wash. This gear allowed fishermen to remain on board and enabled them to work in poor weather. The cumbersome bedstead was replaced by a modified oyster drag in the mid 1940s. The oyster drag was four feet wide, weighed approximately 100 lbs. and had a removable bar on the bottom with three inch teeth. The bag was made of metal rings connected together. A kicking stake was used to anchor the boat while allowing movement in a complete circle. Cable was paid out to increase the circle size with each revolution (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). Increase demands from northern states, along combined with the use of efficient gear soon lead to increased landings. However, by 1953, market demand declined and landings dropped (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 to carry the catch up to the vessel. Hard clam landings remained stable through the 1960s and 1970s. An increase in demand for North Carolina clams was created during the 1976/77 season, when abnormally thick ice covered clam beds in the northeastern US, making clams inaccessible. Since then, the landings have declined. This decline may be the result of a decrease in abundance, increase duration of closures of shellfish waters, and several storms in Core Sound.

6.2 Present Hand Harvest Fishery

The hand harvest fishery for hard clams is an important fishery in North Carolina. Hand harvesting methods include signing (spotting siphon holes), treading, hand raking, hand tonging, and bullraking. Clams are taken by hand and rake in shallow water ($\leq$1.2 meters) while hand tongs and bullrakes are used in deeper water (1.2 to 12.2 meters). Bullrakes, a gear introduced to North Carolina in the mid 1970s have been used to exploit clam populations in New River, White Oak River, Bogue Sound, and the Intracoastal Waterway channel of Brunswick, New Hanover, Pender, and Onslow counties. There is a large number of subsistence fishermen in the southern area of the state, who use bullrakes to harvest clams as a source of income. Landings from this year round fishery average approximately 57,660 bushels annually (1994-1999). There are from 2,200 to 3,300 vessels recorded in the trip ticket data base for each fiscal year (1994-1999) that have hand harvested clams. Most hand clamming occurs in the spring and summer when warm water is conducive to wading. The number of hand harvest trips decreased from 51,987 in 1994 to 39,079 in 1998 (Figure 3). Much of the decline can be attributed to state wide closures imposed because of excessive storm water run off following hurricanes Bertha and Fran in 1996 and Bonnie in 1998. The number of shellfish licenses and shellfish and crab licenses issued decreased from 6,610 in 1995 to 3,507 in

1999. Beginning July 1, 1999, the shellfish license was made available to any North Carolina resident for $25.00 while SCFLs were made available only to those fishermen with endorsements to sell. This was to enable those subsistence fishermen who only shellfish

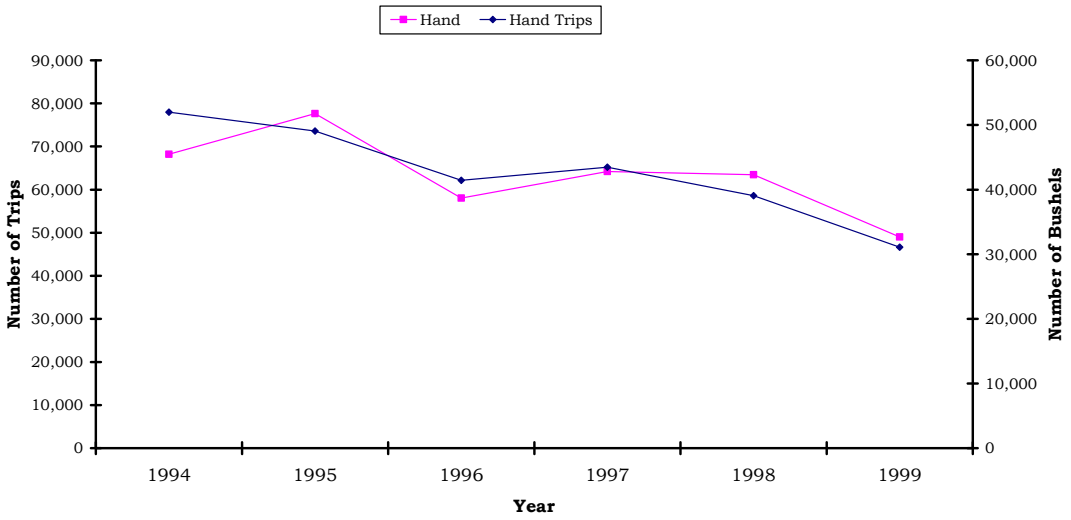


Figure 3. Landings and number of hard clam trips by hand

to continue to do so with a low priced shellfish license. A free shellfish endorsement was made available to SCFL holders. A total of 7,545 shellfish licenses and shellfish endorsements were sold in fiscal year 2000. Out of 5,775 SCFLs sold 5,456 have shellfish endorsements (95%), while only 2,089 shellfish licenses have been sold.

6.3 Present Mechanical Harvest Fishery

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. In clam trawling or "kicking", directing prop wash downward dislodges clams, and a heavily chained trawl behind the boat then gathers clams. Kick boats are generally 20 to 30 ft long, and can operate in depths from three feet to 10 feet (1.0m to 3.05 m). One person operates smaller kick boats, while larger boats may have a crew of two or three (NCDMF 1997).

Mechanical harvest season usually begins the first Monday in December and extends through the week of March 31st. Harvest is allowed only during daylight hours on Monday through Wednesday of each week. Harvest areas are located in New River, White Oak River, Bogue Sound, Newport River, North River, and Core Sound (Figures 4-9).

White Oak River and New River are fished mainly with escalator dredges and are rotated on a yearly basis. Harvest limits vary by waterbody, with maximum daily harvest of 3,750 clams (15 bags at 250 clams per bag) in North River, Newport River, and Bogue Sound and a maximum daily harvest of 6,250 clams (25 bags at 250 clams per bag) in Core Sound, part of the Intracoastal Waterway (Marker 65 to the BC Marker at Banks Channel), White Oak River and New River.

Mechanical harvest landings averaged 17,877 bushels from 1994 through 1999. Between 80 and 130 vessels per fiscal year have recorded harvests in the Trip Ticket data base from 1994 through 1999. Mechanical harvest trips increased from 985 in 1994 to 1,723 in 1999 while landings decreased in 1996 and but leveled off between 15,000 and 16,000 bushels (Figure 10). The number of permitted mechanical clam harvesters has dropped from 348 in 1989 to 132 in 1999

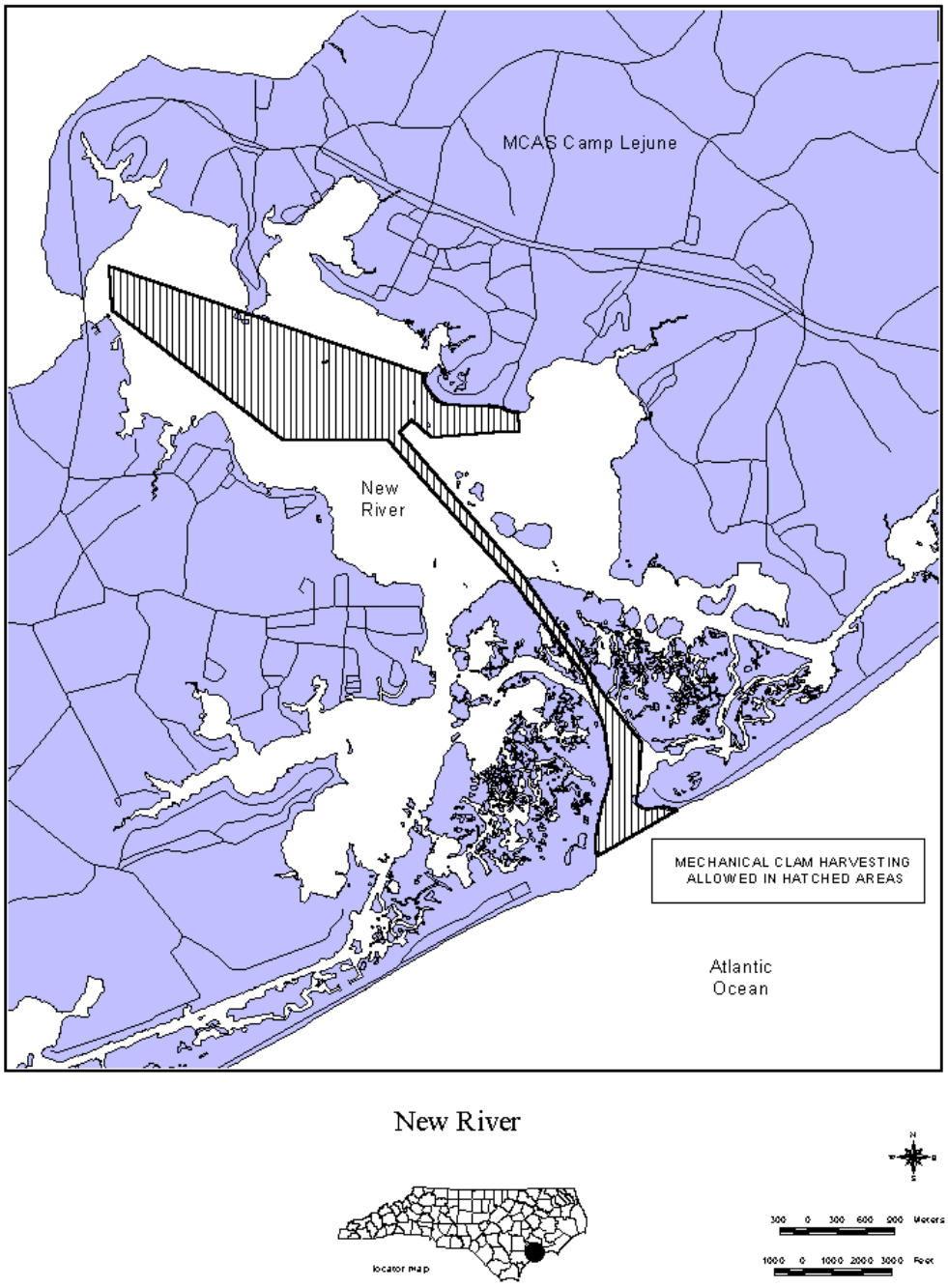


Figure 4. Mechanical harvest area in New River

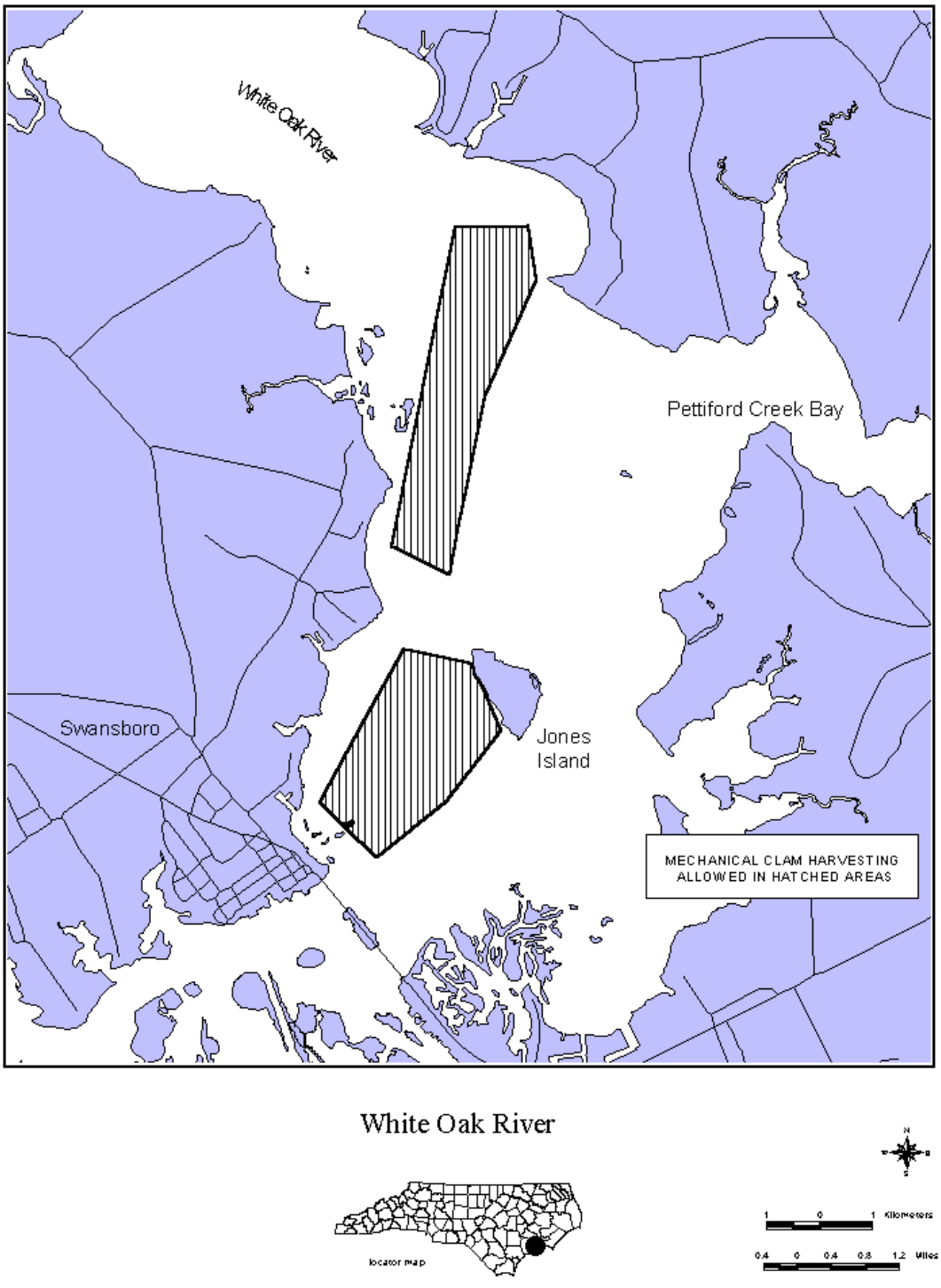


Figure 5. Mechanical harvest area in White Oak river

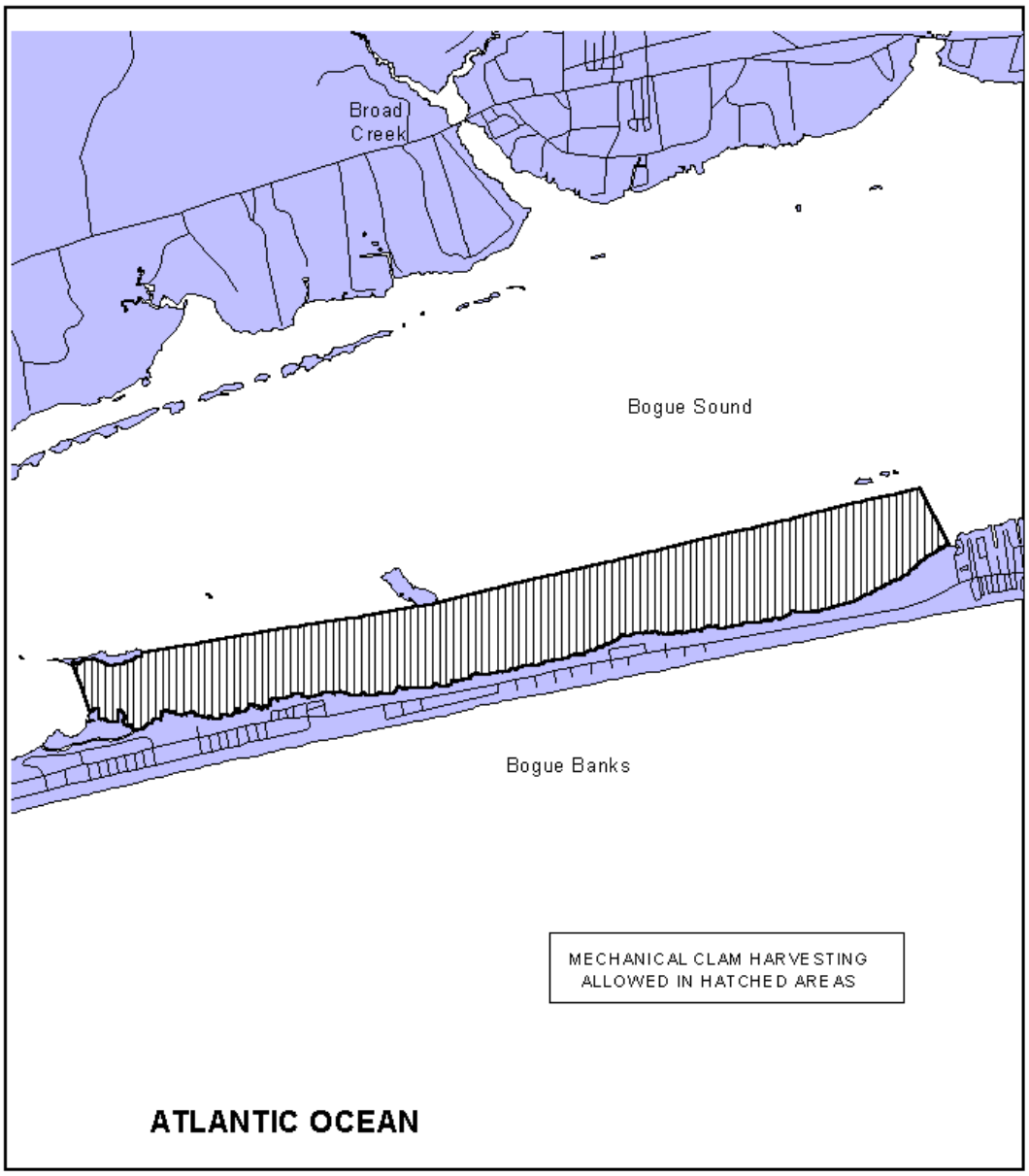


Figure 6. Mechanical harvest area in Bogue Sound

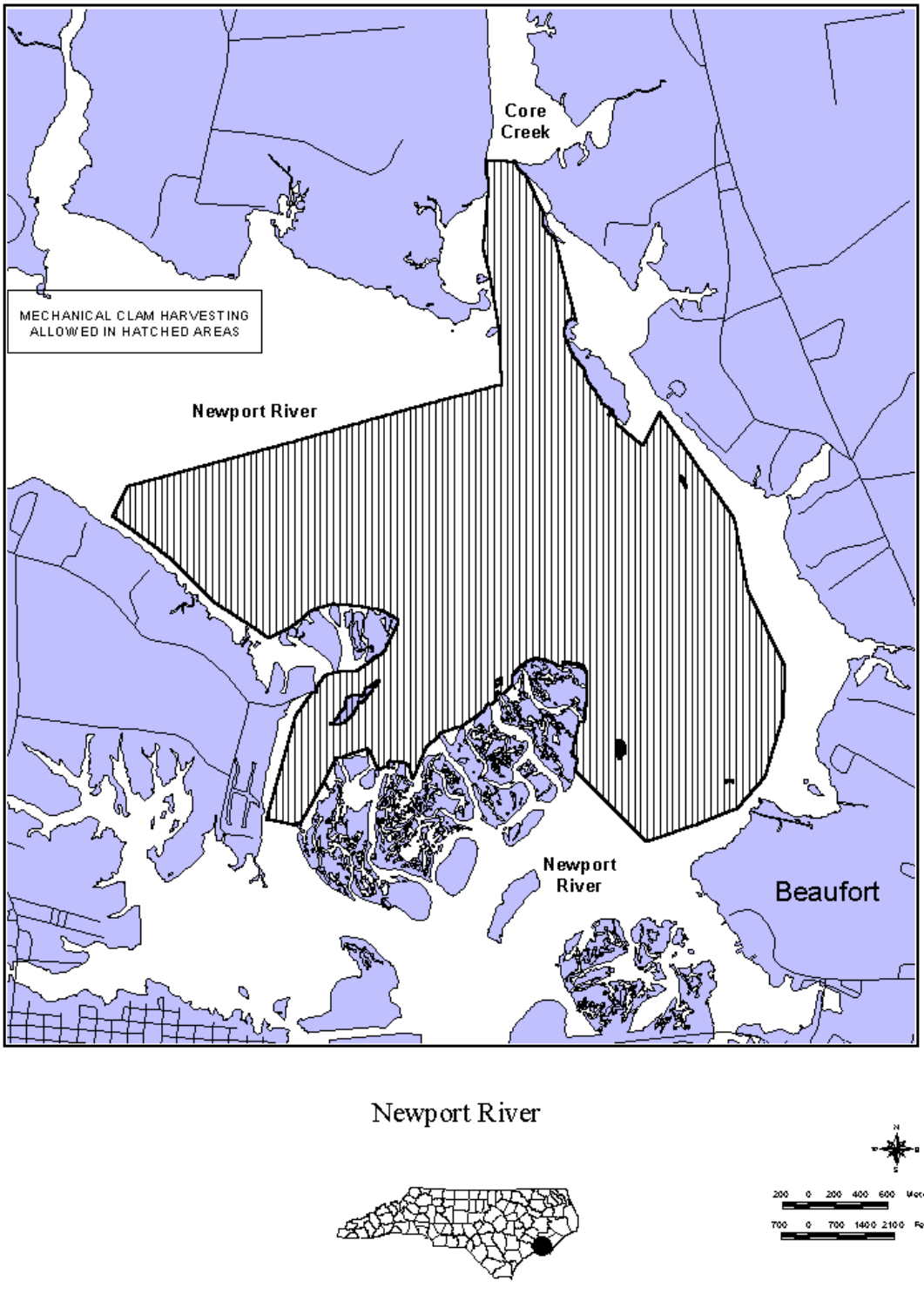
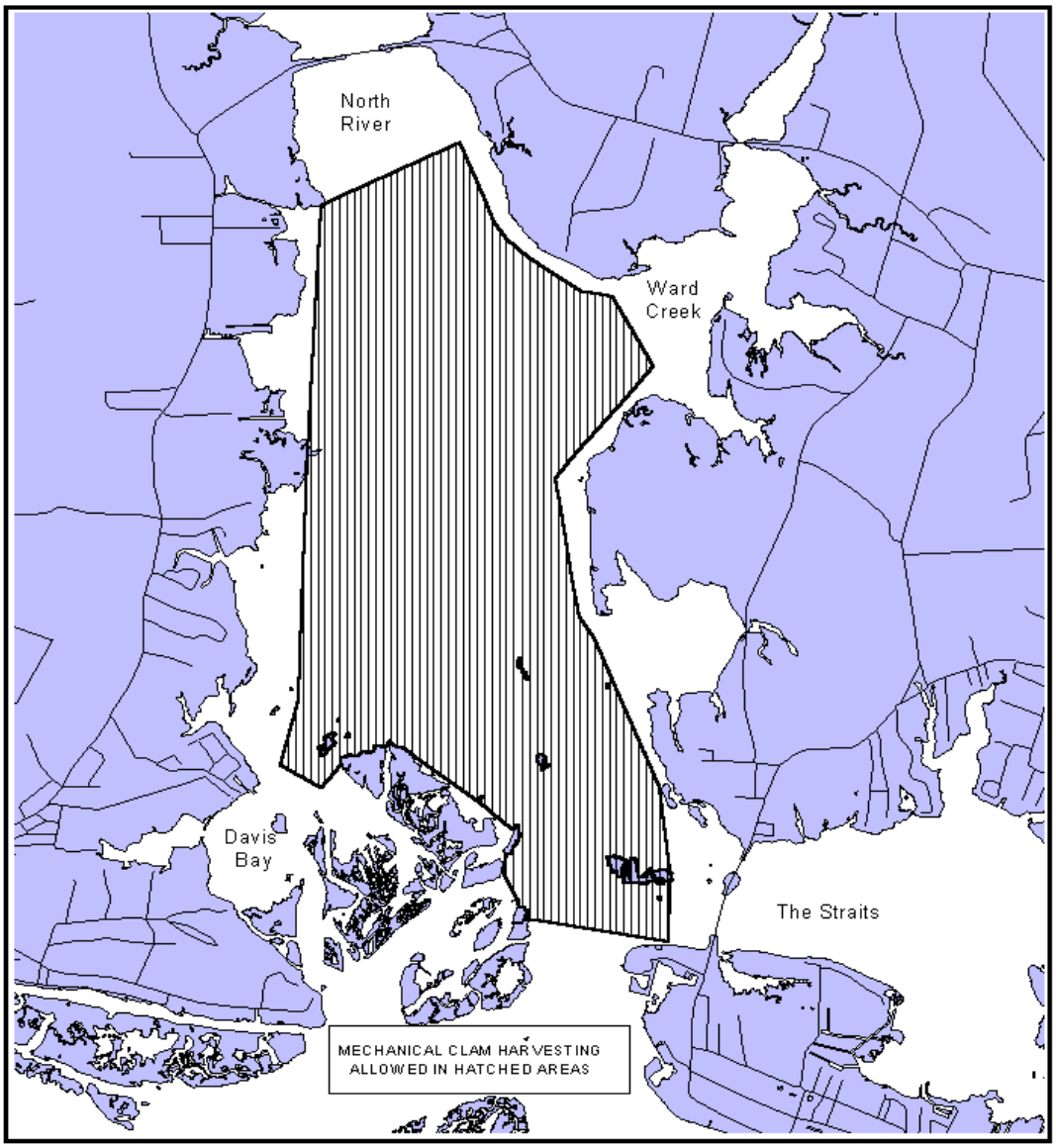


Figure 7. Mechanical harvest area in Newport river



North River

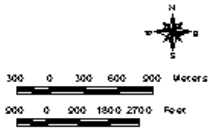


Figure 8. Mechanical harvest area in North river

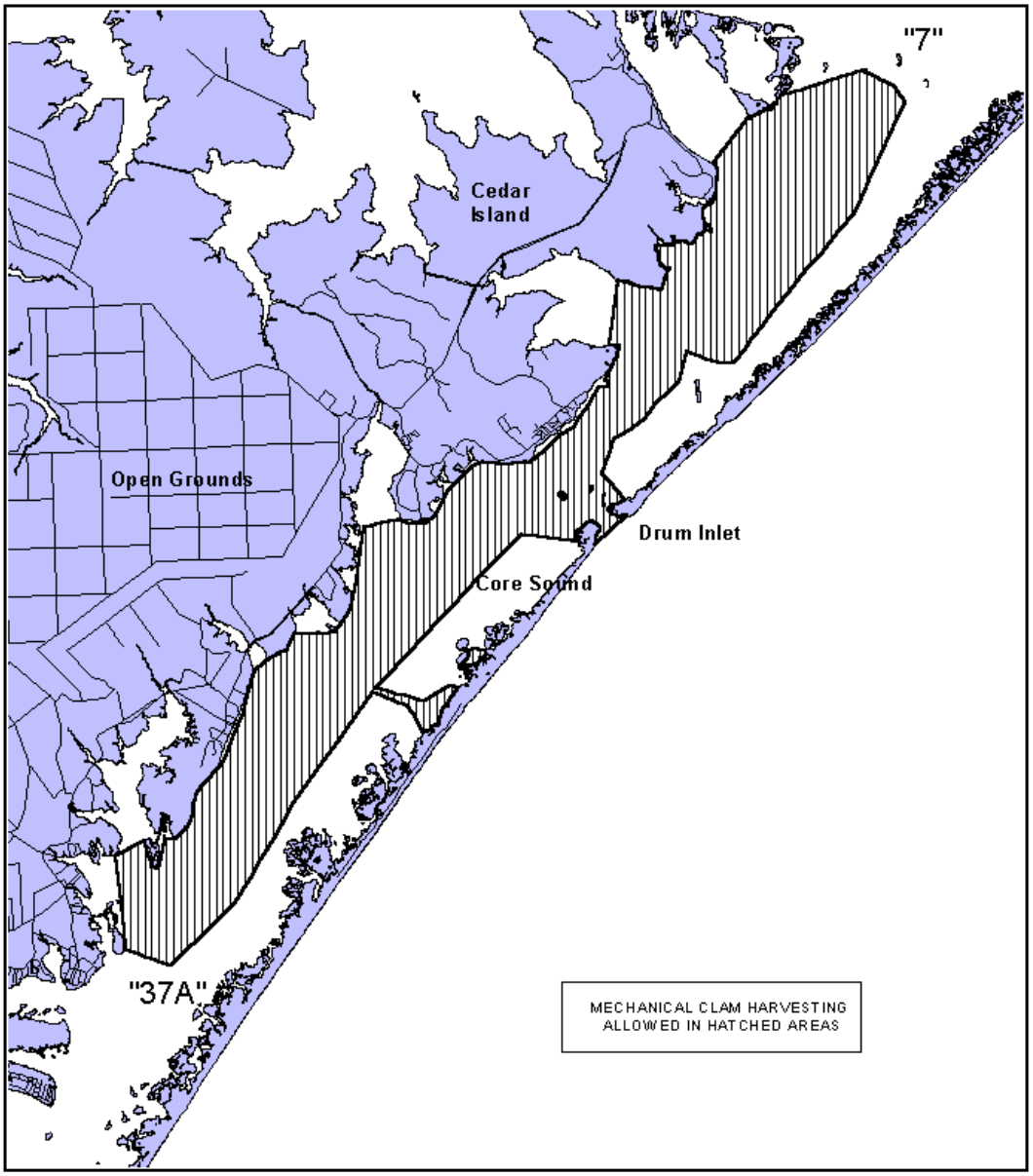


Figure 9. Mechanical harvest area in Core Sound

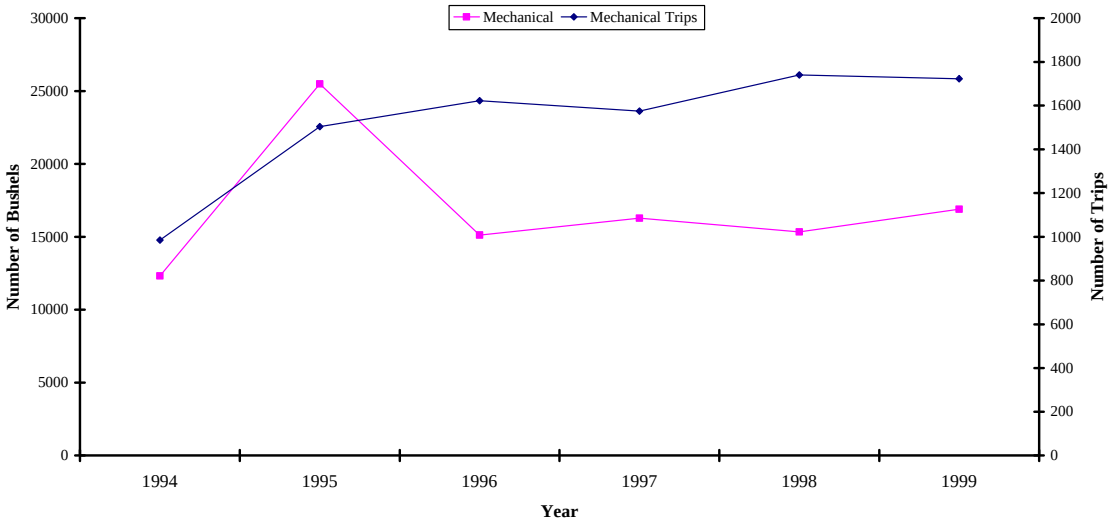


Figure 10. Landings and number of mechanical harvest trips

6.4 Historical Private Culture

There is no evidence of clam culture in North Carolina before 1950 but several leases existed for holding surplus clams until market conditions improved (Chestnut 1951). Carricker successfully spawned and raised clam larvae from Chesapeake Bay during the 1950s while minimal success was also achieved with clams from North Carolina by Porter. Bayer and Chestnut (1964) began a project to determine the potential of rearing clams in North Carolina in February 1963. Their work consisted of spawning adult clams, rearing larval clams to the juvenile stage, then broadcasting the seed over bottom. Problems encountered included mass moralities of larvae because of disease and also mass moralities by predation of seed not covered with mesh screens (Bayer and Chestnut 1964). Other culture operations over the next 15 to 20 years experienced varying levels of success because of predation resulting from lack of covering seed. North Carolina culturists began to purchase seed clams from various out of state companies in the 1990s. Some of these companies have also established portions of their businesses in North Carolina because of the milder climate.

Table 2. Reported clam planting and harvesting activities (1979-1999) (BU= 400 clams).

YEAR	LEASES NUMBER ACREAGE	PLANTING SEED(BU) + RELAY(BU)	HARVEST (BU)	%STATE CLAM LANDINGS
1979	246 2,185	13,975 Seed 44,290 Relay	10,781	7
1980	260 2,333	120,000 Seed 101,762 Relay	18,018	10
1981	262 2,257	195,000 Seed 21,817 Relay	13,128	8
1982	262 2,257	5,436 Seed 8,596 Relay	17,734	9
1983	265 2,286	2,925 Seed 8,134 Relay	10,179	7
1984	269 2,291	669 Seed 82,806 Relay	11,585	7
1985	272 2,304	1,285 Seed 136,358 relay	10,547	7
1986	282 2,380	8,696	11,040	7
1987	279 2,354	9,069	9,334	7
1988	285 2,330	15,021	14,611	13
1989	276 2,232	20,242	13,950	9
1990	276 2,214	15,319	13,147	9
1991	281 2,208	30,222	16,444	14
1992	280 2,191	34,154	17,412	21
1993	300 2,441	27,657	19,159	22

YEAR	LEASES NUMBER ACREAGE	PLANTING SEED(BU) + RELAY(BU)	HARVEST (BU)	%STATE CLAM LANDINGS
1994	285 2,282	36,595	9,190	12
1995	279 2,216	47,371	9,707	9
1996	295 2,193	63,485	9,515	13
1997	295 2,196	55,819	12,011	15
1998	284 2,149	27,656	12,309	15
1999	284 2121	38,409	12,859	17

*Total only

Table 2 shows the number of leases, along with the amount of acreage leased. Acreage has fluctuated very little over time while number of leases have shown a gradual increase over time indicating leases are getting smaller. Planting clam seed and relaying clams have greatly fluctuated over time. Although production from leases vary from 9,515 bushels in 1996 to a high of 19,159 in 1993, the percent contribution of lease production has increased over time, from seven percent in the early 1980s to a high of 22% in 1993 (Table 2).

6.4.1 History of the Lease Program

Although North Carolina law did not formally prescribe the methods for obtaining private shellfish bottoms until 1858, laws existed giving private shellfish growers special privileges in harvesting and selling their shellfish as early as 1855. Evidently, early cultivation sites were based on "squatters" rights.

The 1858 law provided for licenses to oyster and clam bottoms to be issued by the Clerk of Superior Court of the respective county at no charge. The grant had to be marked and used on a continuing basis for the production of shellfish. Initially, grants could be no larger than two acres. In 1873 this restriction was raised to allow ten acre sites. Only one grant could be held per person. Riparian owner's rights could not be affected, and no natural shellfish bed could be enclosed. Some clerks required surveys for these shellfish licenses (Winslow 1889).

Winslow (1889) reported that there were 250 such licenses in the state. He described the plots as "gardens," a term which is still in use today to describe shellfish leases. The production from these gardens was normally limited to amounts adequate to supply the licensee's table (Winslow 1889). Although subsequent laws for shellfish cultivation were passed, this system remained in effect in some counties until 1907 (Jernigan 1983).

On 15-16 October 1884, papers were presented at the Fishermen's Convention in Raleigh that created a great deal of interest in oyster culture. Lieutenant Francis Winslow, U.S. Navy, and Professor W. K. Brooks, John Hopkins University, both presented arguments for encouraging a privately controlled oyster industry in North Carolina. They cited the depletion of the public oyster beds in Chesapeake Bay and the increasing oyster production from private beds in Connecticut and foreign countries as examples of what could be expected here (Winslow 1885; Brooks 1885).

Pursuant to the interest generated at the Fishermen's Convention, a survey began on 12 April 1886 to determine the extent and condition of North Carolina's oyster-producing habitat. It was conducted under the direction of Lieutenant Francis Winslow who found 8,327.9 acres of oyster producing bottom in Dare, Hyde, Pamlico, Carteret and portions of Onslow counties. He also identified some 583,000 acres of bottom suitable for oyster cultivation (Winslow 1889). In his report, Winslow proposed an entirely new system for allowing private cultivation of oysters on public bottomlands. Even though oyster cultivation was the driving force for leasing shellfish bottom, the General Assembly adopted these recommendations under the authority of the 1887 Session Laws, Chapter 90, for Onslow County and Chapter 119 for Pamlico Sound (Jernigan 1983).

Under these laws, natural oyster beds to be held in the public trust were established by a board of three Shellfish Commissioners. Shellfish franchises were to be approved by the Secretary of State who issued the grant. Application fees were $2.05, and franchises were purchased at a cost of 25 cents per acre. Surveys of each grant were conducted for the applicant by a state surveyor at set rates. The grounds were recorded for tax purposes (Winslow 1889).

It was required that these grants be improved within five years. Within two miles of the shore of Pamlico Sound, grants could be for no more than ten acres, and only one grant per creek was allowed. However, one person could be granted up to 640 acres in any five-year period. Non-residents were allowed to enter grants more than two miles from shore in Pamlico Sound. This new law caused a great deal of interest and by 1889 approximately 50,000 acres had been issued in franchises.

Statutory authority to lease bottomlands for shellfish cultivation can be traced back to a statute adopted in 1909. Interest was generated from the cultivation experiments of the North Carolina Geological and Economic Survey as fishermen

harvested oysters from the planted areas and probably influenced the adoption of the legislation (Pratt 1911). The early legislation contained concepts that are still in use today. All leaseholders had to be residents of North Carolina. A survey was required and an investigation of existing shellfish stocks was conducted by qualified personnel for each application. There were rental fees and strict marking requirements. The application fee was a $10 deposit to be applied to survey costs if the lease was approved.

Other aspects of the law were somewhat different from today. The acreage of shellfish leases was limited to ten acres in the bays and smaller sounds. Single leaseholders could be up to fifty acres in size within two miles of the shore of Pamlico Sound and 200 acres farther from shore. Shellfish leases were issued for an initial 20-year term with the option for unlimited 10-year renewals. The performance requirement for leaseholders was strictly set at planting an average of 50 bushels of shells or seed per acre after the first two years and an average of 125 bushels per acre after four years. For up to four months after the granting of the lease, the public could protest on the grounds that the area contained a natural shellfish bed. Chestnut (1951) reviewed the shellfish lease system that had operated under this basic legislation until 1949. At the time there were 264 leased areas totaling 3,232 acres.

During the early 1960s the shellfish lease statute was changed to reduce the initial lease period to ten years. The rental fee was raised to $5.00 per acre per year for all leases. A differential system had previously been in place, basing rent on the area and the length of existence of the lease. Due to the extended length of time necessary to legally put these changes in place, all leases did not operate under these changes until 1997.

In 1965 the Fisheries Commission was given the authority to adopt rules defining commercial production of shellfish based upon the productive potential of areas and considering climatic or biological conditions, availability of seed oysters and clams, and availability of shells or other cultch materials. From 1966 through 1975, the MFC adopted the production requirement of "at least five bushels of oysters or clams per lease acre per year, averaged over any two consecutive years after January 1 following the second anniversary of an initial lease and throughout the term of a renewal lease" (North Carolina Fisheries Regulations for Coastal Waters 1975. H-12 Cultivation of Oysters).

In 1976 this rule was changed to read "Failure to produce and market at least 25 bushels of oysters or clams per lease acre per year, averaged over the most recent three-year period after January 1 following the second anniversary of an initial lease and throughout the term of a renewal lease, shall constitute failure to utilize the leasehold on a continuing basis for the commercial production of shellfish" (North Carolina Regulations for Coastal Waters 1977, 15A NCAC 3C.0311). The **produce and market** wording was intended to emphasize the commercial purpose. This production requirement remains in rule today.

Following a legislative study in 1981, the shellfish lease application fee was raised from $25.00 to $100.00 and a lease renewal fee of $50.00 was established. There have not been any other significant changes in the leasing of shellfish bottomlands to date.

The legislation authorizing the MFC to adopt production requirements also made provisions for periods of low oyster productivity. The statute further provided that as long as a leaseholder made a diligent effort his or her lease could not be terminated; "Acts of God" were also reason to excuse lack of production.

During the period 1982-86, an average of 10 bushels of shellfish per acre of leased bottom was produced in North Carolina. This figure includes both oysters and clams and falls well below the requirement of 25 bushels per acre. The production requirement was not being met by 71% of the active shellfish leaseholders during 1982-86. Furthermore, by policy, the Division was accepting the planting of 25 bushels per acre of seed or shells as a diligent effort to meet production. A total of 100 of the 285 leases could meet neither of the avenues for production requirements during that period. Action to terminate these shellfish leases was blocked by legislative action for one year. In the interim, leaseholders were given an opportunity to attend instructional seminars and receive a two-year extension to meet production.

A generalized analysis would state that the majority of the shellfish leases today are used by commercial fishermen to supplement their income from public area harvests and to provide opportunities for holding shellfish for better meat condition or better market. Beginning in the early 1980s, was a move to fully utilize shellfish lease potential by full-time shellfish culturists, but due to market and available technology, they have largely cultured clams.

Some shellfish franchises (private culture areas obtained for a one-time fee under the 1889 laws) issued prior to the shellfish leasing program still exist and are currently going through a process to evaluate their validity under North Carolina General Statutes 113-205 and 113-206. Those that are recognized as valid claims to bottomlands were required beginning 1 January 1991, to meet the requirements for surveys, management plans, and commercial shellfish production set for shellfish leases. Currently, 46 shellfish franchises have been so recognized. Production data from these franchises began showing up in the 1991 statistics but is not differentiated from the shellfish lease landings. Franchises that are not recognized may be subject to special leasing provisions. It is unknown what portion of the approximately 300 franchise claimants may be issued a shellfish lease.

In 1989 legislation was enacted to allow the use of the water column above shellfish leases. At this time, only eight water column leases exists. The high rental fee of $500 per acre per year has probably deterred many potential leaseholders.

6.5 Present Private Culture

Hard clams are the principal species produced on leased bottom in North Carolina where unique environmental conditions enable development of various hard clam culture methods. Presently, of 284 leases making up 2,121 acres in eight coastal counties, there are 269 leases covering over 2,000 acres that planted and harvested hard clams in 1999 (Table 3). Carteret County was the number one producer of hard clams from leases, making up 28% of total landings for the county. Table 4 lists different culture methods and the results from a survey conducted in 1995 by Diaby (1997) of the percentage of leaseholders that use these methods. The most basic approach is for individuals to use their leases as traditional culture sites for naturally setting clams, although this approach often yields low production and fails to realize the full production potential of many of the leases. Other methods of extensive clam aquaculture can be successful in some areas. These methods require large acreage of estuarine bottom planted at low densities. Research has shown a return of clams when planted at rates of approximately one/m^2 (Peterson et al., 1995). Cultch plantings are also used to attract natural settlement of hard clam spat. Growers can produce clams by planting shell cultch for oysters and later harvesting the crop of clams that settle underneath the cultch that protects them from predation. Cultch planting is not used as extensively for clams as with oysters. Seed clams are planted on leased bottom using methods such as planting with protective netting mesh bags, and broad-casting seed. Harvesting is accomplished by hand and by mechanical gear that require permitting and adherence to regulations established by MFC.

Table 3. Planting and harvesting of hard clams by county (1999)

County	Leases Number Acreage	Clams Planted(bu)	Clams Harvested(bu)
Carteret	120 563	25,457	7,587
Dare	5 75	3,750	908
Hyde	25 412	1,725	867
Onslow	80 737	3,295	2,452
Pender	39 267	3,684	686
Total	269 2,054	37,911	12,500

Another widely used method of extensive culture is relaying polluted clam stocks from closed areas during a 6-week relay season beginning in April. Relaying polluted clams coincides with polluted oyster relay and requires appropriate permitting and access to designated shellfish management areas. Relayed clams are bedded and allowed to depurate (purification of adulteration from clams by any natural or artificially controlled means) on a posted lease for a period of time mandated by the NC Division of Shellfish Sanitation. Clams are approved for consumption only after representative meat samples indicate that depuration is complete. Clams harvested from closed areas are broadcast onto an open-water lease that is posted for a period of time sufficient for clams to depurate or naturally purge themselves before re-harvest.

A few leases are cultured intensively. Sections of the lease are planted with cultured immature or "seed" clams. Often various lease sections are rotated through harvest and planting cycles to use all available space and maintain a steady crop. Leaseholders may also produce and rear their own seed clams in small raceways and upwellers in conjunction with their commercial clam production.

Clam aquaculture also occurs on a large scale with hatchery and nursery facilities that produce seed for sale and planting. Many of these operations are small family oriented businesses and are often conducted in conjunction with other commercial fishery activities such as crab shedding. Such leases typically realize much greater production than those on which extensive culture methods are utilized. These aquaculturists routinely utilize predator exclusion devices such as mesh covers to protect their small clams. Intensive culture requires smaller acreage of bottom leases and/or water-column areas. Water-column leases are also useful for some intensive culture operations depending on water depth.

Table 4. Percent of lease holders who use different culture methods for culturing clams in 1995.

Culture Methods	Clam Culturists Surveyed
Plant on bottom without protection	14%
Plant on bottom and cover with shell	12%
Plant on bottom and cover with mesh	46%
Plant in cages	4%
Plant in bags	18%
Transplant seed from management areas	6%
Plant cultch for substrate	8%
Relay from closed areas	8%

Culture Methods	Clam Culturists Surveyed
Nursery	14%
Hatchery	12%

Source: Diaby (1997)

Seed supply is critical to successful clam production. Most operations in North Carolina rely on hatchery-produced seed clams for planting their operations. A few small-scale hatcheries are operating in NC. There are no large-scale shellfish hatcheries in the state that can supply the industry's needs, thus most seed are imported from other states. Some clam growers produce or purchase very small seed and grow it to a larger plantable size in on-shore or water-based nurseries.

Predation by various crabs and snapping shrimp are the greatest cause of mortality in aquaculture clam crops. Planting larger clam seed and covering the planted areas with mesh netting can help control predation. Other causes of mortality are shifting sediments that can cover clam beds, and freshwater intrusion. Diseases of clams are not considered a major threat to cultured stocks in North Carolina.

Most clams are marketed out-of-state. Clams reared in an aquaculture operation are exempt from size limitations for marketing purposes. Limited markets exist for as small as 7/8-inch (22.0 mm) thick clams. The minimum size for wild-harvested clams is 1-inch (25.0 mm) thick. If a grower can develop a market for smaller clams, the risk of mortality and time-to-market are reduced, increasing the economic viability of the operation. Value-added markets are not yet developed for aquaculture clams in North Carolina.

The DMF administers a shellfish lease program whereby State residents may apply to lease estuarine bottom or water columns for commercial production. The Division does not differentiate between clam, oyster, and mussel leases; consequently, the total number of leases culturing only clams is not known.

An application for a bottom or water column lease must be submitted along with a management plan, a map of the site, and a $100.00 application fee. Once the application is received, the DMF investigates the site and DMF Biologists, Marine Patrol and Shellfish Sanitation officials review the resulting report prepared by DMF staff. Hearings are held to solicit public input regarding the issuance of a proposed lease. The Secretary of the DENR or his proxy then evaluates the proposed lease. After approval by the Secretary, the applicant must provide a survey plat before execution of the lease contract. The contract includes production and reporting requirements and yearly lease fees. The lease contract is renewable on a 10-year cycle for bottom leases and five years for water column amendments.

The current climate for shellfish aquaculture in North Carolina is one of contention among user groups. One of the primary problems is once leases are granted, it is up to the lease holder to make it productive. Public opposition to leasing has become a problem in some areas, especially around Core Sound. Obtaining new leases may be difficult depending on the region of the coast. The public often opposes leasing on the grounds that it is a violation of public trust and creates potential conflict between commercial fishermen and leaseholders. This has lead to a legislated Indefinite Moratorium to new leases on the east side of Core Sound and a Temporary Moratorium on the west side (Orbach 2001).

Once leases are granted, theft often becomes a serious problem for many aquaculturists. Leases are often located away from shorelines and are thus difficult to observe. There is little to deter theft as the court system has seldom imposed high fines on the rare individual actually caught poaching on a lease.

Diaby (1997) conducted a mail survey of 227 private culturists to describe culture operations, examine attitudes of leaseholders concerning the lease program and to gather socioeconomic data. The response rate of the survey was 22%. Of those that responded, only 10% provided usable data. Only 13% of leases meet production requirements, so the survey was considered representative of the industry that met production. In this study it was found that the majority of the leaseholders feel that the oyster and clams stocks have been reduced and that culturing would increase overall production of these shellfish. The majority of those surveyed also agreed with reporting harvest and economic information as requirements for holding a lease. However, there are a large number of leaseholders that fail to meet production and effort requirements because of high start up costs and inconsistent production methodologies. Sixty-six percent of those surveyed felt that the

Table 5. Leaseholders reporting production (1988-1998)

Year	Total leaseholders	Met requirements Planted Harvested	20 to 24 bushels Planted Harvested	Less than 20* bushels
1988	234	11(4.7%) 23(9.8%)	6(2.6%) 4(1.7%)	190(81.2%)
1989	263	14(5.3%) 27(10.3%)	1(.4%) 1(.4%)	220(83.6%)
1990	267	11(4.1%) 35(13.1%)	7(2.7%) 3(1.1%)	211(79.0%)
1991	289	23(8.0%)	14(4.9%)	216(74.7%)

Year	Total leaseholders	Met requirements Planted Harvested	20 to 24 bushels Planted Harvested	Less than 20* bushels
		34(11.7%)	2(.70%)	
1992	295	43(14.6%) 33(11.2%)	5(1.7%) 5(1.7%)	209(70.8%)
1993	294	64(21.8%) 33(11.2%)	5(1.7%) 3(1.0%)	189(64.3%)
1994	282	113(40.1%) 41(14.5%)	11(3.9%) 3(1.1%)	114(40.4%)
1995	280	119(42.5%) 35(12.5%)	15(5.4%) 2(.7%)	109(38.9%)
1996	293	125(42.7%) 34(11.6%)	12(4.1%) 1(.30%)	121(41.3%)
1997	295	129(43.7%) 36(12.2%)	10(3.4%) 3(1.0%)	117(39.7%)
1998	284	128(45.1%) 40(14.1%)	18(6.3%) 2(.70%)	96(33.8%)
1999	284	131(46.1%) 38(13.4%)	17(6.0%) 1(.35%)	97(32.0%)

*Total includes new leases, and polluted leases that are exempted from production requirements.

state should provide more technical assistance. Table 5 shows the number of leaseholders from 1988 through 1999 and the number of leaseholders who meet production requirements. Leases that fail to meet production are terminated at renewal.

6.6 Recreational

Hard clams are harvested recreationally by hand and rakes. The recreational limit is 100 clams per person per day and 200 clams per vessel. Little data are collected on the recreational harvest of shellfish in general and none is collected on the recreational harvest of hard clams specifically.

According to the 1991 Addendum to the 1985 National Survey of Fishing, Hunting and Wildlife-Associated Recreation (US Fish and Wildlife Service 1991), 129,973 shellfishermen aged 16+ expended 1,009,000 days shellfishing in North Carolina in 1985. Shellfishing included (clams, oysters, scallops) and crustaceans (shrimp, crabs). North Carolina ranked twelfth and eleventh nationally in those two

categories, respectively.

During 1991, the telephone survey portion of the Marine Recreational Finfish Statistics Survey included a question on the number of recreational shellfishing trips taken. Results indicate there were more than one million trips to harvest shellfish in North Carolina in 1991 (Doug Mumford DMF, pers.com.).

7.0 SOCIOECONOMIC STATUS

7.1 Commercial Fishery and Aquaculture

The value of hard clams harvested in North Carolina gradually increased from $163,000 in the early 1970s to a peak of $8.4 million in 1989 and then substantially decreased to $3.7 million in 1994. The landed value of hard clams was approximately $3.8 million in 1999.

The price per pound of hard clam meats received by North Carolina's fishermen rose when evaluated on both a nominal or real (adjusted for inflation) basis. The nominal price per pound increased from $0.73 in 1972 to almost $4.00 per pound of meats in 1992 (Table 6). Prices peaked during 1997-1999, although total production in North Carolina continued to decline. After adjusting for inflation, the price of hard clams was $3.43 per pound of meats in 1999, or 219% higher than it was in 1972 (Table 6).

Commercial hard clam fishermen are not fully dependent on this species for their total fishing income. Data from the trip tickets indicate that, on average, hard clams accounted for about 22% of the total reported fishing income during 1998-1999 for those fishermen reporting sales of hard clams; the remainder of their fishing income was derived from other fisheries. However, the extent of the dependence of these fishermen on non-fishing activities to supplement their fishing incomes is unknown. Aquaculture accounted for 22.5% of leaseholders' total household income (Diaby 1997).

The number of commercial hard clam fishermen can only be estimated because the basic unit licensed in North Carolina is the vessel rather the individual fisherman. Fishermen participating in the fishery can be divided into two groups: non-lease fishermen and leaseholders, however many lease holders are also wildstock harvesters. The total number of fishermen, using one or more endorsement-to-sell (ETS) licenses to report any sales of hard clams on trip tickets, decreased from 1,961 in 1997 to 1,718 in 1998. Although the exact number of hard clam leasees is unknown, the total number of leaseholders (hard clams and oysters) ranged from 246 in 1979 to 295 in 1997, with an average of 277. Overall, non-lease fishermen in North Carolina dominate the hard clam fishery.

Table 6. Nominal and real (adjusted for inflation) price per pound of hard clam meats received by North Carolina fishermen

Year	Weight (lbs of meat)	Current Price	Deflated Price	Current Price/lb	Deflated Price/lb
1972	274,153	$162,655	$430,304	.59	$1.57
1973	379,573	$294,098	$650,659	.77	$1.71
1974	287,675	$321,983	$665,254	$1.12	$2.31
1975	285,089	$226,087	$436,461	.79	$1.53
1976	306,179	$258,163	$400,253	.84	$1.31
1977	739,066	$1,068,880	$1,533,544	$1.45	$2.07
1978	892,235	$2,449,054	$3,305,066	$2.74	$3.70
1979	1,449,570	$4,473,737	$4,921,603	$30.9	$3.40
1980	1,541,719	$5,554,047	$6,325,794	$3.60	$4.10
1981	1,458,196	$5,386,803	$6,025,507	$3.69	$4.13
1982	1,701,793	$6,606,132	$6,606,132	$3.88	$3.88
1983	1,341,620	$5,401,824	$5,125,070	$4.03	$3.82
1984	1,387,864	$5,506,233	$4,885,744	$3.97	$3.52
1985	1,393,294	$5,653,779	$4,933,490	$4.06	$3.54
1986	1,356,316	$7,522,393	$6,022,733	$5.55	$4.44
1987	1,207,400	$7,822,801	$5,587,715	$6.48	$4.63
1988	939,976	$6,178,117	$4,154,753	$6.57	$4.42
1989	1,294,628	$8,388,051	$5,869,875	$6.48	$4.53
1990	1,354,842	$6,584,756	$4,473,340	$4.86	$3.30
1991	984,410	$5,235,182	$3,501,794	$5.32	$3.56
1992	722,235	$3,853,005	$2,468,293	$5.33	$3.42
1993	741,248	$3,922,932	$2,506,666	$5.29	$3.38
1994	718,356	$3,720,117	$2,304,905	$5.18	$3.21
1995	902,369	$5,880,446	$3,442,884	$6.52	$3.82
1996	640,261	$4,514,163	$2,721,014	$7.05	$4.25
1997	704,392	$4,940,527	$2,774,019	$7.01	$3.94
1998	689,510	$4,559,846	$2,488,999	$6.61	$3.61
1999	576,961	$3,774,446	$1,977,185	$6.54	$3.43

Total gross fishing income as indicated in Table 7 varied substantially among fishermen during 1998-1999. For example, total income from fishing ranged from $176 to over $34,000 and the average income was about $4,150 in 1999. Similarly, income earned from hard clam fishing averaged $1,896 and ranged from $155 to 9,095 during the same period.

Hard clam fishing accounted for approximately 46% of the total fishing income with average annual landed value of $1,896. Fishermen, earning an average total fishing income of less than $10,000, derived at least half of their income from the fishery, while hard clam contributed only 27% of the income that ranged over $20,000. This result

Table 7. Average distribution of revenue from hard clams (1998-1999)

	1998				1999			
Income	Number of Fishermen	Average Income All species	Average Income Hard clam	% contribution	Number of Fishermen	Average Income All species	Average Income Hard clam	% contribution
Under $500	532	$169	$136	80	516	$176	$155	88
$500-$1000	163	$727	$496	68	135	$78	$522	74
$1000-$2000	177	$153	$986	66	137	$1383	$940	68
$2000-$3000	113	$2430	$1439	59	96	$2500	$1853	74
$3000-$4000	103	$3456	$2218	64	79	$3427	$2317	68
$4000-$5000	68	$4454	$2550	58	66	$4497	$2541	57
$5000-$10000	189	$7263	$495	56	120	$7190	$3825	53
$10000-$20000	188	$14683	$6677	45	118	$14149	$6453	46
$20000 and more	185	$53125	$8852	17	52	$34036	$9095	27
	Total 1718	$8946	$2654	30	Total 1319	$4159	$1896	46

indicates that the majority of hard clam fishermen participate in more than one fishery during the year. By comparison, mariculture (i.e., hard clam and oyster) provided 22.5% of the total household incomes for leaseholders (Diaby 1997).

The numbers of hard clam seafood dealers and processors licensed have decreased. The number of dealer licenses decreased from 71 in 1984 to 40 in 1993 and then fluctuated in the 75-91 range during 1994-1999. Similarly, the number of hard clam processors licensed averaged seven during 1984-1988 before falling to zero in subsequent years. No processing licenses have been issued since 1985. Lack of processing implies that all hard clams landed in North Carolina are sold in the shell for consumption by consumers, for restaurant use, or shipped out of state.

7.2 Demographic Characteristics of Commercial Fishermen and Aquaculturists

Although there is no specific information on the socioeconomic characteristics of non-lease hard clam fishermen, it can be assumed that their profiles may be similar to those of other commercial fishermen in North Carolina. Johnson and Orbach (1996) provided a detailed description of fishermen's profiles across coastal counties. Diaby (1997) indicated that leaseholders tended to be middle aged, with an average age of 50 years. Their average level of education corresponds to more than a high school diploma, with 21% of the leaseholders holding college degrees.

7.3 Recreational Fishery

The extent of recreational hard clam fishing is unknown. The number of participants and estimated catch are not currently available. No information exists concerning recreational clamming because no license is required to fish recreationally in North Carolina. The Marine Recreational Fishery Statistics Survey (MRFSS) conducted by the Division does not collect data on recreational clamming. No data exist concerning socioeconomic characteristics of recreational hard clam fishermen in North Carolina.

8.0 ENVIRONMENTAL FACTORS

8.1 Essential Habitat

Hard clams occur extensively in estuarine systems. Essential Fish Habitat (EFH) is defined by the Magnuson-Stevens Act as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." EFH for the hard clam, as designated by the South Atlantic Fisheries Management Council, are subtidal and intertidal flats, oyster reefs and shell banks, and submerged aquatic vegetation (SAV) (South Atlantic Fisheries Management Council 1998). Spat prefer bottom substrates with shell and SAV, possibly because these substrates offer increased protection from predators. Juvenile and adult habitat includes several substrates such as mud/silt/clay, sand, shell, and SAV. The greatest densities of adult hard clams are in sandy bottom with shell and in seagrass beds (South Atlantic Fisheries Management Council 1998).

Hard clams are more abundant in sand flats than in mud flats. Because hard clams are suspension feeders they cannot compete with deposit feeders that dominate mud flats. This is because the method of deposit feeding tends to resuspend sediment particles and clog the feeding apparatus of suspension feeders such as the hard clam. On the other hand, deposit feeders are not found on sand flats because the larger sediment particle size has fewer bacteria to ingest (Peterson and Peterson 1979).

Peterson (1983) found there were higher abundance of hard clams in seagrass beds than in sand bottom. He also found that growth rates were higher in seagrass beds compared to sand bottom. The higher growth rates are possibly due to the baffling effect of grassbeds on current flow. This baffling effect slows current on the bottom of the seagrass bed creating a concentration of food particles on the bottom where the hard clam feeds.

8.2 Habitat Protection Status

The North Carolina Division of Coastal Management (DCM) is responsible for issuance of development permits along the estuarine shoreline in 20 coastal counties. Wetland development activity throughout North Carolina is permitted through the United States Army Corps of Engineers (COE) and the North Carolina Division of Water Quality (DWQ; 401 certification program). Various federal and state environmental and resource agencies, including DMF, evaluate projects proposed for permitting and provide comments and recommendations to the DCM, DWQ, and COE on potential habitat and resource impacts. Habitat protection relies on enforcement, the efforts of commenting agencies to evaluate impacts, and the incorporation of recommendations into permitting decisions.

Various public agencies (state and federal) and private groups have established

parks, refuges, reserves, sanctuaries, and natural areas that help to protect adjacent public trust estuarine habitats.

In an effort to protect SAV and other habitats from bottom-disturbing fishing gears, the MFC prohibits the use of rakes and dredges of a specific weight and type in internal coastal waters (MFC 1997; 15A NCAC 3J .0303, 3K .0102, and 3K .0503), dredges/mechanical methods to take shellfish and crabs (15A NCAC 3K .0204, 3R .0108, and 3I .0203) in certain areas, and trawl nets (15A NCAC 3J .0104 (b) (4) and 3R .0106(2)) in certain areas. Harvest methods for hard clams have been established in beds of submerged aquatic vegetation (15A NCAC 3K .0304), and the Fisheries Director has been granted proclamation authority to specify means and methods for mechanical harvest of shellfish by season and area (15A NCAC 3K .0302 and 3K .0501). The MFC has also provided habitat and fishery resource protection by prohibiting the use of various commercial gears in Primary Nursery Areas (PNAs) (15A NCAC 3N .0104 and 3R .0103), and prohibiting the use of trawl nets in Secondary Nursery Areas (15A NCAC 3N .0105, 3R .0104, and 3R .0105).

8.3 Water Quality

Water quality, influences the hard clam fishery in two ways. First, biological contamination of shellfish growing waters by fecal coliform bacteria or marine biotoxins can lead to harvest restrictions in some areas because of public health concerns. These closures remove hard clams in the affected areas from the population of shellfish available for harvest. Such clams continue to serve as spawning stock and are at times relayed from some closed areas for private culture purposes. Second, is chemical contamination of waters by pollutants such as heavy metals, hydrocarbons, and pesticides that can be detrimental to the clams themselves and also leads to harvest restrictions

8.3.1 Biological Contamination

Surveys conducted by the Shellfish Sanitation Section indicate stormwater runoff is the primary cause of water quality contamination. Bacteria and other contaminants from development activities, animal operations, agricultural croplands, wildlife, domestic pets, marinas, and forestry operations are washed into coastal estuaries by stormwater. If survey results indicate shellfish growing area stations exceed approved area standards, the recommendation is made to the Director of the DMF to close those areas to shellfish harvesting. Proclamations are then issued, closing those areas to harvesting. Wild growing clams can be moved from restricted areas to open water leases during a 6-week season in April and May. This relay allows clams to cleanse themselves of bacteria in open waters.

Studies done by Mallin (1998) in New Hanover county on the effects of land-use practices on water quality have shown that fecal coliform abundance was significantly correlated with watershed population and percent of developed land. However, he found

that the most important factor contributing to fecal coliform abundance was percent impervious surface cover. In areas with urban development, non-point source runoff from impervious surfaces is considered a major source of many pollutants. Removing vegetated pervious surfaces removes the natural filter and groundwater recharge capability and forces water into areas of smaller pervious surfaces. These smaller surfaces are then over whelmed and leads to standing water and flooding. As amounts of impervious surface increases, so does the amount of runoff and flooding.

Turbidity is another source of poor water quality. Turbidity can adversely effect shellfish because they are filter feeders. Turbidity particles can accumulate nutrients, heavy metals and fecal coliform and transport them down stream. Turbidity also provides a safe haven for fecal coliform bacteria by protecting it from ultraviolet radiation from the sun (Phillips and Garrity-Blake 2000).

Two other commissions, along with the MFC are involved in activities that impact shellfish areas. The CRC regulates development activities in the coastal zone through the Coastal Area Management Act (CAMA) and issues; and the EMC has responsibilities under the federal Clean Water Act for protecting and restoring water quality in the coastal region. All three commissions are involved in the development of CHPPs to protect and restore shellfish and fisheries habitat.

The Division of Environmental Health (DEH) is charged with the responsibility of monitoring shellfish growing areas and classifying those areas as to their suitability for shellfish harvesting. Surveys are conducted and shellfish growing waters are regularly sampled and analyzed for fecal coliform bacteria contamination. Areas are classified as Approved, Conditionally Approved, Restricted or Prohibited (Table 8). The majority of waters normally open to shellfishing between Cedar Island and the South Carolina state line are classified as conditionally approved (approximately 40,000 acres).

Table 8. Classification of shellfish growing areas

Classification	Criteria
Approved	No contamination with fecal material, pathogenic organisms, poisonous or deleterious substances or marine biotoxins. Fecal coliform median MPN or geometric mean not to exceed14 per 100 ml and not more than 10% of the samples exceed an MPN of 43 per 100ml Each station must have a minimum of 15 sets of samples during the three year evaluation period.
Conditionally Approved Open	Sanitary Survey indicates an area can meet approved area criteria (see above) for a reasonable period of time and the pollutant event is known and predictable and can be

	managed by a plan
Conditionally Approved Closed	Sanitary Survey indicates an area can meet approved area criteria (see Approved Criteria) on occasion and the pollutant event is known and predictable and can be managed by a plan
Restricted	Sanitary Survey indicates limited degree of pollution and the area is not contaminated to the extent that consumption of shellfish could be hazardous after controlled depuration or relaying.
Prohibited	No Sanitary Survey Point source discharges Marinas Data does not meet criteria for Approved, conditionally Approved, or Restricted Classification

Mallin (Phillips and Garrity-Blake 2000) also found a very strong relationship (R^2=. 6935) between human population growth and closed shellfishing areas in southeastern NC (Figure 11). This demonstrates that human population alone is one explanation as to why closures have increased. Animals, both pets and wildlife are also a major source of pollution.

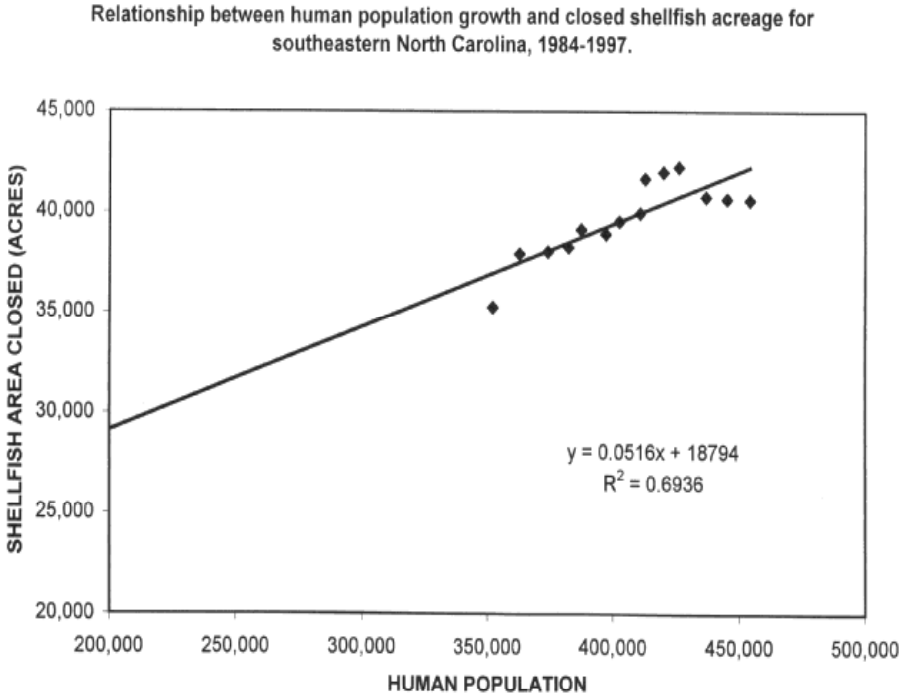


Figure 11. Relationship between human population growth and closed shellfish acreage for southeastern NC, 1984-1997. Source: Dr. Michael A. Mallin UNC-Wilmington, Wilmington, NC

Young and Thackston (1999) compared sewered basins to unsewered basins and found that sewered basins had much higher levels of E. coli, fecal coliforms, and fecal streptocci than unsewered basins. Their findings showed fecal densities to be related to housing density, development and population density and domestic animal density and not failing septic systems. Like Mallin (1998), they also found a relationship between the amount of impervious area and bacterial density. Fecal bacteria data collected from surface runoff in urban neighborhoods also demonstrate that a relationship may exist between various urban land uses and potential bacteria loading.

Temporary closures of conditionally approved open harvest areas can occur following storm water runoff from heavy rainfall events while temporary openings of conditionally approved closed harvest areas may occur after extended periods of dry weather. Prohibited shellfish growing areas are necessary where sampling consistently indicates high fecal concentrations regardless of rainfall events. Excessive shoreline development often results in these permanent closures in adjacent growing waters. Removal of vegetated buffers along shorelines, introduction of impermeable surfaces (concrete driveways, paved streets, etc.), and to a lesser degree failing septic tank

systems, add to increased fecal contamination in many areas. Runoff from areas with high concentrations of domesticated or wild animals can also lead to closures of adjacent waters.

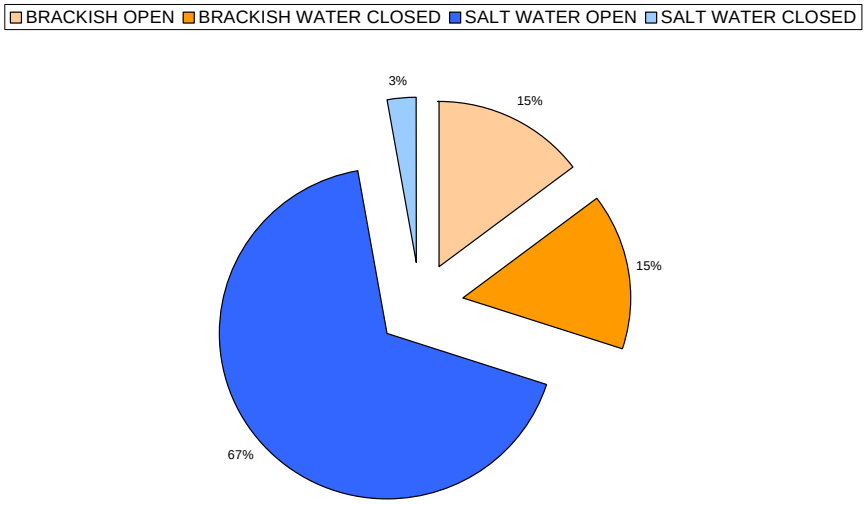


Figure 12. Percent of brackish and saltwater opened and closed to shellfish harvesting in North Carolina.

North Carolina has approximately 2 million acres of coastal waters of which 364,000 acres are "permanently" closed to shellfish harvesting. This total includes both saltwater and brackish water and represents 18% of total statewide acreage closed to shellfishing (Figure 12). There are 1,425,675 acres (saltwater open and closed) representing 70% of total coastal waters that are suitable for shellfish production (Figure 12). Three percent of those waters are closed to shellfish harvest. It should be noted, however, that this total includes the open waters of Pamlico Sound (nearly 1,000,000 acres) where little shellfish production occurs.

Between 1971 and 1985 the number of acres of suitable shellfish bottom closed to harvesting declined (Figure 13). This decline was due primarily to increase sampling efforts by DEH resulting in a "fine tuning" of growing area classifications and improvements made to point source discharges in coastal waters. Since 1985, the annual average acreage closed to shellfishing has been 54,156 acres (Patty Fowler, DEH, per. com.). A net increase of 4,787 acres of bottom suitable for shellfishing was closed also occurred during this same period (1985-1999) (Patty Fowler, DEH, per. com.).

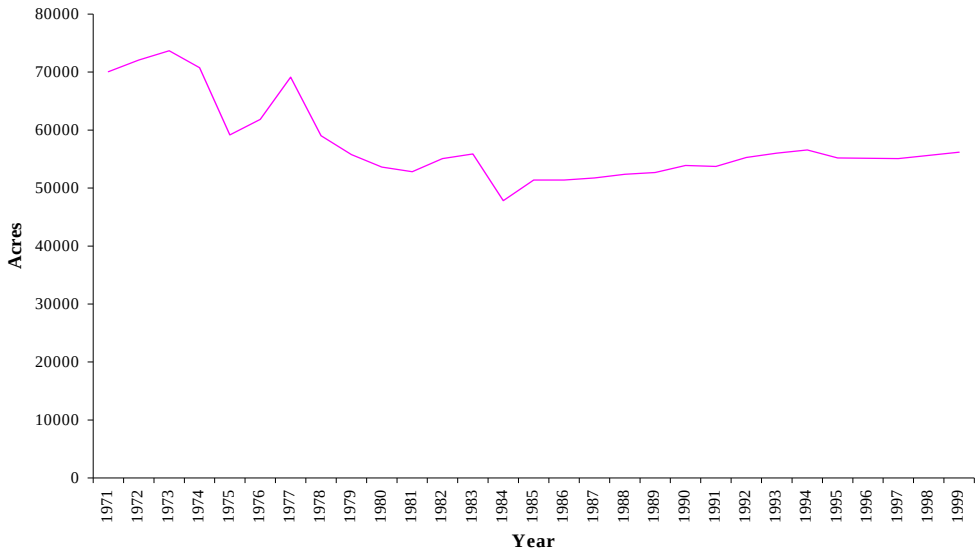


Figure 13. Number of acres of shellfish bottom closed

Most seafood related illnesses in the U.S. are caused by the consumption of raw molluscan shellfish. Most of these are caused by pathogens such as *Vibrio vulnificus* bacteria and Norwalk viruses that occur in open waters and are unrelated to fecal contamination closures. There is no shellfish or water-monitoring program for these pathogens. Most illnesses occur in persons who already have weak immune systems and are caused by raw oysters harvested from the Gulf of Mexico areas during warmer summer seasons. North Carolina clams have not been implicated in outbreaks of these illnesses.

8.3.2 Red Tide

The first recorded red tide (*Gymnodinium breve*), a toxic dinoflagellate, was recorded in North Carolina in October of 1987 causing 358,993 acres (145,280 hectares) of shellfish growing waters to be closed between 2 November 1987 and 21 January 1988. These closures effected 98% of the clam harvesting areas. This red tide normally occur in low concentrations (<1000 cell/l) in the Gulf of Mexico but blooms (>5,000 cells/l) can occur offshore of which 25% can move to nearshore waters (Tester and Fowler 1990).

There have been three documented cases of *G. breve* on the Atlantic coast of Florida. Each of these occurrences happened after a bloom on the west coast and it is believed the Florida Current-Gulf Stream system transported these cells to the Atlantic coast . In August of 1987, a *G. breve* bloom occurred off the coast of Naples Florida. By 19 October, an intrusion of the gulfstream water containing *G. breve* cells moved

shoreward onto the continental shelf and continued to move shoreward east of Cape Lookout (Tester and Fowler 1990).

G. breve cells are a motile and are attracted to light, therefore they concentrate on the surface of the water during the day where their distribution can be affected by cloud cover, wind, and tide (Tester and Fowler 1990). The Food and Drug Administration (FDA) recommended shellfish closures when cell counts were higher than 5,000 cells/liter (Tester and Fowler, 1990).

G. breve produces a neurotoxin that will accumulate in filter feeding shellfish such as clams. Mild to severe nausea, vomiting, diarrhea, chills, dizziness, numbness and tingling of the face and extremities will occur within three to four hours after consumption of contaminated shellfish (Tester et al, 1988). There were approximately 48 persons with confirmed neurotoxic shellfish poisoning (NSP) in North Carolina. Most of the cases (35) occurred before the first shellfish closure on 2 November (Tester et al., 1988).

The economic lost to the coast was estimated at $25 million and had its greatest impact on the clam fishermen. Clam landings were less than half of the previous year and caused a $2 million reduction in dockside value (Tester and Fowler, 1990). The Shellfish Sanitation Section now has a contingency plan, required by the FDA, in case another red tide should occur. This plan includes a monitoring program and a management plan. DMF also has a contingency plan to provide assistance to Shellfish Sanitation by conducting aerial surveillance of offshore waters, collecting samples, and closing and patrolling areas closed to harvest because of red tide (Patricia Fowler, Shellfish Sanitation, pers. com.).

8.3.3 Green Gill

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. The diatom produces a blue pigment called marennine. This pigment is released into the water turning it a bluish color. Clams pick it up while filtering the blue colored water, which combines with the clam's natural yellow color, turning the gills green. The greened gilled clams, usually found in the cooler months are harmless. The French consider the green gilled shellfish a delicacy and actually culture the alga to produce a somewhat nuttier tasting shellfish. However, in the US, shellfish markets have a hard time selling them because the American consumer thinks they are inedible.

8.3.4 Chemical Contamination

Marine bivalves have been shown to accumulate chemical contaminates such as hydrocarbons and heavy metals in high concentrations. Exposure to organic contaminates has resulted in impairment of physiological mechanisms, histopathological

disorders, and loss of reproductive potential (Capuzzo 1996). Reductions in growth and increased mortality have been observed in soft shelled clams (*M. arenaria*) following oil spill pollution events (Appeldoorn 1981).

Increased respiration, reduction in shell thickness, inhibition of shell growth, and general emaciation of tissues has been attributed to adult bivalve exposure to heavy metal contamination. Early developmental stages of bivalve molluscs are most sensitive to metal toxicity. Metals such as mercury, cadmium, and copper are capable of adversely affecting genetic development in bivalve embryos (Roesijadi, 1996).

Hackney et al. (1998) studied North Carolina's estuaries, widespread contamination of surface sediments by several chemical contaminates including heavy metals, DDT, and hydrocarbons. Although attributing direct impacts to the hard clam fishery from such chemical contaminates may be difficult at best, the presence of these contaminants in many of the State's estuaries is a cause of concern for clam stocks in those areas.

8.4 Water Quality Protection

Federal and state laws mandate water quality protection activities through government commissions and agencies. Several divisions within the North Carolina Department of Environment and Natural Resources are responsible for providing technical and financial assistance, planning, permitting, certification, monitoring, and regulatory activities that have a direct or indirect impact on coastal water quality and habitat.

Various federal and state environmental and resource agencies, including DMF, evaluate proposed projects and provide comments and recommendations on potential water quality and resource impacts. Water quality protection relies on enforcement, the ability of commenting agencies to evaluate impacts, and whether recommendations are incorporated into permitting decisions.

An increase in population and land-based development, demands on water resources for various uses, and an inadequate understanding of impacts on estuaries have caused water quality degradation in spite of management efforts. The principal problems are a lack of strict pollutant standards, inadequate pollution abatement, and insufficient monitoring to protect water quality and the complex ecology of estuarine systems.

North Carolina has established a water quality classification and standards program for "best usage." Recent water quality classifications and standards have been implemented to promote protection of surface water supply watersheds, high quality waters, ecosystem functions, and the protection of unique and special pristine waters with outstanding resource values. Classifications, particularly for High Quality Waters

(HQW), Outstanding Resource Waters (ORW), Nutrient Sensitive Waters (NSW) and Water Supply (WS) waters, outline protective management strategies aimed at controlling point and nonpoint source pollution. Many water quality standards are based on potential impacts in the immediate receiving waters and do not factor in the cumulative and long-term effects to the complex functions that characterize estuarine systems. Standards should be based on the assimilative capacity of, and impacts to, the entire system. The Comprehensive Conservation and Management Plan of the Albemarle-Pamlico Estuarine Study (EPA and NCDEHNR 1994) and other earlier plans for water quality management have recommended strategies that need to be implemented to improve water quality. Many of these recommendations have not been accomplished. Achievement of basinwide water quality management planning by the Division of Water Quality (DWQ) will hopefully improve coastal water quality.

Various public agencies (state and federal) and private groups have established parks, refuges, reserves, sanctuaries, and natural areas that help to protect adjacent public trust estuarine water quality.

8.5 Ecological Benefits of Clams

Important ecological functions of clams such as fishery nursery habitat and natural water filtration have beneficial effects on the surrounding marine environment. Clam bed covers in aquaculture operations develop a growth of marine organisms and may provide good nursery habitat for other species such as fish, shrimp and crabs. Juveniles of those species escape predation by hiding in clam beds and some juveniles derive food from attached organisms and clam pseudofeces.

Clams are filter feeders and use suspended plankton and detritus for food. This ability to filter feed has created an interest in the use of clams and oysters to possibly act as filters of the estuarine system. Their filtering ability decreases turbidity, and microalgal concentrations in the water column thus improving water quality. This ability to decrease turbidity and improve water clarity would also promote growth of seagrass beds (Joergensen 1990). Economic values of these secondary public benefits are not well known and may actually have a greater economic impact than the clam production itself.

Work done in the Chesapeake Bay seems to indicate that based on bivalve abundance, filtering capacities, and water mixing parameters, bivalves could consume more than 50% of the primary production in shallow freshwater and low salinity areas. However, in deeper more saline systems, primary production was reduced by 10%. Estuary width may also influence the ability of bivalves to filter primary production because of the low transport of water to the flanks of an estuary where bivalves can be abundant. These results suggest that by using bivalves to improve water quality may be limited by depth and width of the estuary, unless the bivalves are suspended in the water column by artificial means (Gerritsen et al. 1994).

9.0 PRINCIPAL ISSUES AND MANAGEMENT OPTIONS

The principal issues concerning management of the clam resource and options for resolving them are grouped according to their capacity to address the four problems identified in Section 4.2. Individual issues may address very specific management questions or broad areas of management depending on their origination and staff's ability to efficiently provide information.

9.1 Insufficient Data

9.1.1 No Data on Recreational Harvest of Shellfish

No recreational shellfish harvest data are currently being collected. This issue originated from the Oyster and Clam FMP Committee (AC).

Background

Despite the importance of the commercial shellfish fisheries (molluscan and crustacean) to the state, very few data exists on recreational shellfish harvest. A 1991 phone survey conducted by Marine Recreational Fisheries Statistics Survey (MRFSS) indicated 3% of households in coastal North Carolina participated in recreational shellfishing (Doug. Mumford, DMF, pers. com.). Recreational data are being collected by MRFSS for finfish but the survey does not currently collect shellfish data. This lack of recreational landings data makes it impossible to estimate the impacts of recreational harvest on each species. In addition, the 1997 FRA requires the DMF to prepare FMPs for all of the state's commercially and recreationally significant species. The shellfish fisheries are under North Carolina jurisdiction alone, so effective state FMPs are very important. Although the FRA created a Recreational Commercial Gear License (RCGL) for recreational fishermen who use limited amounts of commercial gear to harvest seafood for personal consumption, shellfish gear was not approved under this license. Also, all state residents are able to purchase a shellfish license at a cost lower than the RCGL and use any commercial shellfish gear. Therefore, data from recreational harvest by shellfish license holders is not captured by the RCGL.

Discussion

It is imperative to collect high quality recreational harvest data to address potential management issues such as harvest limits, size limits, and gear restrictions. To better manage shellfish fisheries, information on recreational harvest such as effort and size distribution for each species by area are needed.

The collection of shellfish recreational harvest data, along with commercial landings data available through the North Carolina Trip Ticket Program would provide data for a better estimate of maximum sustainable yield (MSY) and fishing mortality (F)

along with increased knowledge of the recreational fisheries in the state. MSY and F would be expected to increase if landings from recreational harvest were added to total landings. These estimates, along with the more accurate accounting of landings would allow managers to examine the proportional harvest of the recreational and commercial fisheries and make better decisions on management strategies for both harvest sectors.

The best way to capture recreational shellfish harvest data is to have a coastal recreational fishing license. This would create a sampling universe of all recreational fishermen that fish in coastal waters. Within this sampling universe, those recreational fishermen who fish for shellfish can be surveyed for information concerning amount of catch, length of time fishing, gear type and waterbody.

A simple way to collect some data on recreational shellfishing is to add the pleasure category to the shellfish license. DMF used to collect data from commercial licenses on whether a fisherman considered himself/herself a full-time, part-time, or pleasure fisherman. Today, SCFLs only capture full-time or part-time fishermen based on their income and pleasure fishermen are only recorded on the RCGL. It is believed that some recreational fishermen (because of the availability of the shellfish license at a low price ($25)) may purchase a shellfish license so that they may catch more than the recreational limit and allow them to sell all or a portion of their catch. Although this limits our sampling universe to recreational fishermen who bought a commercial license and leaves out those recreational fishermen who did not buy a license. It would still provide some limited information on recreational shellfishing.

Management Options/Impacts

A. Status Quo

+ No additional regulation on recreational fishery
- Information not available for MSY estimates

B. Intercept survey

+ Catch/effort data per species collected
+ Gear data collected
+ Species identification and size data collected
+ Ability to gather social economic data
- Expensive to implement
- Difficult to intercept shoreline fishermen
- Unable to intercept fishermen originating from private residence

C. Phone survey

+ Kinds of species caught
+ Gear data collected
+ Some effort information (number of trips)
+ Ability to gather social economic data
- Sampling universe not defined
- Expensive to implement
- Unable to get individual species data (lengths, etc)
- Survey dependent on recollective memory
- Intercept survey required to extrapolate trip data

D. Recreational License

+ Defines a sampling universe
+ Provides revenue for phone survey
+ Ability to gather socioeconomic data
- Additional regulation on the recreational fishery
- Additional financial burden on the recreational fishermen

E. Recreational Shellfish Permit

+ Defines a sampling universe
+ Ability to gather social economic data
- Additional regulation on the recreational fishery
- Additional financial burden on the recreational fishermen
- No revenue for phone survey

F. Add “pleasure” category to shellfish license

+ Defines a sampling universe
+ Easily implemented
- Leaves out those recreational fishermen who do not buy a license

DMF Recommendation

D. Recreational License
F. Add “pleasure” category to shellfish license

AC Recommendation

Agreed with DMF

MFC Selected Management Strategies

Support adoption of a mechanism that would provide data on recreational

shellfish harvest and add “pleasure” category to the existing Shellfish License.

9.2 Management Strategies

9.2.1 Clam Relay During Extended Shellfish Closures

This issue discusses the development of a clam relaying program involving shellfishermen during times of extended closures because of effects of catastrophic storms or hurricanes. It also considers the effects these storms have on the clam environment. This issue originated from public comments at Public Information Document (PID) meetings.

Background

Traditionally, clam relaying from the Morehead City area south to the South Carolina line is an annual project taken on by shell fishermen who are interested in restocking their leases. Commercial shell fishermen gather clams from permanently closed polluted areas and place these clams on their individual leases. All work is done under the direct supervision of the Marine Patrol. The obvious benefit is to the shell fisherman who owns the lease, but there are several disadvantages in this program which are discussed later. The Division has initiated its own clam relay, on a small scale in the central and southern districts, utilizing its own staff and equipment. There has been a suggestion for the Division to get more involved with the shellfishing public when there are extended closures of shellfish areas due to hurricanes and other catastrophic storms.

Because of the increase in shellfish closures in recent years, the state is studying the feasibility of increasing clam relaying to benefit the public sector. When a hurricane or catastrophic storm strikes our coastal counties, it brings heavy winds and torrential rains that can be detrimental to all shellfish and is usually is followed by a complete and immediate shellfish closure.

A physical effect of these storms includes the sanding over of clam and oyster beds. Turner and Miller (1991) found this resulted in a decrease in shell growth and increase in pseudofeces production. Growth rates declined because the energy normally expended for growth was transferred to filter out sand particles and produce pseudofeces instead. This study suggests there are negative short term effects from a storm event on hard clams.

Another major impact these storms have on the clam environment is the influx of fresh water caused by the associated torrential rains. Rain and runoff introduce bacteria, pollutants, pesticides, and other contaminants into rivers and estuaries. Consequently, areas normally open to shell fishing are often closed for at least several weeks. Mallin et

al.(1998) reported that Hurricanes Bertha and Fran in southern North Carolina in 1996 caused hog waste lagoons to rupture and power failures which diverted partially treated sewage and storm water to run directly into the Cape Fear River. These chemical, biological, and physical effects resulted in extremely low dissolved oxygen (DO) levels, very high biological oxygen demand (BOD) levels (at least sixfold) and a significant decline in benthic abundance immediately after the storm. Recovery did not occur until ~3 months later. In the summer and fall of 1999, Hurricanes Dennis, Floyd, and Irene caused state shellfish areas to close for several weeks.

Discussion

A few commercial fishermen have expressed interest in a state-managed clam relay as a relief effort in the wake of these storms. The Division already has an oyster relay program in the southern district that has been in place for over 30 years. This program is budgeted by the state legislature and each year the funding has been sufficient but uncertain. Each April, after the oyster season closes, the state pays oystermen a flat fee ($1.50) per bushel of oysters harvested from permanently polluted waters. These oysters are then placed in Oyster Management Areas, allowed to purge, and are available for harvest when oyster season reopens the following October. The only similar state program for clams is the previously mentioned relay program for private leases involves Marine Patrol. Disadvantages associated with this program include the number of officers and their time involved in the surveillance of these clams. Theft and the possibility of these polluted clams showing up in the markets are a concern.

The DMF conducted an experimental clam relay in the Southport area in spring of 1999. Using DMF personnel and equipment, approximately 250,000 clams were moved from polluted waters in the Intracoastal Waterway (ICW) and relayed to area bays. Marine Patrol increased surveillance of these clams over a two-week period. These marked areas are closed to harvest for an eighteen-month period. If the state were to initiate some relay program, it would most likely operate in a similar manner as this project, where each shell fisherman would be compensated on a per clam basis. Yet to be determined are the criteria for initiating such a program.

New York has an extensive clam relay program where the majority of responsibility lies on the shellfishermen. They're responsible for the permits, harvest, relay, bagging, and security. The fees are high, but necessary to cover the cost of supervision provided by the state. The clams are either taken to depuration plants or back to private bottoms until the appropriate depuration period has passed. These shellfish transplant supervision fees for the 1999 permits had a biweekly minimum cost of $1,147.36 to the shell fisherman (Debbie Barnes, NYDEC, pers. com.).

Florida has a clam relay program in the Indian River lagoon similar to New

York's, in that the shell fishermen pay for their security and laboratory fees. Florida does not have the high permit fees that NY does. Florida has an additional program of emergency relief/public assistance that deals with oyster closures because of extensive rainfall in the Apalachicola River area. This is funded either through legislative actions, government grants, or a tax-like fund collected from the oystermen for these "rainy-day" occurrences (Mark Barrigan, FWC, pers. com).

In the winter of 1987 red tide impacted the coastline negatively affecting clams, oysters, fish, and other marine species. The DMF and several other agencies implemented a temporary state oyster relay program. This program provided monetary payments to shell fishermen for transferring the oysters from closed shellfish areas to unpolluted waters. The following spring of 1989, excessive rainfall closed most of the southern district's shellfish beds for approximately nine weeks. The state did not initiate any relay efforts after this rain event and the results of not being able to work for that prolonged period were detrimental to the local shell fisherman. In fact, several long time commercial fishermen withdrew from the fishery entirely (Dave Beresoff, commercial fisherman, pers com.). Storms and other catastrophic weather events can severely impact those commercial fishermen whose income is derived primarily from oysters or clams.

Management Options/Impacts

A. Status Quo

+ would require no additional funding
+ would require no additional law enforcement
- no additional money available for fishermen impacted by storm closures
- possibility of fishermen withdrawing from fishery

B. Increase the intensity of our present clam relay schedule

+ Increase amount of shellfish available for market
+ Reduce polluted shellfish poaching potential by increasing clam abundance in non-polluted areas
+ Increase use of underutilized resource
- Increases stress on the resource and the habitat
- Reduces spawning sanctuary function of polluted (prohibited) areas
- Would require funding currently used for oyster habitat enhancement

C. Initiate a type of statewide clam relay "relief" program after catastrophic

storms.

+ Polluted clams would be relayed to open areas where after depuration, they would benefit the commercial shell fishermen as well as the general public.
+ Would put money in the pockets of shellfishermen that would rather work than accept a “handout”.
+ Would join other states in this “pro-active” relief program.
- Would require additional funding.
- This program would most likely require legislative action.
- This program would be labor intensive for Marine Patrol unless program was similar to NY or FL where burden and cost is on the shellfishermen.
- The state contract procedure could take longer than the closure period after a storm.

DMF Recommendation

B. Increase the intensity of our present clam relay schedule

AC Recommendation

Agreed with DMF

MFC Selected Management Strategy

Increase the intensity of our present clam relay schedule

9.2.2 Rotation of Southeast Pamlico Sound with Core Sound

A rotation system is needed in the mechanical clam harvest fishery to allow clams to repopulate in the northern portion of Core Sound. Under this system, an area of Southeast Pamlico Sound and Core Sound would be alternately opened and closed to harvest to permit recovery of both sand bottom habitat and hard clam populations and prevent overharvest. This issue originated from fishermen and managers who have expressed the need for rotation schemes since the mid-1980s.

Background

When “modern” clam kicking began, there were no bounds to the harvest areas, times of harvest, or bag limit. In the late 1970s, sea grass beds and oyster rocks were protected and mechanical harvest was largely confined to the deeper waters of the sounds

and rivers. After many confrontational seasons, the present harvest areas were established for mechanical clam harvest (Figures 3-8). Today mechanical harvest gears include clam kicking trawls and hydraulic dredges. In the early 1980s, the hydraulic dredge operators proposed a rotation scheme between White Oak River, including a portion of the Intracoastal Waterway and New River. New and White Oak rivers would be opened in alternate years and the bag limit would be reduced from 40 bags (250 clams/bag) to 25 bags to reduce the possibility of overharvest. Although White Oak River is depleted within a month or so of opening, New River seems to support that harvest level throughout the season.

Many Core Sound fishermen and DMF staff are of the opinion that harvest areas should be rotated to prevent overharvesting of 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 majority of the Carteret County fishermen would like to see open areas of Core Sound closed and alternatively rotated with a new area in southeastern Pamlico Sound. In 1991, the Marine Fisheries Commission wanted to prevent growth of this fishery because of habitat concerns and prohibited the opening of any new bottom that had not traditionally been opened since 1977.

Current Authority

North Carolina Fisheries Rules for Coastal Waters (1999-2000)
15A NCAC 3K .0302. Mechanical Harvest Season

Discussion

A chief objective of mechanical harvest management is to minimize impacts on grass beds. Peterson et al. (1987) found that raking and "light" mechanical harvesting decreased seagrass density approximately 25%, but recovery occurred within a year. Intense mechanical harvesting reduced the seagrass biomass approximately 65% and recovery had not occurred after four years.

The Division conducted several surveys with DMF vessels and commercial vessels in response to requests for additional clam kicking bottom. These surveys indicated significant clam populations did exist in southeastern Pamlico Sound, but the higher concentrations were associated with seagrass beds. Surveys of Kingfish Shoal north of Wainwright Island resulted in its being opened to mechanical harvest from 1988 through 1993, but closed in 1994 when fishing effort ceased. Surveys in the Intracoastal Waterway from Swansboro to Morehead City in 1989 yielded almost no clams. The "Cut Bank" of the Bogue Sound ICW has been opened in the past, but seagrass, hand clam harvesters, and development have prevented its opening in recent years.

The Oyster and Clam Advisory committee proposed a new area west of

Portsmouth Island in the vicinity of Schooner Shoal (Figure 14). DMF recently surveyed this area in May and again in August of 2000. Tows were made with a 40-foot vessel using a 22ft clam trawl with a cod-end cage four feet long, three feet wide and 3 ft deep. The stern of the boat was weighted with water to bring the prop wash approximately two feet from the bottom. For each tow, tow time, salinity, water depth, bottom type, presence/absence of SAV, total number of clam, and any bycatch was recorded. GPS position data were also taken for each tow. Thickness and length of a subsample of 40 to 80 clams from each tow were also recorded.

Sixteen tows produced a sample of 2,820 clams of which 770 clams were measured. Tow times ranged from 7 to 19 minutes and averaged 17 minutes. Catch per unit effort averaged 176 clams per tow and 11 clams per minute. Water depths ranged from 7 to 13 feet. Samples were not taken from the Schooner Shoal. Bottom types were mostly hard sandy mud with the exception of two tows where shell bottom was encountered. Very little SAV was observed in catches made in seven feet. No SAV were observed in tows taken at greater depths. Salinity ranged from 17 to 20 ppt. Bycatch was minimal and included one pigfish, four flounder, two blue crabs, one horseshoe crab, two skates, several moon snails, numerous hogchokers, a channeled whelk and a blood ark. One bag with 258 clams was taken back to the dock and graded out with 9 chowders, 58 cherries, 159 topnecks, and 32 littlenecks.

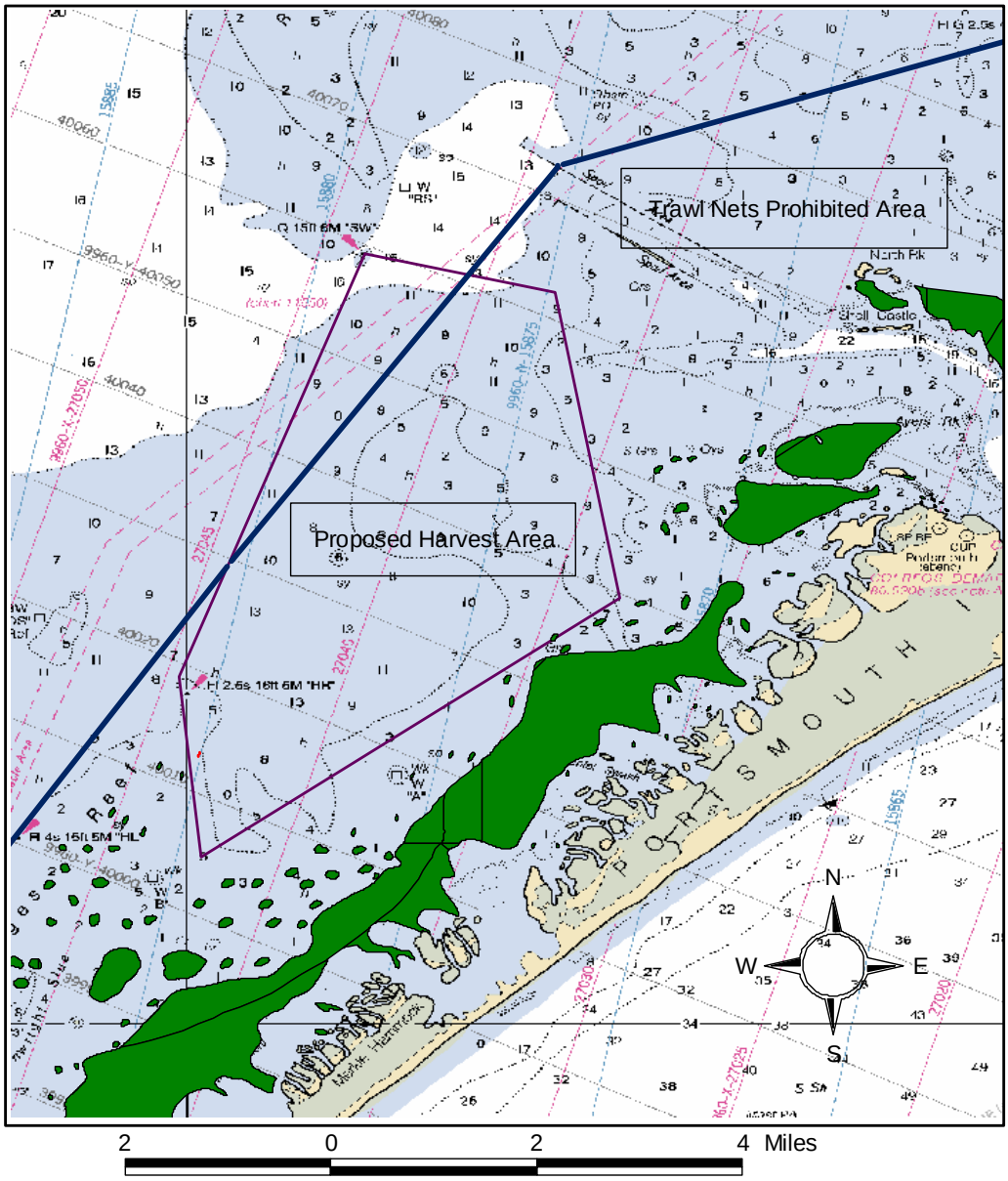
There were significantly more clams ($p < 0.05$) found in the shallow water (<10.0 ft) than in deep water (≥10.0 ft.) These clams were also significantly bigger ($p < 0.05$) than those caught in deep water (Figure 15). Average age of these clams were approximately 7 to 8 years old.

Aerial photographs of seagrass beds taken by National Marine Fisheries Service (NMFS) in 1988 show the presence of grass along the eastern edge of the proposed area and possibly some small patch beds on Schooner Shoal. Shellfish mapping data taken in 1998 also show seagrass beds along the eastern edge of the proposed area.

Additional sampling of the area was performed by DMF staff in August of 2000, using the Division's escalator dredge. Sampling sites were the same as those sampled in May with the clam kick boat. Fewer clams were captured by the escalator dredge than with the clam kick gear because of the bottom type. Thirteen tows produced 1078 clams of which 384 clams were measured. SAV was observed in the same sample stations as with the clam kick boat but in much greater quantities. Bottom types observed were mostly hard sandy mud. An additional sample was taken on the Schooner Shoal that produced only seven clams in a 19minute tow. Large SAV patches were observed on the shoal in the vicinity of the sample. Later in September of 2000, these grass patches were sampled. These patches averaged approximately eight meter square in size and consisted of shoal grass (*Halodule wrighttii*) with an average shoot density of 2000 shoots per meter square.

From these data, there appears to be a resource of hard clams adequate to support a small closely regulated fishery in the surveyed area. However, because of the observed presence of seagrasses and seagrass habitat, any open mechanical harvest area should be moved farther offshore to provide a buffer between SAV and mechanical harvest. Protection of the Schooner Shoal because of grass patches is also recommended. Based on these recommendations, the DMF proposed two separate areas within the area proposed by the AC (Figure 15). This will ensure effects on grassbeds from harvest gear and turbidity will be prevented.

There has been concern expressed by DMF staff and the public about the proposed area existing in a No-Trawl-Zone (Figure 14). However, DMF believes that this particular No-Trawl-Zone, with its expanse of sand bottom has a viable clam resource that would otherwise not be utilized unless open to mechanical harvest. Rotation of the area combined with a relatively short recovery time needed from bottom gear disturbance on an unstructured bottom should allow recovery from mechanical clam harvest.



Proposed Mechanical Clam Harvesting Area in Southeast Pamlico Sound

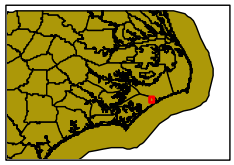
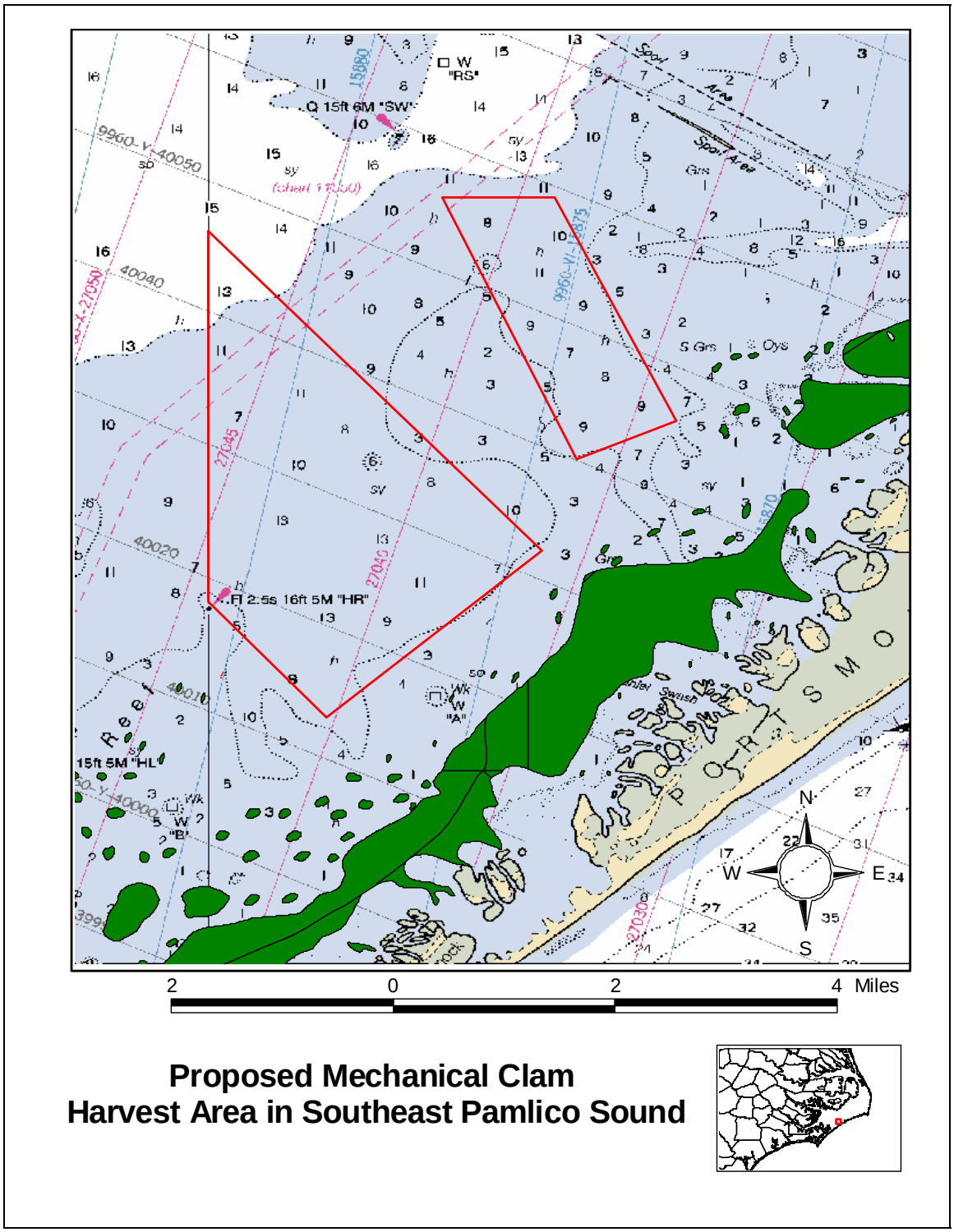


Figure 14. Mechanical clam harvest area proposed by the Advisory Committee



Proposed Mechanical Clam Harvest Area in Southeast Pamlico Sound

Figure 15. Mechanical Harvest area proposed by the DMF

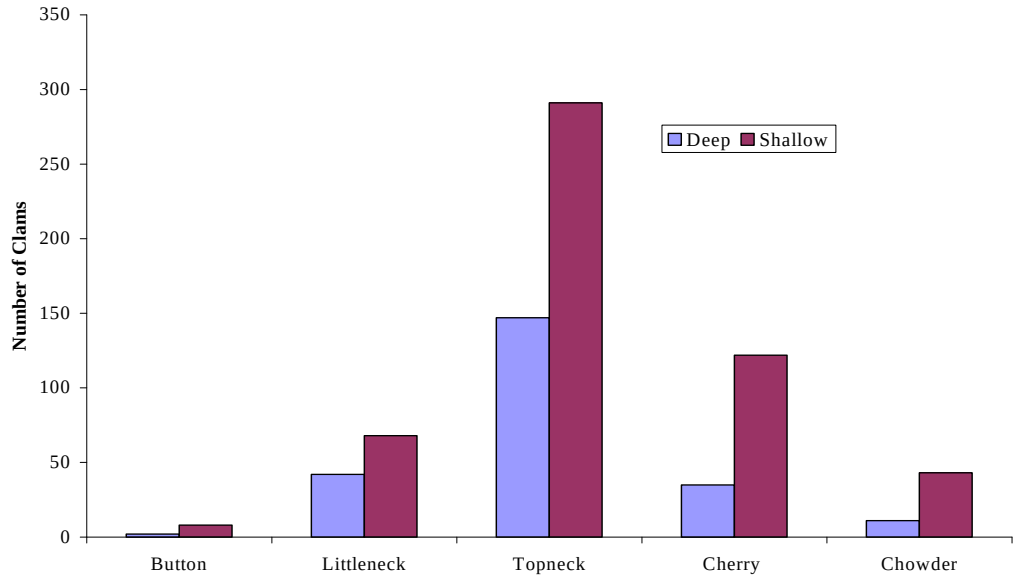


Figure 16. Number of clams sampled by grade in Southeast Pamlico Sound

Management Options

A. Status Quo

- Continued overharvest of clam stocks in mechanical areas of Core Sound

B. Increase rotation of mechanical harvest areas within existing sites

+ Decease amount of habitat affected by mechanical harvest at one time
+ Ability for closed portions of area to recover from harvest impacts
- Larger number of boats forced into a smaller area could increase impacts on habitat.
- Only part of the existing open mechanical harvest areas are used at this time; during periods when "non-productive" areas are opened, few clams would be available.

C. Add SE Pamlico Sound area and rotate with Core Sound. **(Rule change required)**.

+ Increase use of an underutilized clam resource in SE Pamlico Sound
+ Allow Core Sound to recover from mechanical harvest impacts
- Increase in overall amount of habitat impacted by mechanical

harvest
- SE Pamlico Sound area will be difficult to mark and enforce.
- Possible social conflicts with Ocracoke fishermen

DMF Recommendation

B. Increase rotation of mechanical harvest areas within existing sites

After exploratory sampling of the area proposed, DMF changed its recommendation to add SE Pamlico Sound area and rotate with Core Sound.

AC Recommendation

C. Add SE Pamlico Sound area and rotate with Core Sound

MFC Selected Management Strategy

Add SE Pamlico Sound area and rotate with Core Sound

9.2.3 Harvest Limits During Mechanical Harvest Season and Length of Season

This issue addresses the bag limits of clams during mechanical harvest season to spread effort over more of the season and to prevent overharvest. This issue originated from fishermen who have voiced concerns in the past and was also included in an earlier draft plan

Background

Past mechanical clam harvest seasons have begun in the first two weeks of December with landings peaking in January and dropping monthly by the end of the season in March. This is true for most harvest areas, with the exception of New River, where landings remain steady throughout the season probably due to historically lower harvest limits and rotation of harvest areas.

Mechanical clam harvest is the harvest of clams with hydraulic escalator dredges and clam kicking trawls. Although mechanical harvest began in the 1940s, it has existed in its present form since the 1970s. Kicking occurs predominantly in the Bogue Sound to Core Sound region, while hydraulic dredges are chiefly used in the White Oak River and the deeper waters of New River and the ICW.

Hydraulic dredge operators requested a 25 bag (250 clams per bag) limit in the early 1980s to conserve the clam stocks in New River because of the efficiency of their harvest methods. New River, which is rotated with White Oak River appears to be sustaining the fishery. However, mechanical harvest landings in Core Sound have shown a decline, especially the past two seasons. This has fishermen and staff concerned about

the sustainability of mechanical clam harvest in Core Sound. Discussion addressing Core Sound mechanical clam harvest has developed several options including shortening the season, lowering the bag limit and setting up a rotation schedule between Core Sound and an area in Southeast Pamlico Sound.

Current Authority

North Carolina Fisheries Rules for Coastal Waters (1999-2000)
15A NCAC 3K .0301 Size and Harvest Limit

Discussion

Landings by month for the past ten seasons, 1988/89 through 1997/98, are shown in Figure 17. Landings generally drop off as the season progressed, although not dramatically. Therefore shortening the season is probably not necessary. Figure 18 shows the same monthly trend in mechanical harvest landings for the same period for Core Sound. However, harvest has decreased each year over this period of time. Figure 19 shows the percentage of the limit taken in Core Sound from 1994 through 1998/99 relative to a 25-bag limit. Since the 94/95 season, fishermen have been landing approximately 40% of the 25-bag limit or around 15 bags per trip instead of catching their limit of 25 bags. Fishermen in the area have had poor seasons the past two years and have reported seeing very few buttons (undersized clams), an indicator of poor recruitment. Data collected over a 20-year period in Back sound has also shown a 50% decrease in annual recruitment of hard clams (Peterson, in prep). Lowering the bag limit from 25 bags to 15 bags may decrease fishing pressure on hard clams in Core Sound.

As mentioned above, landings by waterbody show that New River landings do not drop off as dramatically as the rest of the harvest areas. The sustained landings may be because a reduced bag limit has been in effect there since the mid-1980s. New River is also on a yearly rotation schedule with White Oak River. Rotation of Core Sound with an area in Southeast Pamlico Sound may also give Core Sound a period of time with no mechanical harvest pressure to increase recruitment in Core Sound.

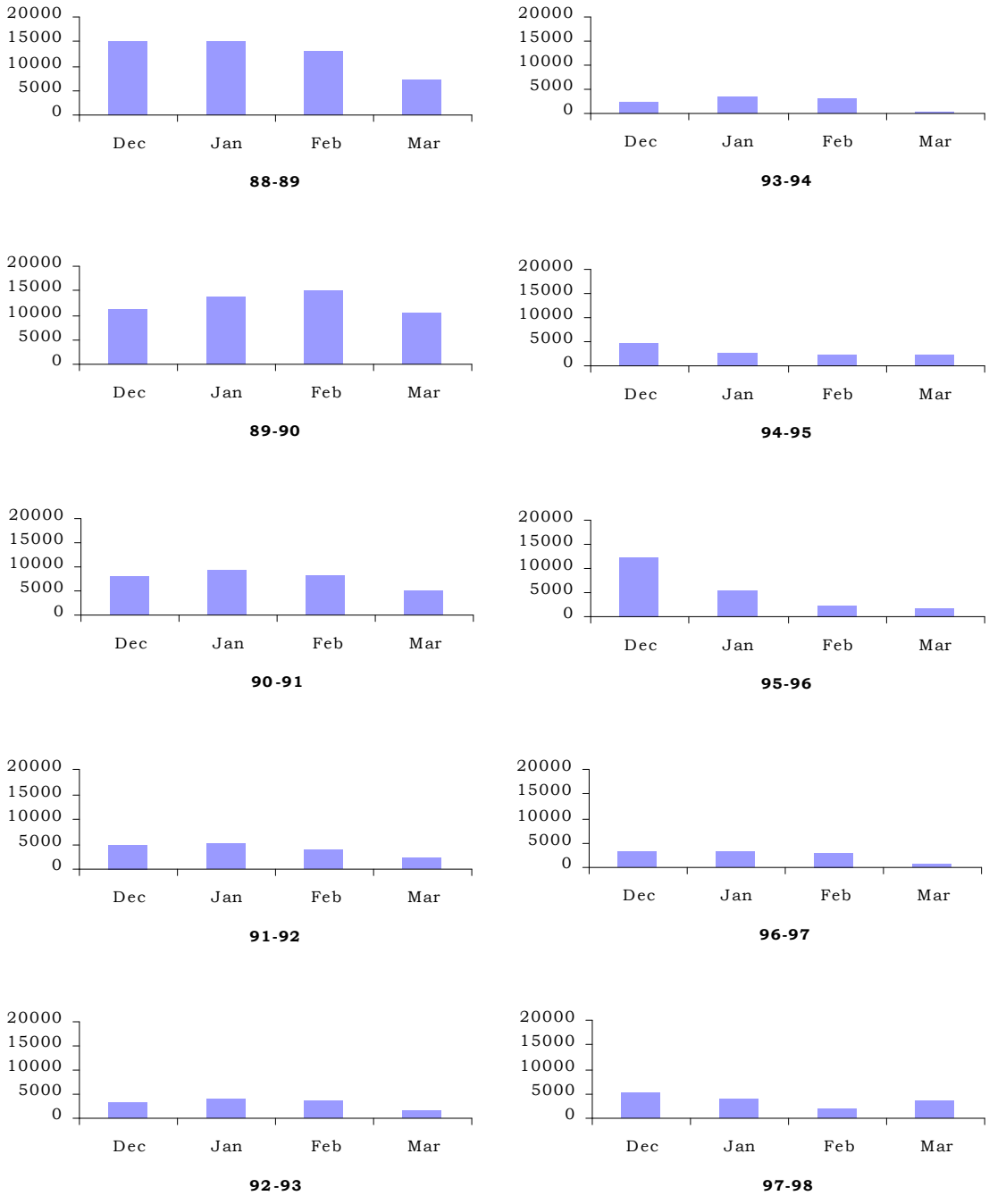


Figure 17. Mechanical harvest landings (1988-1998)

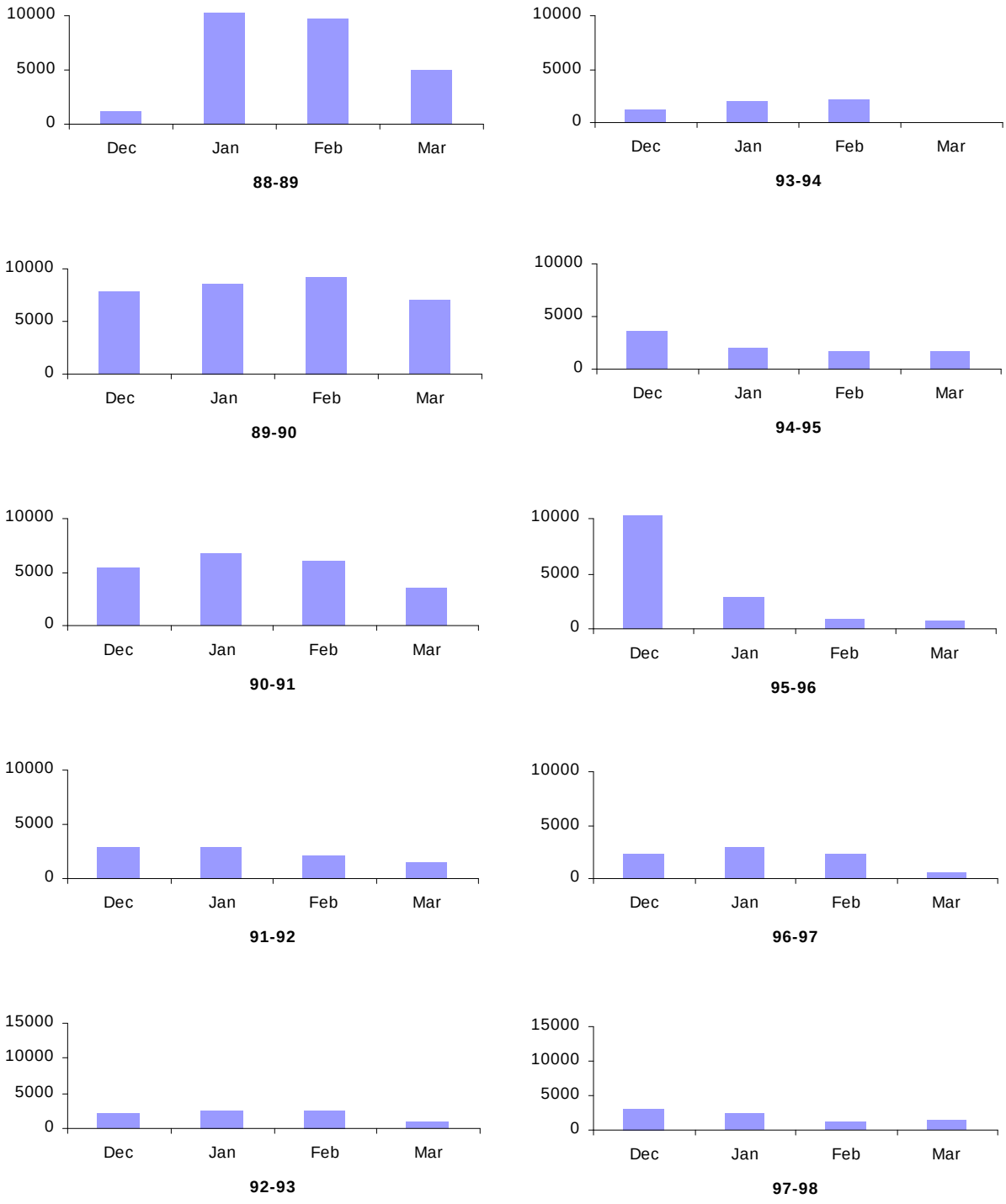


Figure 18. Mechanical harvest landings of Core Sound (1988-1998)

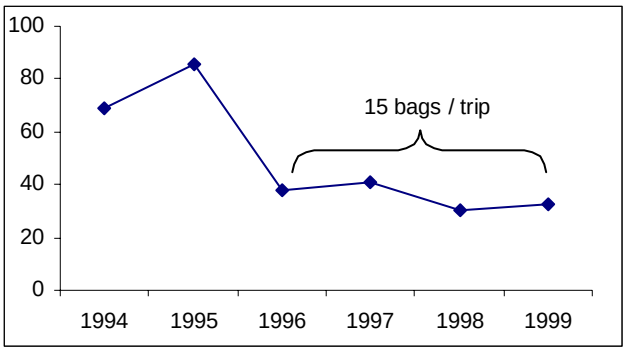


Figure 19. Percentage of trips harvesting the 25-bag limit taken in Core Sound (1994-1999)

Management Options

A. Status Quo

- Possible depletion of the clam stocks past a point at which they are able to replenish themselves.

B. Reduce the bag limits allowed during the mechanical harvest season from 25 bags to 15 bags in Core Sound.

+ Spread the harvest over more of the three month period which may improve prices.
- Reduce income for mechanical harvest because of lower volume of clams

C. Shorten the mechanical harvest season

+ Longer recovery time for habitat and clam resource
+ May improve depleted clam stocks
- Reduced income for mechanical harvesters during a time when few other fishing opportunities exist

D. Rotate Southeast Pamlico Sound area with Core Sound and lower the bag limit in Core Sound to 15 bags. Pamlico Sound area bag limit would also be 15 bags.

+ Allow Core Sound to recover from mechanical harvest pressure.
+ Allows use of an underutilized clam resource.
- Increases overall amount of habitat impacted by mechanical harvest.
- Southeast Pamlico Sound area will be difficult to mark and

enforce.
- Possible social conflicts with Ocracoke fishermen

DMF Recommendation

D. Rotate Southeast Pamlico Sound area with Core Sound and lower the bag limit in Core Sound to 15 bags. Pamlico Sound area bag limit would also be 15 bags.

AC Recommendation

Agreed with DMF

MFC Selected Management Strategy

Rotate Southeast Pamlico Sound area with Core sound and lower the bag limit to 20 bags. Pamlico Sound area bag limit would also be 20 bags.

9.2.4 Effects of an Open Harvest License on Shellfish Fisheries

What are the effects of an open license for shellfish on shellfish fisheries? This issue originated from members of the MFC.

Background

During the fisheries moratorium, it was decided that the shellfish license would be open to the citizens of North Carolina at a low cost so those subsistence fishermen would be able to afford a license. Also, during the moratorium, many hand harvesters did not have an Endorsement to Sell (ETS) and their shellfish were sold by an ETS holder. These fishermen did not have access to a SCFL. It was also decided that to allow for flexibility of the commercial fisherman the shellfish endorsement would be free on the SCFL.

Current Authority

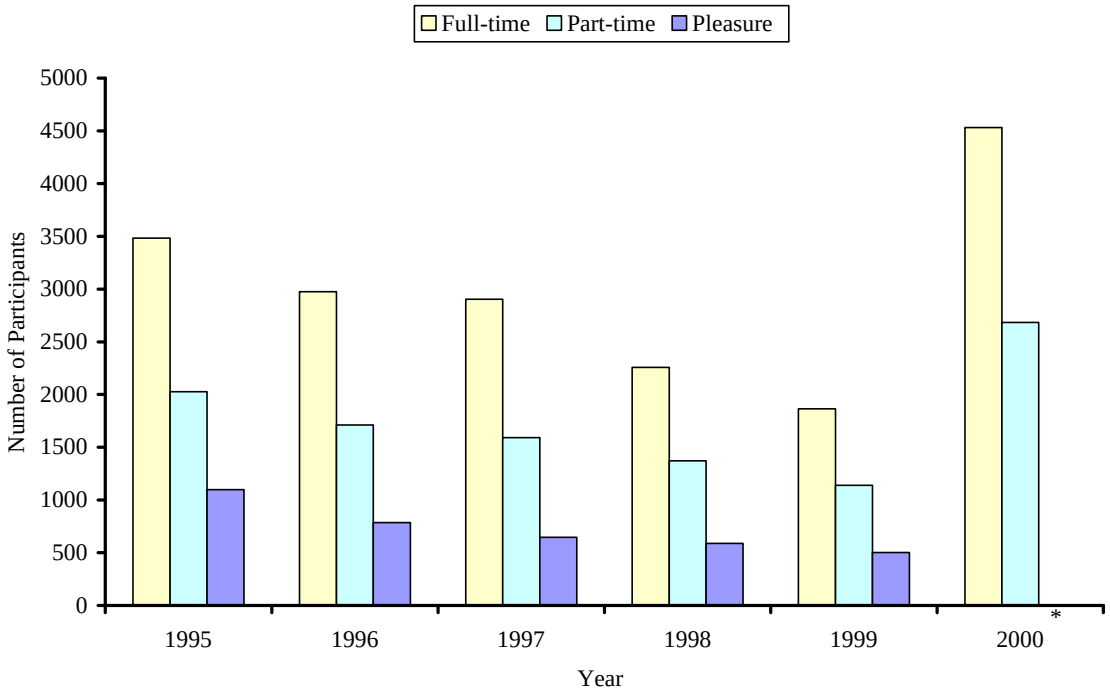
General Statutes of North Carolina
113-168.5 License endorsements for Standard Commercial Fishing License.
113-169.2 Shellfish license for North Carolina residents without a SCFL.

Discussion

DMF License Data indicate the total number of shellfish licenses issued between 1995 and 1999 decreased (Figure 20). For the 1995 license year, 4,294 Shellfish and Crab Licenses and 2,360 Shellfish Only licenses were issued. Number of licenses decreased every year afterward and by the 1999 license year, only 2,150 Shellfish and

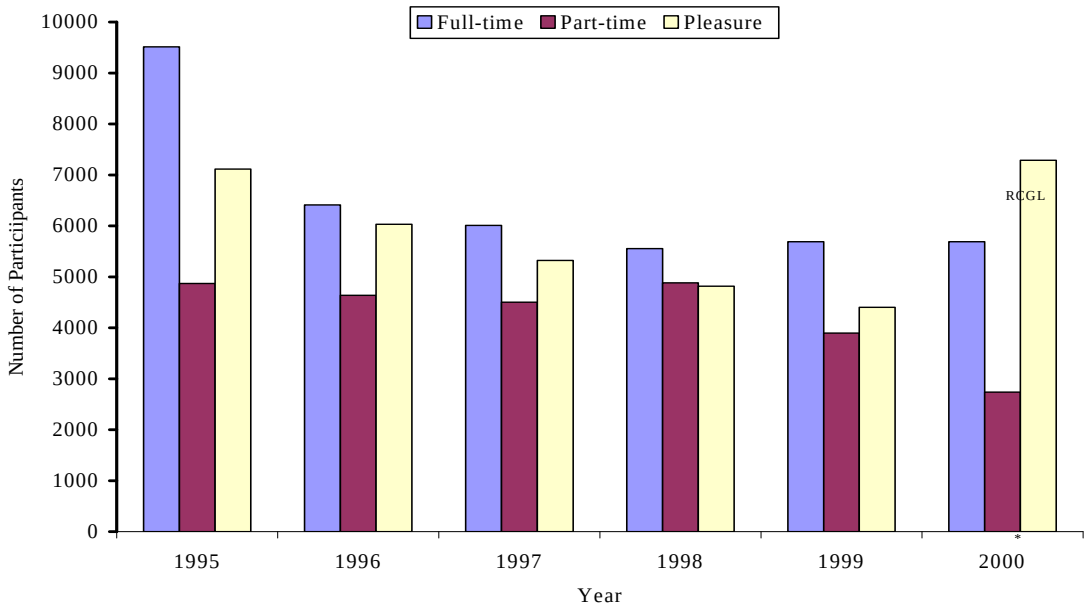
Crab licenses and 1,542 Shellfish Only licenses were issued. The number of fishermen who considered themselves as either full-time, part-time, or pleasure also decreased over time (Figure 20). Vessel license data shows the same trend with an overall decrease of vessel licenses issued by the state from 1995 to 1999 (Figure 21).

By the year 2000, with the implementation of the new license system, the number of participants able to harvest shellfish does increase, however, it must be noted that this



*New License System Implemented. Data may not be comparable

Figure 20. Total number of shellfish licenses issued. (Note 2000 includes shellfish licenses and shellfish endorsements on SCFLs)



*New License System Implemented. Data may not be comparable

Figure 21. Total number of vessel licenses issued

number includes those fishermen with a SCFL who elected to have the free shellfish endorsement on their license along with those fishermen who purchased only a shellfish license. When this number is broken down into number of free endorsements and number of licenses (Figure 22) there is a decline in the number of participants who purchased a shellfish license. These data indicate no apparent increase in effort because of the decrease in number of participants over time. Because of the change in the licensing system and the short amount of time since implementation (one year), more time is needed to establish a trend before limited entry can be considered.

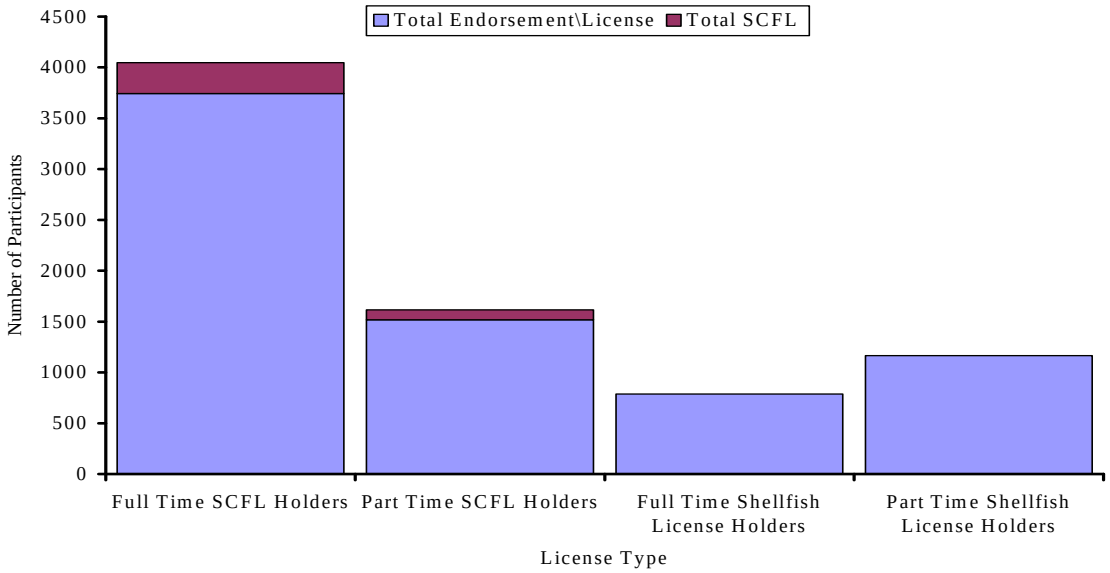


Figure 22. Number of shellfish endorsements and shellfish licenses issued in 2000

Management Options/Impacts

A. Status Quo until enough license data gathered to make a management decision

+ No additional regulation on fishery
- Possible increase in number of fishermen harvesting shellfish

B. Limited Entry

+ Reducing fishing effort can protect viability of shellfish
+ Enhance fishery by reducing costs and increasing earnings
+ More efficient management
- No data to support limited entry
- Displace fishing effort to other fisheries

DMF Recommendation

A. Status Quo until enough license data gathered to make a management decision

AC Recommendation

Agreed with DMF

MFC Selected Management Strategy

Status Quo until enough license data gathered to make a management decision

9.2.5 Unloading Shellfish at Night

Shellfishermen feel that the provision that requires all oysters and clams to be unloaded from vessels before sundown is too restrictive due to present fishing conditions. This issue originated from the Oyster and Clam FMP Committee

Background

The rule prohibiting the unloading of oysters at night first appeared in 1967. There were no exemptions cited in the original rule except that oyster-unloading operations partially completed before sundown could be completed after sundown in the presence of a Fisheries officer. In 1971 the rule was amended to include a total exemption for the unloading of oysters in Brunswick and New Hanover counties. The origination of the unloading after dark rule for hard clams did not occur until 1988 when the current wording was adopted for both species. The 1988 amendment dropped the total exemption from the unloading provisions for Brunswick and New Hanover counties and instituted the two-hour past sundown extension for unloading oysters and clams in Brunswick, New Hanover, and Pender counties. Unloading after sundown is prohibited in all other areas. The oyster and clam rules concerning unloading at night were combined during recodification of the rulebook in 1991.

Recollection of long term staff indicates that the reason for implementing the rule prohibiting unloading oysters and clams at night is to aid in the prevention of harvest of oysters and clams from polluted areas and poaching of oysters and clams from shellfish leases and franchises. The special provisions for unloading up to two hours after sunset for the three southern counties was enacted to address problems with late afternoon low tides. Many harvesters could not work on those days due to the fact that they could not harvest and return to the dock before sunset since there was no navigable water in the harvest areas for several hours around low tide. Tidal amplitudes in Brunswick, New Hanover and Pender counties are the greatest in the state and almost all shellfish harvesting is done by hand around low tide.

Advisors report that shellfishermen must travel long distances to locate suitable shellfish resources during the winter and that the reduced daylight hours and extended travel periods shorten the available harvest time to a point where commercial harvest is not feasible. Advisors also stated that they could see no difference between the

prohibition on fishing crab pots at night and shellfishing at night with respect to being able to unload after sundown. They also find that if special conditions warrant an exception in one part of the state, similar special conditions deserve similar special conditions in other parts of the state.

Current Authority

North Carolina Fisheries Rules for Coastal Waters (1999-2000)
15A NCAC 3K .0106 Taking or Unloading Oysters and Clams on Sunday or at Night

Discussion

The incentive to harvest shellfish from polluted areas and poach shellfish off of private culture sites increases when stocks are down and prices are high. This situation occurs most often during the winter months when the number of daylight hours is short in duration. The cover of darkness also provides the greatest opportunity for successfully committing rules violations. For these reasons, the prohibition on harvesting oysters and clams at night appears to be justified. The additional step of adding the prohibition on unloading of these two shellfish after dark ensures that there will be no wanton violations of the rule prohibiting nighttime harvest. However, poachers could hide their illegal catch until several hours after sunrise the next day and appear to comply with the unloading provisions.

Low harvests in both the hand and mechanical oyster fisheries have necessitated those shellfishermen travel long distances from home to locate harvestable resources. In some areas fishermen are able to locate local dealers where they can sell their catch. However, in other areas and, this option is often not available. This requires that harvest hours be considerably reduced to allow for the long trip back to home port. The same situation occurs to a lesser degree in the mechanical harvest fishery for clams.

Marine Patrol officers find that the prohibition on unloading oysters and clams between sundown and sunrise is a significant enforcement tool and recommend that if any changes are proposed that they not exceed the two hour after sundown extension now in place in the southern coastal counties.

Management Options/Impacts

A. Status Quo

+ No rule change required
+ Current rule provides maximum protection from illegal harvest
- Does not address current situation
- Current rules do not treat all users equally

B. Allow all oysters and clams to be unloaded until two hours after sunset **Rule change required**

+ Addresses current shellfish harvest situations
+ Provides for equal treatment of users
- Weakens enforcement for illegal shellfish harvesting
- 2 hr. time extension is not needed in all seasons and all areas

C. Allow all oysters and clams to be unloaded until two hours after sunset during the period of Eastern Standard Time (last Sunday in October to the first Sunday in April) **Rule change required.**

+ Addresses current shellfish harvest situations
+ Provides for equal treatment of users
+ Only weakens enforcement for approx. five months
- Weakens enforcement for illegal shellfish harvesting
- If applied coast wide, would limit harvest time in Brunswick, New Hanover, and Pender counties

D. Allow oysters and clams to be unloaded at any time. **Rule change required.**

+ Addresses current shellfish harvest situations
+ Provides for equal treatment of users
- Totally removes an enforcement tool which works to prevent illegal shellfish harvesting

DMF Recommendation

A. Status quo

AC Recommendation

Agreed with DMF

MFC Selected Management Strategy

Status quo

9.3 Private Culture

9.3.1 Public Trust Issue

The exclusive use of certain shellfish resources and submerged bottomlands by private shellfish culturists violates the Public Trust Doctrine. The issue was raised during public comment at PID meetings.

Background

Members of the public, including commercial and recreational fishermen and riparian property owners, have often questioned how the DMF could lease areas of submerged bottomland to individuals when the marine and estuarine resources of the State belong to the people of the State as a whole. Commercial fishermen are also concerned because shellfish lease and franchise holders are allowed to take oysters and clams from areas closed to public harvest because of pollution for cleansing on their leases and franchises and subsequent sale. DMF expends a small percentage of its Shellfish Rehabilitation budget to move shellfish from polluted areas to public bottoms for cleansing and these shellfish are available, under certain restrictions, to any member of the public.

The use of public trust areas in coastal fishing waters is essential to the culture of shellfish because the cost of raising shellfish in upland facilities increases the production costs to a point where the cost of production exceeds the market value. Private culture of shellfish is practiced in many locations around the world. All U.S. coastal states have some form of private shellfish culture either through ownership or leasing of submerged lands.

Current Authority

Constitution of North Carolina
Article 1, Section 32. Exclusive Emoluments

General Statutes of North Carolina
113-201. Authority of the Marine Fisheries Commission
113-202. New and renewal leases for shellfish cultivation
113-202.1. Water column leases for aquaculture
113-202.2. Water column leases for aquaculture for perpetual franchises
113-203. Transplanting of oysters and clams

North Carolina Fisheries Rules for Coastal Waters (1999-2000)
15A NCAC 3K .0104 Permits for Planting Shellfish from Polluted Areas
15A NCAC 3O .0201 Standards for Shellfish Bottom and Water Column Leases

Discussion

The Exclusive Emoluments Clause of the Constitution of North Carolina appears to support those claiming that shellfish leasing and relaying to leases and franchises violates the Public Trust Doctrine by proclaiming "No person or set of persons is entitled to exclusive emoluments or privileges from the community…." However, it goes on to state that there is an exception "…but in consideration of public services." The North Carolina courts have established two tests to determine whether the exclusive privilege meets the public services intent of the state constitution. The privilege must (1) provide a significant benefit to the general public welfare above the benefit to the individual and (2) the legislature in granting the privilege must show reasonable basis to conclude it served the public interest.

DMF and the MFC determined that the public benefit test was met because private shellfish culture would promote the growth of the shellfish industry in the State and foster an increase in the market quantity of shellfish being sold for public consumption. Under the authority of G. S. 113-201, the MFC adopted rules concerning production requirements on shellfish leases and franchises (15 NCAC 3O .0201) that serve to strengthen the position that private shellfish culture provides public benefit. The North Carolina General Assembly devised standards for issuing shellfish bottom leases in G. S. 113-202 that assured the granting of a lease would not significantly affect the public's rights to access public trust resources and provide for compliance with the second test. Similar standards were put in place for issuing water column use amendments above bottom leases and franchises in G. S. 113-202.1 and 202.2, respectively. Therefore, the MFC and the General assembly actions suggest that private shellfish cultivation does not violate the Public Trust Doctrine. Concerns of those opposed to shellfish leasing are further addressed in Section 9.3.2 on allocation of areas for shellfish leases.

Transplanting of shellfish from prohibited (polluted) areas to shellfish leases and franchises for cleansing (relaying) is authorized by G. S. 113-203 and implemented in 15A NCAC 3K .0104. Shellfish from polluted areas can only be harvested if they are kept in approved harvesting waters for a specified period of time to allow for pollutants to be naturally purged from their systems (depuration). Under current rules depuration can be accomplished by allowing lease and franchise holders to relay shellfish to their sites, state funded programs moving shellfish to public bottoms which must be monitored until depuration is complete, or by placing polluted shellfish in an approved depuration facility. Depuration facilities are rarely used and are the subject of Section 9.3.9.

Hard clam relay is strictly controlled on a few sites because clams must be monitored to prevent them from being sold to consumers since there is no closed season for hard clam harvest. Few hard clam harvest sites are available because the predominant harvest method for hard clam relay is with mechanical gear which is only allowed in limited areas. Hard clam relay to leases and franchises has varied widely but in recent years has averaged about 5,000 bushels per year. Public bottom relay of hard clams

occurs sporadically in response to special circumstances leaving yearly averages below 1,000 bushels. Pilot projects are underway to increase public bottom hard clam relay.

The public's concern that relaying shellfish to leases and franchises is exclusive use of shellfish resources implies that the general public is unable to obtain a shellfish lease. Shellfish leases may be granted or transferred to any state resident provided the issuance standards are met. Therefore, this is not a closed fishery. Also, many lease and franchise holders hire local, licensed fishermen to work with them relaying shellfish. However, other states approach relaying programs in a more open manner. During the relay season, Connecticut opens selected polluted areas to harvest by licensed fishermen who then sell their catch to lease and franchise holders. Further public benefits for the lease program include enhancing spawning stock, filtering the water, and providing habitat for juvenile finfish. To achieve a perception of balance in the allocation of shellfish resources would be to increase the scope and extent of the public bottom relay programs.

Management Options/Impacts

A. Status quo

+ No rule or statutory changes required
- Does nothing to improve concerns about shellfish lease program

B. Retain the statutory shellfish lease program

+ Continues a traditional fishery
+ Supported by the Aquaculture Development of 1998
+ Complies with the intent of the North Carolina Constitution

C. Eliminate shellfish relaying/depuration **(Statute and rule changes required)**

+ Eliminates perceived shellfish resource allocation problem
+ Reduce administrative and law enforcement responsibilities
+ Effectively makes polluted (prohibited) areas shellfish sanctuaries
+ Increase shellfish habitat effects in polluted (prohibited) areas
- Eliminates a traditional shellfish culture tool
- Reduce the amount of shellfish available for market
- Creates an underutilized resource
- Increases potential for poaching from polluted (prohibited) areas

D. Allow relay harvesting by any SCFL or Shellfish License holder

+ Reduce perceived shellfish resource allocation problem
- Invalid for hard clams unless closed season is implemented

- Increases administrative and law enforcement burden
- Currently no means for limiting the number of participants
- Increased stress on the resource and the habitat
- Reduces sanctuary function of polluted (prohibited) areas

E. Increase public bottom shellfish relay

+ Reduce perceived shellfish resource allocation problem
+ Increase amount of shellfish available for market
+ Reduce polluted shellfish poaching potential
+ Increase use of underutilized resource
- Increases stress on the resource and the habitat
- Reduces sanctuary function of polluted (prohibited) areas

DMF Recommendation

B. Retain the statutory shellfish lease program
E. Increase public bottom shellfish relay

AC Recommendation

Agreed with DMF

MFC Selected Management Strategies

Retain the statutory shellfish lease program
Increase public bottom shellfish relay

9.3.2 Allocation of Areas for Shellfish Leases

Investigate the allocation of areas for shellfish leases to reduce protests by concerned citizens and relieve the burden placed on prospective leaseholders. This issue originated from the Plan Development Team (PDT), Shellfish Advisory Committee, and public comment.

Background

The granting of exclusive shellfishing rights to State residents is controversial in several coastal areas. Commercial fishermen and some tourist industry/residential groups oppose shellfish leasing because they feel it infringes on their use of public trust resources. Shellfish lease applicants complain because they are often criticized in their own communities for selecting a site for a shellfish lease even though it meets the statutory standards.

Available records indicate that the selection of shellfish lease sites has always

been the responsibility of the applicant. The site is then judged on several standards that have been fairly constant through the various statutes and amendments that have governed private shellfish cultivation. While there have been several provisions governing the size of individual site applications and the total area that could be held by an individual, family or corporation, there has never been a cap on the total acreage that could be leased in the state. There have also never been any areas set aside for individual shellfish leases although the idea has been discussed for over a decade.

There are currently two areas where the leasing of shellfish bottoms is indefinitely banned. The coastal waters of Brunswick County have been exempt from the shellfish lease statute since 1967. No history could be located on the events that preceded this action. An indefinite ban on shellfish lease issuance covering more than half of Core Sound and a portion of Pamlico Sound in Carteret County was initiated in May of 1996. The remainder of Core Sound is also under a moratorium on shellfish leasing that expires on October 1, 2001 (Figure 23). Legislative action banning shellfish leases in Core Sound began after a seven-acre lease was granted on the eastern side of the sound in 1993. The shellfish leases existing at the time were all on the western side of Core Sound and a petition with over 875 names was received to protest the granting of the lease near Core Banks because it interfered with fishing and recreational activities in the area. The MFC approved the lease over the protest because it found that the application met the statutory standards. The N.C. General Assembly took action and imposed a two-year moratorium on the granting of shellfish leases for all of Core Sound

The moratorium legislation included a mandate to study the leasing of shellfish bottoms in the area but no work was accomplished and no changes were made to shellfish lease rules or statutes. Immediately after the moratorium lifted, DMF received eight applications for lease areas also on the East Side of Core Sound. More than 400 protests were received on these applications and the legislation presently in place banning shellfish leases in the area was passed before any leases were granted.

A similar situation existed in Hyde County in 1989 when a fishermen's organization was formed to fight the granting of four shellfish leases near Swan Quarter. The Hyde County group was unsuccessful at getting legislation passed banning shellfish leasing in that county. The towns of Pine Knoll Shores and Topsail Beach have also attempted to stop shellfish leases in nearby waters but have been unsuccessful.

The failure to address the causes for the moratorium enacted in 1995 may have been due to an underestimation of the magnitude of the problem. In many cases during the lease application process in the above examples, tensions were high among the protestors, applicants and staff. This was evident in the emotional comments made at public hearings and extended into the daily lives of all involved. Reports of threats, discriminatory actions, and general ill will were made by many involved in the proceedings. It appears that changes to the shellfish lease system are necessary to resolve the problems in areas where protests to lease issuance have been intense.

On the other hand, the Onslow County Commissioners passed a resolution asking the Governor to take steps to increase private shellfish culture in their county but gave no specifics on amount or locations. The Blue Ribbon Advisory Council on Oysters (BRACO) also encouraged expanded shellfish culture and more user friendly means for obtaining shellfish leases but only identified large areas in Pamlico Sound as areas for pre-approved shellfish lease sites.

The 1988 version of the Oyster, Clam and Scallop Committee (now know as the Shellfish Committee) recommended that changes be made in the shellfish lease rules and statutes to allow for block leasing which consisted of one mile square lease blocks containing 64 ten-acre lease sites. They proposed that DMF select the areas using the existing criteria and that state surveyors survey the sites. They reasoned that lease blocks would reduce the improper marking problems commonly found on shellfish leases and encourage a community watch system that would eliminate the significant poaching problem. They did not offer guidance on how the leaseholders in these areas would be selected.

An attempt at solving the problems surrounding the selection of shellfish lease sites was conducted by the Shellfish Working Group – a subcommittee of the Joint Legislative Commission on Seafood and Aquaculture. The 15 member subcommittee met during the fall of 1996 under a legislative charge to study the shellfish lease program and consider specific issues; among them (1) establishment of a maximum percentage of available water body for leases and (2) preservation of areas used substantially by commercial and recreational fisherman. The group drafted a suite of recommendations concerning the shellfish lease program and made major recommendations concerning the selection of shellfish lease areas. The recommendations included the establishment of shellfish culture zones with pre-approved lease sites or areas within the zone. Corridors for access by the public would be maintained within the zones. A cap on shellfish leasing of an additional 2% of the State's shellfish waters was also recommended. The cap was to be applied to each of the 89 Shellfish Sanitation growing areas to avoid disproportionate growth in any local area.

The Joint Legislative Commission on Seafood and Aquaculture accepted the recommendation on capping shellfish lease growth but failed to act on the shellfish culture zone proposal. The Commission also chose to recommend funding a human use mapping pilot project for Core Sound to answer the charge of preserving areas of substantial use by commercial and recreational fishermen. The human use mapping proposal was approved by the NC General Assembly but the cap on shellfish lease growth was not.

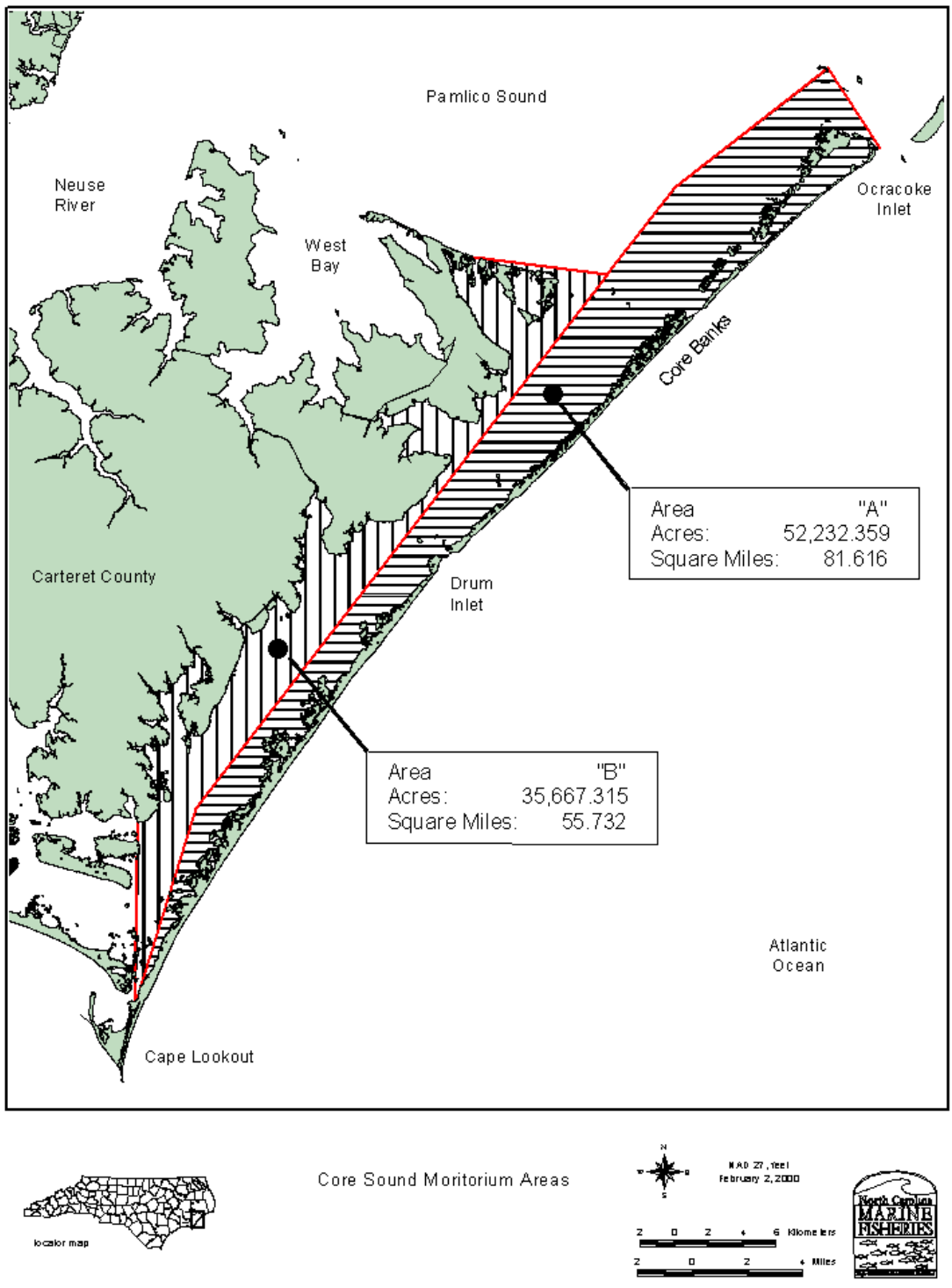


Figure 23. Area closed due to moritorium

Current Authority

North Carolina General Statutes
G.S. 113-201. Authority of the Marine Fisheries Commission
G.S. 113-202. New and renewal leases for shellfish cultivation
G.S. 113-202.1. Water column leases for aquaculture
G.S. 113-202.2. Water column leases for aquaculture for perpetual franchises

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
3O .0201 Standards for Shellfish Bottom and Water Column Leases

Discussion

The underlying fear expressed by commercial fishing interests opposing the issuance of shellfish leases was that the uncontrolled proliferation of lease sites would eventually deprive them of their livelihood by overtaking traditional fishing areas or by driving down shellfish prices because of an oversupply from culture operations or by shifting control of shellfish culture to large corporations. In the area of the most recent and intense outcry from the public, 0.1% of the total acres of estuarine bottom were under lease at the time of the protests. Statewide, 0.18% of the waters with salinity suitable for oyster and clam growth is under shellfish lease or franchise and that percentage has not changed appreciably for twenty years. Shellfish cultivation has increased substantially in other states like Florida and the best approach for managed growth appears to be careful identification of existing uses, shellfish resources, and environmental parameters necessary for shellfish cultivation.

The human use mapping project (Orbach 2001) funded by the legislature included a provision for a user coordination plan to be developed using the human use data, DMF shellfish mapping data and input from the public about problems and issues in the area. The results of the project (copy attached) appear to be a template for establishing managed shellfish lease growth in North Carolina. Areas of heavy public use are recognized and public preferences for resolution of the current leasing bans are identified. However, long-term data are needed for better trend analysis. The provision for a cap on lease acreage is also included.

The approach of identifying areas where leasing is not suitable rather than designating suitable shellfish lease sites is appealing from a management perspective because it continues to allow a degree of flexibility for shellfish lease applicants who have needs outside the statutory standards. It also removes the possibility that unsuitable sites could be identified by staff that could result in attempts at recourse by dissatisfied leaseholders.

Utilization of human use mapping and user coordination planning information would involve identification of incompatible fishing and recreational uses in the water body and establishment of a incompatible use threshold above which the sampling block

would not be used for shellfish leasing. The legislation that spawned the idea for human use mapping also indicated an overall standard should be adopted that preserves areas of substantial use by commercial and recreational fishermen. So, a two tiered approach assessing individual use conflicts and cumulative conflicts could be developed. Since only one water body has been sampled, data is not conclusive as to what the appropriate thresholds might be or whether use levels are comparable between different areas. Adoption of threshold levels of use should be accomplished through rule making if possible.

Management Options/Impacts

A. Status Quo

+ Provides maximum flexibility for selecting lease sites
- Highly contentious method for lease site selection
- Fails to address concerns expressed by the public
- Hinders shellfish culturists seeking to expand operations
- Data to address all issuance standards is not presently available

B. Establish predetermined shellfish lease sites. **Statute and Rule changes required**

+ Removes site selection responsibility from applicants
+ Conducive to manageable boundaries and shared responsibility
+ Lease groups can be shaped to conform to standards
- Removes flexibility to address applicant's needs
- Requires a mechanism for selecting successful applicants (i.e.. eligibility pool)
- Places burden for selecting successful sites on DMF
- Data to address all standards is not presently available

C. Utilize user coordination plans for shellfish lease issuance. **Rule change required**.

+ Gathers and utilizes data necessary to address issuance standards
+ Likely to retain some flexibility for applicants in site selection
+ Addresses water usage in a comprehensive manner
+ Addresses public concerns
- Much time and funding needed to expand coastwide
- Site selection responsibility remains on applicant

D. Enact a prohibition on issuance of shellfish leases in all NC waters. **Statute and Rule changes required.**

+ Removes a contentious program

+ Maximizes public use of public trust waters
+ Addresses concerns of some fishing groups and municipalities
- May eliminate a traditional fishing occupation
- Eliminates potential growth of a seafood industry
- May create a high demand for existing shellfish leases

DMF Recommendation

C. Utilize user coordination plans for shellfish lease issuance.

Advisory Committee Recommendation

Agreed with DMF

MFC Selected Management Strategy

Develop and utilize user coordination plans for shellfish lease issuance.

9.3.3 Review of Shellfish Bottom Lease Requirements

Review and modify shellfish bottom lease requirements to simplify management, enforcement, permitting and licensing. Consider a new lease category for docks and/or riparian shoreline owners. Resolve the concern over use of planting effort to meet shellfish lease production requirements. This issue originated from the Oyster and Clam FMP Advisory Committee, Public comment, MFC Shellfish Committee and BRACO.

Background

Laws allowing private shellfish cultivation first appeared in North Carolina in 1858. There have been three separate programs for issuing exclusive rights for shellfish culture on submerged lands since then. The first two programs were aimed at the culture of oysters. The initial program substantially limited the acreage that could be held and was described as an oyster gardening program where the bottom holder consumed most of the shellfish production. The second program was similar to the oyster culture initiative in Virginia that set aside natural oyster grounds but otherwise allowed large acreage for cultivation and wide participation. The third and current program started in 1909 mostly addressed the culture of oysters, however clams were also included. A complete history of private shellfish culture in North Carolina can be found in Section 6.

The standards and requirements for private shellfish cultivation areas have varied over the years as attempts to force higher production and achieve better accountability were undertaken. The amount of acreage that can be held for cultivation has generally declined. Utilization requirements have changed from standards specifying the amount of seed and cultch to be planted to shellfish harvest and sale provisions. When the

proposal to amend the existing production rule to include both harvest and planting effort provision was made, commission members expressed concern that leaseholders could keep unproductive leases as long as they wished simply by planting approximately $12.50 worth of cultch per acre and paying the $5.00 per acre rental fee. They did not feel this was sufficient effort and chose to insert a sunset provision to insure the public was getting a good return for its loss of use of public trust bottomlands. The provision to allow planting effort went into effect in 1994 and expired on March 1, 1999. The North Carolina Shellfish Growers Association successfully petitioned the MFC in January of 1999 and requested an extension of the sunset provision until the matter could be considered in the FMP process. The provision was included in the FMP issues and a temporary rule was put into effect that removed the sunset clause. That interim measure needs to be resolved during the FMP process.

Fees have modestly increased and lease terms for holding bottomlands for culture purposes have decreased. Authority to use the water column above an existing shellfish lease was granted in 1989 in an attempt to increase production. The current specifications for these matters are shown in Table 9.

Table 9. Comparison of shellfish lease and amendment types

	Bottom	Water Column	Demonstration Project
Application Fee	$100.00	$100.00	$0.00
Renewal Fee	$50.00	$50.00	$0.00
Survey Required	Yes	Yes[1]	Variable
Rental Fee	$5.00/acre/yr	$500.00/acre/yr[2]	$0.00[3]
Production Required	25 bushels/acre	100 bushels/acre	None

[1]Unless area is identical to bottom lease
[2]Fees are additive
[3]Unless commercial production occurs

Recently shellfish culturists have become more vocal about recognizing the beneficial effects that shellfish culture can have on the estuarine environment and other species that utilize shellfish habitat. Researchers studying shellfish habitat have recently theorized that the value of shellfish habitat may be greater than the value of the shellfish found there when used as a seafood product. Suggestions have been made that shellfish lease fees be reduced or eliminated in recognition of the benefits provided by shellfish culture. Recommendations such as increasing the lease term, planting, and relaxing the prohibition on leasing natural shellfish bed areas were also suggested by the BRACO and have been carried on by shellfish culture groups.

Some areas of the state have groups that support shellfish culture and leasing is

not contentious. However, there has been increased tension over leasing bottoms in other areas. Those opposed to shellfish leases cite the lack of production on leases, lack of enforcement of lease production requirements, and disagreement with DMF's methods for determining the presence of a natural shellfish bed as reasons to reduce or eliminate private shellfish cultivation. Some groups are opposed to the leasing program in general. They feel that shellfish leases will eventually overtake their fishing grounds. Sometimes unproductive leases are not terminated and new ones are being granted in areas where they catch other fisheries resources. Production from private culture sites averages about 10 bushels per acre and provides 15% of the state's hard clam harvest and 10% of the state's oyster harvest. However, successful shellfish culturists produce many times more than natural shellfish beds can produce.

Current Authority

North Carolina General Statutes

113-202 New and renewal leases for shellfish cultivation; termination of leases issued prior to January 1, 1966.
113-202 Water column leases for aquaculture.
113-202 Water column leases for aquaculture for perpetual franchises.
113-205 Registration of grants in navigable waters; exercise of private fishery rights
113-205 Chart of grants, leases and fishery rights; overlapping leases and rights; contest or condemnation of claims; damages for taking of property.
113-208 Protection of private shellfish rights.
113-269 Robbing or injuring hatcheries and other aquaculture operations.

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)

3K .0205	Marketing Oysters Taken form Private Shellfish Bottoms
3K .0305	Clam Size and Harvest Size Exemption
3O .0200	Leases and Franchises (entire section)

Discussion

The states with active lease programs or private ownership using large acreage have spawned fast growth in shellfish culture industries. In North Carolina, only about 2,600 acres are leased for shellfish production. Clam mariculture in the states of Florida, Virginia, New Jersey, New York, Massachusetts, Maine and Washington has increased recently. In Florida the growth is largely a response to the availability of leases and other factors such as new restrictions on commercial fishing activity. The presence of large shellfish hatcheries in those states also has had a significant impact on the growth of the industry.

The BRACO was tasked to address leasing; by default clam leases were included in many of the recommendations. The state's regulatory and leasing system needs to be

improved and updated to accommodate new technology and encourage shellfish farming. Production requirements and cost of the water column are restrictive to leasing. Required permitting is excessive and confusing. An effective law enforcement program is critical to maintaining private shellfish culture systems. A system of support for shellfish aquaculture would improve access to lease sites and increase shellfish production in the state.

Shellfish beds, both naturally occurring and those created by shellfish culture activities, serve as nursery areas for juvenile marine species and serve other ecologically important functions. (NCDMF in Prep) The leasing system in North Carolina does not recognize the ecological public benefits that accrue from private shellfish production. If these benefits were to be quantified economically, they may actually be worth more than the shellfish produced on the leases. Additional research would be required in order to determine the economic value of ecological benefits from mariculture.

Leases are issued for the purposes of production, harvest and marketing of shellfish, yet additional licenses are required to accomplish this. The lease should automatically include the licenses required to complete production activities. If the lease itself were to include, grant, or confer the additional provisions currently licensed separately, it would streamline the system for both DMF and the shellfish producer (See Section 9.3.4 Shellfish Permits).

Similarly, many permits are required for shellfish production activities in addition to the licenses. A blanket permit for the above activities could be issued to leases or included in the lease license (See Section 9.3.4 Shellfish Permits).

Potential shellfish culture yields and risks differ between oysters and clams yet the rules require the same production requirements. Risk of disease loss is not as serious for clams as for oysters yet there is no exemption to account for disease-caused crop losses. Oyster cultivation methods have lower potential yields than clams yet production requirements are identical. These differences are not recognized in guidelines for leases and rules. Eliminating production requirements in favor of an operational management plan using best management practices would simplify and reduce restrictions on leasing.

Production requirements are not realistic considering the problems with current shellfish culture methods and may be unnecessary if other public benefits are considered. Educating leaseholders about best management practices along with filing and following a management plan can replace production requirements. The uncertainty of environmental conditions can make compliance with three-year production averages impossible. The concerns expressed by MFC members that 25 bushels of cultch is not sufficient effort for tying up public bottoms could be resolved by increasing planting requirements instead of dropping them. This would allow shellfish culturists to continue cultivation efforts and focus on long term production. Or production efforts could be gauged by using the best three of the most recent five years production. That would help account for uncertain conditions and uneven year-to-year harvests. Additionally, if leases

were to be issued for longer terms, i.e. 20-year term instead of 10-year term, it would encourage long-term investments. Documented adherence to the management plan would eliminate non-use and ensure public benefits from the leases areas.

Water column use is a requirement for off-bottom oyster culture methods and is an integral part of some intensive culture leases. The annual fee for water column leases is $500 per acre, which is one hundred times (100 X) higher than the equivalent fee for bottom leases. This high cost of water column leases is restrictive to most potential shellfish growers. The term of water column leases is only 5 years compared to 10 years for bottom leases. After almost ten years availability, very few water column leases have actually been issued in the state. The cost of leasing water columns for shellfish culture should be lowered so that it is more in line with the other requirements and the terms should be increased to match that of bottom leases.

Production requirements for water column leases are currently set at four times that of bottom leases or 100 bushels per acre. If lease fees were set at the same multiple, that would result in a fee of $20 per acre of water column.

Areas around private docks are a source of much potential culture activity yet there is no separate category to lease them or to permit culture for personal use. A new category of leases or permit is needed for dock owners to grow oysters or clams for personal consumption. Alabama riparian rights include control and utilization of the bottom 600 feet from shore for shellfish culture with no lease. Virginia waterfront owners can obtain a riparian lease permit for $1.50 and grow shellfish for personal consumption. More people use this category than any other form of shellfish culture in Virginia. If shellfish culture along docks were permitted for personal consumption in N.C. the cumulative environmental effects of small amounts of shellfish growing at numerous locations could be substantial.

This new option could be accomplished with a permit or by changing the minimum size of leases. Currently the minimum lease size is 1/2-acre. Changing that to 1/4-acre could allow dock owners to apply for leases in and around their docks where they could grow shellfish for personal consumption. They would still be subject to the commercial intent of the leasing program and would need to market and sell the minimum production requirements.

A new permit allowing a certain square footage surrounding docks to be used to grow shellfish for personal consumption could also accomplish that option. Rules similar to ones enacted in Virginia would be required. The permit in Virginia is $1.50 and allows 160 square feet of area to be used for growing shellfish for personal consumption. These permits are also allowed for docks in polluted areas, but the shellfish cannot be consumed from those areas.

Another option is a new lease category for docks that could be issued for the water columns under private docks. The allowed area could be designated as a certain

fixed size area such as 1/10-acre. The lease/permit would allow the dock owner to cultivate shellfish for personal consumption under and immediately adjacent to the dock. Docks already impact navigation but by State Statute are a riparian right. Shellfish cultivation associated with private docks would not increase problems with navigation but could significantly increase production of shellfish and reduce fishing pressure on wild stocks.

Management Options/Impacts

A. Status Quo for shellfish lease planting and production requirements

+ Requires a high level of return for use of public resources
- Data indicates that current production levels are unrealistic

B. Adopt a new policy statement by amending the General Statutes officially finding it in the public interest to encourage and develop shellfish culture for its public benefits. That shellfish culture provides these public benefits: (1) increasing seafood production and associated long-term economic and employment activity, (2) increasing ecological services to the natural environment by promoting natural water filtration and increased fishery habitats. **Statute change required.**

+ Creates a new atmosphere to encourage and facilitate private shellfish production in public waters
+ Recognizes the public benefits from private shellfish culture efforts
- Requires statutory changes

C. Require harvest and sale of 10 bushels of shellfish per acre to maintain lease production. **Rule change required.**

+ Reduces the production efforts requirement for leaseholders
+ Matches lease production requirements to current production levels and aligns production requirements with minimum-level natural shellfish beds
+ Allows for natural year-to-year variations in production
- May reduce habitat creation and ecological services
- Requires recognition of other public benefits to equal current situation
- May reduce the amount of shellfish reaching markets

D. Require harvest and sale of 10 bushels of shellfish AND planting effort of 50 bushels of seed or cultch to maintain lease production. **Rule change required.**

+ Increases the management efforts of leaseholders and resultant benefits
+ Increases leaseholder efforts, which may address prior concerns, evidenced in the sunset provision on planting effort
+ Requires a higher level of production effort than previous requirements
+ Considers current production problems and natural variations in production areas and species

E. Require only planting efforts of 50 bushels of seed or cultch to maintain lease requirements. **Rule change required.**

+ Simplifies the production effort requirement for leaseholders
+ Requires a higher level of input effort that may result in greater output levels than currently producing
+ Allows for yearly or unforeseen crop variations
+ Recognizes the ecological public benefits of private culture efforts
- Removes requirement for harvest and sale and resulting public benefit

F. Require the submission of and activation of best management plan in lieu of production requirements. **Rule and Statute change required.**

+ Accounts for variation in natural production capacity among leased areas
+ Requires leaseholder knowledge of production methods (education/certification)
+ Accounts for the ecological public benefits from mariculture activities
- Requires some form of verification for culture activities, such as receipts
- Requires research to determine BMP's for different areas and species

G. Drop Production Requirements Entirely. **Rule and Statute change required.**

+ Eliminates unnecessary rules
+ Mirrors the successful lease programming of other states
+ Reduces lease terminations due to production anomalies
- No documentation of any lease benefits
- May not meet North Carolina constitutional requirements for use of public resources

H. Change present shellfish lease statute to allow a minimum size for leases

of ¼-acre to allow shellfish culture for riparian shoreline owners. **Statutory and rule changes required.**

+ Allows for increased effort at shellfish cultivation with resultant ecological benefits
+ Increased public awareness of water quality and shellfish issues
+ Would not significantly increase navigational hazards
- Statute changes required
- May create conflicts with existing uses of shorelines or dock areas including existing leaseholders
- May create further issues related to shellfish cultivation in closed areas
- Personal consumption would be allowed but retain commercial harvest and sale provisions
- Would not be allowed if dock areas have pre-existing shellfish beds

I. Develop a special permit for dock owners to grow shellfish for personal consumption in limited-size (1/10-acre) areas under and around their docks. **Statutory and rule changes required.**

+ Allows for increased effort at shellfish cultivation with resultant ecological benefits
+ Increased public awareness of water quality and shellfish issues
+ Would not significantly increase navigational hazards
+ Would not require harvest and sale provision of commercial leases
- May require other regulation and Statute changes
- May create conflicts with existing uses of shorelines or dock areas including existing leaseholders

J. Status Quo on opportunities for riparian shoreline owners to culture shellfish.

+ Maintains focus on creating a documented shellfish production program showing returns to the public.
+ Avoids potential conflicts over public trust issues
+ Avoids concerns over riparian owner's use of shellfish during temporary closures
- Fails to increase public awareness of water and shellfish issues
- Does not allow for increased shellfish culture with resultant ecological benefits
-

K. Set fees for water column leases at four times bottom lease fees. **Statutory change required.**

+ Reduces the financial burden of the high water column lease price
+ Sets water column lease fee in line with the increased production requirements over bottom leases
+ Recognizes the ecological public benefits from private shellfish culture
- May encourage water column amendments for the purpose of limiting public access

L. Eliminate size restrictions on oysters raised in an aquaculture operation. **Rule change required.**

+ Allows oyster producers to maintain existing accounts and sales
+ Recognizes the increased value of oysters reared in aquaculture operations
+ Aligns size limit exemption for oysters and clams reared in aquaculture operations
- Requires tagging of product and verification of documentation by Marine Patrol
- May increase opportunities for undersize, wild oysters to be harvested and sold

M. Extend lease terms to 20 years. Renewals submit approved management plan and document production activities. **Statutory change required**.

+ Gives leaseholder greater incentive to invest for long-term returns
- May maintain inactive leases in the system longer, unless documented adherence to management plan
- May prevent addressing public trust conflicts for extended periods

N. Provide four-year exemption of fees for new leases. **Statutory change required.**

+ Allows for a reasonable period of start-up expenses and returns
- May not recoup cost for administration of shellfish lease program

O. Require shellfish culture training certification for new lease applicants. Grandfather existing leaseholders that meet production requirements. **Statutory change required.**

+ Helps assure competency of new applicants
+ Increases the likelihood of BMP's in shellfish culture
+ Adds course elements for community colleges or other approved educators/courses
- Temporarily restricts new entrants
- Educational institutions may not be available in all areas of the

coast. This may require development of an Internet or correspondence training course.

DMF Recommendation

B. Adopt a new policy statement by amending the General Statutes officially finding it in the public interest to encourage and develop shellfish culture for its public benefits. That shellfish culture provides these public benefits: (1) increasing seafood production and associated long-term economic and employment activity, (2) increasing ecological services to the natural environment by promoting natural water filtration and increased fishery habitats. **Statute change required.**

D. Require harvest and sale of 10 bushels of shellfish AND planting effort of 50 bushels of seed or cultch to maintain lease production. **Rule change required.**

J. Status quo on opportunities for riparian owners to culture shellfish.

K. Set fees for water column leases at four times bottom lease fees. **Statutory change required.**

L. Eliminate size restrictions on oysters raised in an aquaculture operation. **Rule change required.**

O. Require shellfish culture training certification for new lease applicants. Grandfather existing leaseholders that meet production requirements. **Statutory change required.**

AC Recommendation

The Advisory Committee rejected H and recommended adoption of B, K, L, and O and modification of D and I as follows:

D. Require harvest and sale of 10 bushels of shellfish AND planting effort of 50 bushels of cultch or 25 bushels of seed per acre per year to maintain lease production.

I. Develop a special permit for dock owners to grow shellfish for personal consumption under their docks in floating culture

DMF staff agreed with the recommended changes in D and subsequently changed their recommendation on riparian shellfish culture to J. ***After DENR review, it was decided to recommend that leaseholders could pay a fee to DMF for planting cultch on public bottom in lieu of planting cultch on their leases.***

MFC Selected Management Strategies

Adopt a new policy statement by amending the General Statutes officially finding it in the public interest to encourage and develop shellfish culture for its public benefits insofar as it does not interfere with traditional fishing practices. That shellfish culture provides these public benefits: (1) increasing seafood production and associated long-term economic and employment activity, (2) increasing ecological services to the natural environment by promoting natural water filtration and increased fishery habitats. **Statute change required.**

Require harvest and sale of 10 bushels of shellfish AND planting effort of 50bushels of cultch or 25 bushels of seed per acre per year to maintain lease production. **Rule changed required**

Status quo on opportunities for riparian owners to culture shellfish.

Set fees for water column leases at ten times bottom lease fees. **Statutory change required.**

Eliminate size restrictions on oysters raised in an aquaculture operation. **Rule change required.**

Require shellfish culture training certification for new lease applicants. Grandfather existing leaseholders that meet production requirements. **Statutory change required.**

9.3.4 Shellfish Permits

This issue addresses modification of shellfish permits to comply with the FRA. This issue originated from the FRA, MFC, DMF, and the AC.

Background

The FRA of 1998 re-institutes the requirement for obtaining permits to conduct activities that are not normally allowed by either rules or statutes. The Act also authorizes permits that are required to collect data under a quota/allocation system. The legislation also specified that the DMF charge a fee for permits to recoup their administrative cost.

The DMF undertook a comprehensive review of the existing permits including the need for the permits, the effort required of the DMF to issue these permits, and the data collected under the permits. This review was conducted by the Rules Review Committee of the DMF and included all permits issued for shellfish related activities. In

its review, the DMF has identified shellfish permits that are necessary to continue, as well as permits that are no longer necessary. The MFC has requested that the DMF prepare a recommendation for all shellfish related permits for them to consider in November 2000.

Prior to the FRA, the BRACO considered the permit system in place of shellfish lease activities and found it to be too burdensome on shellfish growers. It was recommended that a blanket permit for all currently permitted shellfish culture activities be developed or that a separate mariculture license be instituted that included all the permitted activities.

Current Authority

FRA - Establishes authority for permits

North Carolina Fisheries Commission Rules (15A NCAC)

3I. 0111 Permits for Aquaculture Operations
3K.0103 Permit to Transplant Oysters from Seed Oyster Management Areas
3K.0104 Permit for Planting Shellfish from Polluted Areas
3K.0107(c) Harvest Permit for Depuration of Shellfish
3K.0205(b) Permit to take Oysters from Private Beds
3K.0206 Permit to Harvest Oysters by Mechanical Methods (Public and Private)
3K.0303 Permit to Harvest Clams by Mechanical Methods (Public and Private)
3K.0401 Permit to take Rangia Clams by Mechanical Methods and from Polluted Areas.

Discussion

A thorough review of all permits currently issued by the DMF has been completed. In assessing the necessity of each permit some of the factors considered were: number of each permit issued, duration of permit, current rules, inspection and reporting requirements, renewal process, license and other qualifying requirements, the rationale for the permit, whether it is still needed and improvements to the permit.

As a result of this examination, the DMF is recommending that the following shellfish related permits remain in effect in some form. These are the aquaculture operation, aquaculture collection, transplanting polluted shellfish, harvest of shellfish for depuration purposes, transplanting oysters from seed management areas, Rangia clam harvest from polluted areas, and harvesting oysters and clams from leases and franchises by mechanical methods. Both permits for taking shellfish from public bottom by mechanical methods as well as the permit to take oysters from private shellfish bottoms are recommended to be dropped.

The regional and standing committees of the MFC have discussed the permit system that is being developed. During these discussions a recommendation was made that as many permits as possible be included as endorsements to a general permit. For example, lease and franchise holders would obtain a general permit that has the options of, taking shellfish from polluted areas, harvesting from Seed Management Areas and using mechanical gear for harvest which would be included as approved activities on the general permit.

Until the provision for administrative costs was repealed, all permits were assessed for administrative and other costs borne by the DMF. Based on this assessment, fees for new permits were developed and were in draft form. Staff is currently considering consolidation of permits to reduce administrative workload for permit holders and DMF. The consolidation of permits may address the recommendations of the BRACO and MFC committees regarding reducing permitting burden.

Management Options/Impacts

A. Apply FRA requirements to current permit system. **Rule change required.**

+ Allows currently permitted activities to continue
- Rule changes required
- Some unnecessary permits would be continued
- Permit fees will be required
- Disorganized permit system would continue

B. Apply FRA requirements to an organized, upgraded permit system (current DMF initiative). **Rule change required.**

+ Allows currently permitted activities to continue
+ Will do away with unnecessary permits
+ May allow some streamlining of the permit process
- Permit fees will be required
- Rule changes will be required

C. Recommend a separate license and permit system for shellfish culture activities. **Statutory and Rule changes required.**

+ Specifically addresses shellfish culture activities
+ Designed to reduce fee burdens
- Recreates an unstandardized permit system
- Further complicates shellfish license system and enforcement
- If implemented, insufficient data will be generated for analysis of new license prior to expiration of current license system in 2003

Research Needs

Continued analysis of the need for permits.

DMF Management Recommendation

B. Apply FRA requirements to an organized, upgraded permit system and reconsider license/permit system specifically for shellfish at scheduled FMP review which will coincide with the new license system implementation schedule.

AC Recommendation

Agreed with DMF

MFC Selected Management Strategy

Apply FRA requirements to an organized, upgraded permit system and reconsider license/permit system specifically for shellfish at scheduled FMP review which will coincide with the new license system implementation schedule.

9.3.5 Shellfish Lease Program-Audit Recommendations

The DMF should request changes to the NC General Statutes to recoup expenses for the Shellfish Lease Program and provide for proper execution of lease renewal contracts. This issue originated from the Office of the State Auditor of North Carolina

Background

A performance audit of the DMF was requested by the JLCSA and mandated by the FRA of 1997. The Office of the State Auditor conducted the audit during 1997. An interim report was submitted in May of 1997 and the final performance audit report was issued in January 1998. The primary reason for the audit was to give an assessment of the current status of DMF operations and to determine DMF's capacity to assume additional responsibilities. Auditors utilized 14 sources of information to evaluate their charges, including a review of existing planning documents, organization charts, policies and procedures, contractual arrangements, and financial data. In the course of their review, the auditors found problems where the current General Statutes did not allow DMF to adequately recover expenses in processing shellfish bottom leases or to complete shellfish lease renewals according to legal principles governing issuance of contracts. The auditors made specific recommendations to resolve these problems and are conducting subsequent reviews of DMF programs to assess compliance with all of the recommendations. The recommendations have been reported in informal discussions in JLCSA subcommittee meetings but have never been raised to an action

issue status.

Current Authority

North Carolina General Statutes

113-202. New and renewal leases for shellfish cultivation; termination of leases issued prior to January 1, 1966.

Discussion

Auditors examined DMF records and recommended that the initial application fee for a shellfish bottom lease be raised to $500 with an annual rental fee of $10 per acre and a renewal application fee of $100. In the auditor's opinion, these increases would allow the program to be self-supporting. Current statutory fees for shellfish bottom leases are a $100 application fee, $5 per acre rental fee, and a $50 renewal application fee. Shellfish lease fees are received through the License and Statistics Section and all fees are credited in Marine Patrol budgets. The fees help offset the cost of additional patrol required for some shellfish lease activities but provide no support for the program's substantial administrative expenditure.

The auditor's examination of the shellfish lease contract process revealed that G.S. 113-202 requires that shellfish lease production reports and rental payments be filed by April 1 each year. During the tenth year of a shellfish lease contract the expiration date of the contract also falls on April 1. Therefore, DMF is unable to assess leaseholder compliance with shellfish production standards for leases until after the contract expires. Consequently, DMF has no choice except to issue renewal contracts for leases after the expiration of the previous contract, which is not in keeping with sound fiscal management. The auditors recommended that rental fees and production reports continue to be required by April 1 of each year and that the expiration date for lease contracts be changed to July 1. In the auditor's opinion, this change would allow time for DMF personnel to determine that the lessee has met all lease requirements, approve the renewal, and process the new contract before the prior contract expires.

Management Options/Impacts

A. Status Quo

+ Maintains low lease fees for shellfish culturists experiencing low production (Dermo) and restricted harvest (temporary closure) situations
- Legal action could cause current contracts to be ruled invalid
- Failure to act on Auditor's recommendations will likely cause further action by the State Auditor

B. Recommend retaining current shellfish lease fees and changing contract expiration dates to the JLCSA. **Statutory change required.**

+ Maintains low lease fees for shellfish culturists experiencing low production (Dermo) and restricted harvest (temporary closure) situations
+ Follows auditor's recommendations and resolves contract expiration dilemma
- Failure to act on Auditor's recommendations on lease fees will likely cause further action by the State Auditor

C. Affirm recommendations of the State Auditor [$500 Application fee; $100 renewal application fee; $10/acre rental fee; and revised contract expiration date] and recommend same to the JLCSA. **Statutory changes required.**

+ Follows auditor's recommendation, i.e. no further action
+ Recovers costs for administration of the shellfish lease program
+ Resolves contract expiration dilemma
+ Increased fees may help eliminate unproductive shellfish leases
- Increase in funds will not directly offset costs of the shellfish lease program
- Increase in fees will place additional burden on leaseholders already dealing with production problems
- Efforts to establish additional value of shellfish cultivation to public trust resources are currently being considered which may substitute for some of the additional fees requested

DMF Recommendation

C. Affirm recommendations of the State Auditor [$500 Application fee; $100 renewal application fee; $10/acre rental fee; and revised contract expiration date] and recommend same to the JLCSA.

AC Recommendation

The Advisory Committee recommended a change in the application fee from $500 to $200. The other provisions of the recommendation were accepted.

C. Adopt the following fees for shellfish leases: 1) $200 Application fee, 2) $100 renewal application fee, 3) $10 per acre rental fee, and adopt a new shellfish lease contract expiration date of July 1.

MFC Selected Management Strategy

Adopt the following fees for shellfish leases: 1) $200 Application fee, 2) $100

renewal application fee, 3) $10 per acre rental fee, and adopt a new shellfish lease contract expiration date of July 1.

9.3.6 Technical Support for Shellfish Culture

Should North Carolina provide support private shellfish culture? Shellfish culture industries in other states and/or countries are sometimes enhanced by successful partnerships between the state and the industry. Some of the ideas are: (1) plant cultch for shellfish seed areas and directly on private leases and, (2) provide funding for shellfish culture hatchery and grow-out research, disease diagnostic labs, and education/training programs for shellfish growers. These issues originated from the Oyster and Clam Advisory Council, Staff, Public comment, MFC and the BRACO.

Background

Shellfish culture is a successful industry in other parts of the US and the world. It has succeeded other places because much effort has been put into developing methods and support services for growers. User friendly systems, appropriate culture methods and scientific support services are common elements of and essential to those successful culture programs. North Carolina has unique environmental conditions and needs to develop its own best shellfish culture methods. The state could provide research and technical support services to develop and enhance the industry.

Research is needed to continue the development of BMP's for shellfish culture and to continue development of appropriate cultivation methods. Additional research is required to develop disease-resistant or fast growing strains of shellfish.

Some New England states such as Maine and Massachusetts enhance clam production in public areas. The local communities in those states plant seed clams and manage the clam beds for subsequent public harvests. In France and Japan, the oyster industry is supported by state monitoring of larval shellfish abundance.

Three states that have increased production-- Washington, Louisiana and Connecticut-- have developed appropriate culture systems using private leases and best management practices. These states have active lease programs or private ownership using large acreage.

Private culture creates employment and increased tax base to the economies where it is successfully implemented. For comparison, wholesale values from U.S. shellfish culture industries in 1998 were $28 million in Washington; $25 million in Louisiana; $40 million in Connecticut; $11 million in Florida; $11 million in Virginia. Other countries with exceptional oyster culture industries are France with $60 million in production and Japan with $220 million in production.

Two levels of shellfish culture exist: extensive methods that use large areas of bottom at low densities and intensive methods that use smaller areas of bottom or water column at higher planted densities. Research must develop and improve unique culture methods for both categories.

Intensive clam production plants higher densities of clam seed per unit of area and maintains mesh-netting covers over the beds to reduce predation. Most clam production in NC is done on an intensive scale however, some research has been done on extensive clam production. Continued research is needed for improving survival and growth of cultured clams.

Intensive operations use seed collected from natural spawns or obtained from hatcheries. Wild collection uses natural selection to obtain the hardiest seed as in Japan. Hatchery seed often contains both the strongest and weakest seed from spawn. Research in NC has yet to develop wild seed collection techniques or genetically improved hatchery seed for culture.

Many shallow areas that are suitable for planted seedbeds are closed due to pollution. Some polluted areas where we allow relay are already used as "seed areas" due to the fact that relaying can occur there. If additional areas were managed as seed areas, the increased shellfish growth and filtering can actually help improve the water quality conditions as well as function as habitat for other marine life and as shellfish spawning stocks.

Consumer demand for shellfish has decreased somewhat from safety concerns. An economically sound strategy is to increase demand while simultaneously increasing production. Consumers have greater confidence in cultured shellfish products. Recent marketing efforts are paying off for Florida farm-raised clams. Of more than 100 million clams produced per year at the farm level, a very large portion are marketed in-state and helped by a large statewide marketing campaign for farm-raised clams. The state could become involved in educational or marketing efforts to increase consumer demand for shellfish products.

Current Authority
North Carolina General Statutes

113-203 Transplanting of Oysters and Clams
113-204 Propagation of Shellfish.
106-756 Aquaculture Development Act
North Carolina Fisheries Rules for Coastal Waters 15A NCAC

3K .0103 Shellfish/Seed Management Areas
3O .0201 Standards for Shellfish Bottom and Water Column Leases

Discussion

What level of technical support should the state offer to private shellfish culture operations? Should it subsidize private shellfish culturists who are investing risk capital in the enterprise? The state could add services that would assist private shellfish culture with necessary information and resources. Some services such as disease diagnosis could help reduce some of the inherent risks of shellfish production. The state could take the approach of participating as a partner in private shellfish culture operations by using heavy state equipment for some required culture activities such as cultch planting.

Although mortality of clams from disease and other causes are much less than oysters, disease of shellfish could be a serious detriment to wild and cultured crops. The North Carolina State University (NCSU) Veterinarian School also has facilities for shellfish and fish disease diagnostics. There is little ongoing genetics research for producing disease resistant stocks for cultured shellfish crops.

Cultch manipulation requires heavy equipment in the form of barges for planting and suction dredges for relaying seeded cultch for grow-out. This equipment is expensive and has a single-purpose use. The Louisiana and Connecticut industries have been operating for many years and maintain privately owned equipment for this purpose however, the states also maintain and utilize similar equipment for use in public areas. The cultch is planted in designated areas that are better for spatfall, then removed by dredges and transferred to leases that are better for growth. Cultch is a valuable commodity and if there is a poor spat set it may be dredged back up and piled back onshore to dry for later re-planting.

If the state were to designate seed areas in locations that generally have good spat settlement, such as high salinity estuaries, it could routinely plant cultch in those areas specifically for seed collection. Then leaseholders could remove the seeded cultch after spatfall and relay to their leases for grow-out. Likewise, the state could also remove the seeded cultch to public restoration areas or created reefs. Many growers relay shellfish from polluted areas to leases during a six-week season in late winter. However, planted seedbeds would give growers an additional source of seedstock to increase shellfish production.

It has also been suggested that the state could use its equipment to plant cultch directly onto private leases for shellfish production. That would take time away from state cultch planting efforts and would bear an undetermined cost to the leaseholder, however, the cost may be less than purchasing the appropriate equipment.

Specific best management culture methods used by each successful industry still need to be developed for North Carolina. The state could work to provide a suitable regulatory climate and shellfish seed resource for private oyster culture. State funded support services for shellfish growers such as biological and environmental monitoring

that are important to other shellfish industries should be available in North Carolina.

Research, development and education initiatives are essential to a successful shellfish culture industry. The state of Virginia is currently operating shellfish culture hatchery and research facilities in addition to providing disease diagnostic services to growers. The state also provides educational centers for the training of shellfish growers to increase proficiency. North Carolina should provide these services to foster the shellfish culture industry.

Management Options/Impacts

(C. is omitted in this plan because it pertained to the oyster FMP only.)

A. Status Quo for technical support of shellfish culture

+ No rule changes or research required
- No improvement in the situation

B. Designate and plant managed seed bed areas for subsequent relay to leases

+ Provides necessary resources for traditional shellfish culture
+ Temporarily creates habitat and ecological services
- Further reduces the funding available for the several facets of shellfish resource restoration and harvest management
- The dedicated use of a portion of the resource to one user group is opposed by some fishing groups

D. State assistance with planting efforts on shellfish leases: Cultch planting with state-owned equipment, subsidized shell purchases, and cost share programs for BMPs.

+ Provides major assistance in shellfish lease management particularly for new leaseholders
+ Increases habitat and ecological services provided by planted lease areas
- Reduces amount of habitat that can be restored in natural areas
- Reduces the amount of enhancement efforts for production of harvestable shellfish in public areas
- The expenditure of state funds for one user group is opposed by some fishing groups

E. Increase funding of research, development and education initiatives as follows:

1. University-based shellfish culture hatchery and research facilities for

development of cultivation methods, improved genetics, disease resistance, and performance of biological monitoring and support services.

2. Shellfish disease laboratory for research and diagnostic services for growers.

3. Educational centers within the University and Community College systems for education of the public and training of shellfish culture students.

+ Provides excellent support and an atmosphere for growth of shellfish culture industry
+ Services provided may have application to wild harvest problems
- Significant expenditures for shellfish culture may remove the focus on natural shellfish population problems

DMF Recommendation

D. Designate and plant managed seed bed areas for subsequent relay to leases

E. Increase funding of research, development and education initiatives as follows:

1. University-based shellfish culture hatchery and research facilities for development of cultivation methods, improved genetics, disease resistance, and performance of biological monitoring and support services.
2. Shellfish disease laboratory for research and diagnostic services for growers.
3. Educational centers within the University and Community College systems for education of the public and training of shellfish culture students.

AC Recommendation

Agreed with DMF

MFC Selected Management Strategies

Designate and plant managed seed bed areas for subsequent relay to leases

Increase funding of research, development and education initiatives as follows:

1. University-based shellfish culture hatchery and research facilities for development of cultivation methods, improved genetics, disease resistance, and performance of biological monitoring and support services.
2. Shellfish disease laboratory for research and diagnostic services for growers.
3. Educational centers within the University and Community College systems for education of the public and training of shellfish culture students.

9.3.7 Allow Shellfish Leases in Prohibited (Polluted) Areas

An increasing number of shellfish leases are being closed to shellfish harvesting due to pollution. Shellfish leases that do not meet certain criteria concerning percentage of days closed to harvest cannot be renewed under the existing statutory and rule standards. Some new applicants would also like to obtain new leases in areas currently closed due to pollution because many are good growing areas and many closed areas are near habitable shorelines offering better opportunities for surveillance and access. The governing statutes prohibit issuance of new shellfish leases in areas closed to shellfish harvest by reason of pollution. This issue originated from public comment and the BRACO.

Background

The problem concerning renewing shellfish leases in prohibited shellfishing areas arose in 1987 when a shellfish leaseholder being denied renewal for failure to meet shellfish production requirements appealed because his lease was in a polluted area and he was unable to market his shellfish. The administrative law judge found that the lease should not be renewed because it did not meet the statutory standards by being in an area closed by reason of pollution not because of a failure to produce commercial quantities of shellfish. Available records indicate that the polluted area standard had not been applied to shellfish lease renewals prior to that finding. The MFC upheld the judge's recommendation and all subsequent shellfish renewal applications have included review of the shellfish harvesting closure status of renewals.

In an effort to minimize the effects of harvesting closures, the Shellfish Sanitation Section of the DEH has implemented management plans and utilized classification systems that allow for conditional closures of open harvest areas and temporary openings of closed areas. The use of these measures benefit public and private bottom shellfish harvesters but it made absolute identification of "an area closed by reason of pollution" difficult. Also, some leaseholders are able to utilize leases in closed harvest areas by

transplanting polluted shellfish to leases in open harvest areas for cleansing, further complicating application of the statutory standard. The MFC realized these difficulties and further defined an area closed to shellfish harvest by reason of pollution as areas closed for more than 50% of the days during the final four years prior to renewal. They also adopted language that made an exception for leases that were closed for more than 50% of the specified days but were able to meet production requirements by lawful sale of shellfish cultured on the lease site (15A NCAC 3O .0205).

New shellfish leases are allowed in closed shellfish harvesting areas in Virginia and are under consideration in Florida. Virginia shellfish growers cite increased patrol by law enforcement as an added benefit of shellfish culture in closed harvest areas. Containerized culture techniques are favored in these areas to facilitate transfer of the shellfish to open areas for cleansing.

Other than the recommendation in the BRACO's report, there has been no action to change the statutory prohibition on shellfish leasing in polluted areas in North Carolina. There are serious concerns related to congregating dangerous food products in high concentrations in marked areas. However, the DEH and DMF have discussed increasing sampling efforts in closed harvest areas if there is interest in shellfish leasing there and the area has a reasonable chance for significant temporary openings. In order to maximize sampling efforts, sampling for temporary openings is concentrated in areas with high existing resource and high probability for conditional opening. Therefore some areas that might be suitable for shellfish leases due to low existing shellfish resources are not sampled with sufficient frequency to allow them to be classified as conditionally approved areas. Identification of these areas could further diminish problems concerning shellfish leasing in closed harvest areas.

Current Authority

North Carolina General Statutes

G.S. 113-201. Authority of the Marine Fisheries Commission
G.S. 113-202. New and renewal leases for shellfish cultivation

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
3K .0101 Prohibited Shellfish Areas/Activities
3K .0104 Permits for Planting Shellfish from Polluted Areas
3K .0205 Lease Renewal

Discussion

While DMF staff was represented on the Blue Ribbon Advisory Council on Oysters, they did not agree with the recommendation to allow shellfish leasing in areas

closed by reason of pollution and made those comments to the JLCSA. Staff found that the new methods of growing shellfish in bags, cages and densely packed under nets created too large a risk for contaminated shellfish reaching the market. The diversity and year-round nature of fishing activity in North Carolina does not allow Marine Patrol officers enough time to adequately patrol increasing numbers of high intensity culture sites in closed harvesting waters. Indeed, one of the reasons for allowing leaseholders to transplant shellfish from closed harvest areas to leases is to remove the potential for poaching of contaminated shellfish. North Carolina has never had a documented case of illness due to shellfish borne pathogens. Recent difficulty in marketing shellfish due to publicity surrounding contaminated flood waters from hurricane Floyd indicate that a case of real shellfish related illness would be devastating to the North Carolina shellfish industry.

The expanded definition of an area closed by reason of pollution was put in place in October 1992. The number of shellfish leases rescued from non-renewal due to pollution closures since then have been minimal, mostly due to the fact that leaseholders must also meet the harvest and sale portion of the production requirements. Leaseholders have argued that the six-week relay period does not allow sufficient time for managing multiple shellfish lease sites and that they would prefer moving shellfish from leases in closed harvest areas during periods when survival may be higher. Permit rules also need to be amended to address lease-to-lease relaying operations.

Management Options/Impacts

A. Status Quo

+ Allows use of existing prohibited-harvest lease sites
+ Minimal increase in enforcement burden
+ Maintains minimal risk of poaching of contaminated product
- Fails to recognize use of marginal polluted areas
- Fails to allow use of all available methods to purify contaminated shellfish and maintain lease productivity
- Allows no additional use of areas closed to harvest for leasing

B. Change operational policy and rules to increase lease use of marginal polluted areas. **Memorandum of Agreement required.**

+ Allows use of existing prohibited-harvest lease sites
+ Minimal increase in enforcement burden
+ Maintains minimal risk of poaching of contaminated product
+ Recognizes use of marginal polluted areas
- Allows no additional use of areas closed to shellfish harvest for leasing
- Potential increase in Shellfish Sanitation workload

C. Allow new and renewal shellfish leases in areas closed to shellfish harvest by reason of pollution. **Statute and rule changes required.**

+ Allows use of existing prohibited-harvest lease sites
+ Recognizes use of marginal polluted areas
+ Allows additional use of areas closed to shellfish harvest for leasing
- Potential large increase in enforcement burden
- Increases risk of poaching of contaminated product

DMF Recommendation

B. Change operational policy to increase lease use of marginal polluted areas.

AC Recommendation

Agreed with DMF

MFC Selected Management Strategy

Change operational policy to increase lease use of marginal polluted areas.

9.3.8 Lead Agency Identification for Shellfish Aquaculture

The NC Department of Agriculture and the DENR both have roles in the development of shellfish aquaculture in North Carolina. There is confusion over the responsibilities of each agency. This issue originated from public comment at PID meetings.

Background

The 1989 session of the North Carolina General Assembly passed the Aquaculture Development Act, which named the NC Department of Agriculture as the lead agency for all types of aquaculture in North Carolina. The statutory (G.S.106-758) definition of aquaculture in the act is broad and includes the propagation and rearing of aquatic species in controlled or selected environments. This broad wording brings all types of private shellfish culture under the definition of aquaculture. G.S. 113-201 gives the MFC authority to make rules and take all steps necessary to develop and improve the cultivation, harvesting and marketing of shellfish from private beds in North Carolina. And, G.S. 113-202 gives the Secretary of DENR the authority to grant shellfish cultivation leases. This situation has lead to confusion over the roles of the different agencies in shellfish culture activities.

Current Authority

North Carolina General Statutes

G.S. 106-759. Lead agency; powers and duties. (Aquaculture Development Act)
G.S. 113-132. Jurisdiction of fisheries agencies.
G.S. 113-202. New and renewal leases for shellfish cultivation; termination of leases issued prior to January 1, 1966.
G.S. 113-131. Resources belonging to the public; stewardship of conservation agencies; grant and delegation of powers; injunctive relief.

Discussion

The Aquaculture Development Act was drafted from recommendations made by the Governor's Task Force on Aquaculture in the Aquaculture Development Plan for North Carolina (1988). The act gave the NC Department of Agriculture specific powers and duties in its role as the lead State agency in matters pertaining to aquaculture:

(1) To provide aquaculturists with information and assistance in obtaining permits related to aquaculture activities;
(2) To promote investment in aquaculture facilities in order to expand production and processing capacity; and
(3) To work with appropriate state and federal agencies to review, develop and implement policies and procedures to facilitate aquacultural development.

In order to clarify the role of the MFC, the act broadened the jurisdiction of the MFC in G.S. 113-132(a) to include regulation of aquaculture facilities as defined in G.S. 106-758, which cultivate or rear marine and estuarine resources. Therefore, the role of the MFC did not change relative to the Aquaculture Development Act nor did the role of the Secretary of DENR.

The intent of the act seems clear particularly when read with the Aquaculture Development Plan for North Carolina. The NC Department of Agriculture is to serve as a facilitator and coordinator for permit information; permit, policy and procedure development; and investment in aquaculture. The DENR is to retain its role as steward of the marine and estuarine resources of the State and protector of the public trust rights of the people of the State (G.S. 113-131). And, the MFC is to keep its jurisdiction over the conservation of (all) marine and estuarine resources.

The major problem appears to be that the public has not been adequately informed about the roles of the various agencies. The DMF and the NC Division of Aquaculture and Natural Resources of the Department of Agriculture need to coordinate an educational initiative to resolve this issue. The Agriculture extension agents, Sea Grant specialists, and DMF staff working with shellfish aquaculture would benefit from this initiative.

Management Options/Impacts

A. Status Quo

+ No action or expenditure of funds required by agencies
- Public confusion over agency roles will persist

B. Inform the public about agency roles concerning aquaculture

+ Public confusion will be reduced
- Action and expenditure of funds required by agencies

DMF Recommendation

B. Inform the public about agency roles concerning aquaculture

AC Recommendation

Agreed with DMF

MFC Selected Management Strategy

Inform the public about agency roles concerning aquaculture

9.3.9 Shellfish Depuration Plants

There are no shellfish depuration facilities located in North Carolina at this time. The establishment of depuration plants in this State could potentially increase shellfish production by utilizing shellfish from public bottom and private culture areas currently closed to harvesting due to pollution. This issue originated from public comment, staff comment at PDT meetings.

Background

Depuration is defined by the Interstate Shellfish Sanitation Conference as *"the process of reducing the pathogenic organisms that may be present in shellstock by using a controlled aquatic environment as the treatment process"*. NC Marine Fisheries Rules define depuration as *"purification or the removal of adulteration from live oysters, clams, and mussels by any natural or artificially controlled means"*. DEH rules define

depuration as *"mechanical purification or the removal of adulteration from live shellstock by any artificially controlled means"*. The latter meaning best describes the use of the term depuration in this issue paper.

The issue originates from shellfish leaseholders that have had their leases closed to harvest by reason of pollution and are looking for a means to maintain their shellfish production. Although the term "pollution" can carry various definitions, for the purposes of this issue paper, the term is restricted to fecal coliform bacteria contamination. Fecal coliform standards are used in North Carolina and across the country to regulate shellfish growing waters and subsequent harvest of shellfish. Staff sees depuration as a conceivable option for better management of shellfish resources in closed harvest areas. The idea of a state managed depuration facility has also surfaced occasionally but has not gathered much support.

New York, New Jersey, Connecticut, and Massachusetts currently have depuration facilities located within their states. These facilities are used in some cases to process only shellfish harvested from certain areas closed to harvesting and in some cases to process all shellfish harvested, those from open as well as closed harvest areas.

Currently, North Carolina fisheries rules only allow the harvest of shellfish from closed waters for the purpose of depuration for shellfish that would otherwise be destroyed in maintenance dredging operations. The provisions for depuration in the current rule were developed in 1987 in response to a situation where shellfish were transported to a depuration plant in South Carolina. No shellfish have been depurated under the existing rule. In the recent past, polluted shellfish threatened by maintenance dredging operations on public bottoms have been transplanted to open harvest areas by DMF for cleansing. Typically this has involved the harvest of shellfish (usually clams) from a navigation channel by DMF staff or commercial shell fishermen and relaying the product to an open area that would be kept closed until the shellfish meet consumption standards.

In lieu of mechanical shellfish depuration from public bottoms, Fishery rules allow for the relaying of shellfish from polluted areas to private shellfish leases during a six week period each year, and the DMF also conducts a relay program each spring in the southern area of the State in which oystermen are paid to move oysters from polluted areas to open public bottom. These programs constitute the extent of shellfish cleansing operations in North Carolina.

Current Authority

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
3K .0107 Depuration of Shellfish

North Carolina Environmental Health Rules
15A NCAC 18A .0700-. 0713 Requirements for Operation of a Depuration Facility

Discussion

As previously noted, several states currently utilize shellfish depuration plants. A New Jersey plant processes more clams than any other in the country, approximately 250 bushels per day operating year round. Depuration has been utilized in New Jersey to reduce the numbers of clams in one very large polluted area in the state in an effort to limit the potential for those shellfish to directly reach the market (Gary Wolff, NJ Dept. of Health, pers. com.).

New Jersey officials indicate that oversight of the two depuration plants in the state and associated monitoring of harvest and transport of shellfish have imposed substantial financial and manpower demands on the departments involved. They also indicate that approximately 60 clammers are regularly involved in harvesting strictly for depuration and that most were currently unhappy with the reduced prices they received for their clams due to high depuration costs.

Since the early 1990s, ten depuration plants in Florida have closed due to high costs of operation, primarily the costs associated with laboratory analysis for quality control (David Wiggins, USFDA, pers. com.). Most often depuration plants are responsible for contracting with private FDA certified laboratories to process the substantial number of water and product samples required by state and federal rules. DEH laboratories would not be available to process samples from a depuration plant due to current staffing and workload levels.

For a depuration plant to be feasible, a constant supply of polluted shellfish would be required, preferably from a singular location. With the scattering of relatively small, polluted areas throughout the coastal counties, as in North Carolina, the oversight of transport of shellfish to the depuration plant would require a substantial commitment from, most likely, Marine Patrol. The varying concentrations of shellfish in each of these polluted areas may also make it difficult to “guarantee” a constant supply of shellfish for plant operators. In addition, some closed areas are opened temporarily from time to time for public harvest when conditions permit. Such areas would most likely not be included as source sites for depuration operations.

New Jersey officials indicated that the two depuration plants operating in their state at this time require enough attention that they easily justify a single state inspector position for those plants alone. Current DEH workloads are such that additional shellfish inspector positions would most likely be required if a depuration plant were established in the State.

Management Options/Impacts

A. Status quo

+ No risk of contaminated shellfish reaching the market through incomplete depuration treatment or during transfer from harvest area to depuration plant
+ No increase in workloads for DMF or DEH
+ Concentrations of shellfish in polluted areas that may act as spawning stocks not removed or disturbed
- Risk of contaminated shellfish reaching market directly from poaching in closed areas remains
- Allows no additional use of polluted areas for shellfish harvesting
- Fails to allow use of all available methods to purify contaminated shellfish

B. Change DMF rules to allow harvest of shellfish from polluted areas for processing in depuration facility. **Rule change required.**

+ Allows additional use of polluted areas for shellfish harvesting
+ Allows use of all available methods to purify contaminated shellfish
+ Reduces potential of contaminated shellfish reaching market from poaching in polluted areas
- Risk of contaminated shellfish reaching the market through incomplete depuration treatment or during transfer from harvest area to depuration plant
- Substantial increase in DMF enforcement and DEH inspection and sampling burdens
- Potential to disrupt / destroy shellfish spawning stocks in polluted areas

C. Amend North Carolina fishery rules to allow harvest of shellfish from shellfish leases and franchises in polluted areas for processing in depuration facilities. **Rule change required.**

+ Allows continued use of shellfish leases and franchises in polluted areas for shellfish cultivation
+ Allows use of all available methods to purify contaminated shellfish
+ Reduces potential of contaminated shellfish reaching the market through incomplete depuration treatment or during transfer from harvest area to plant
- Substantial increase in DMF enforcement and DEH inspection and

sampling burdens

D. Establish State-operated depuration facilities

+ Removes the need to have a constant supply of product for depuration
+ Mitigates the State's failure to maintain water quality
- Likely to have a low cost: benefit ratio
- Removes the focus on maintaining and restoring water quality

DMF Recommendation

C. Amend North Carolina fisheries rules to allow harvest of shellfish from shellfish leases and franchises in polluted areas for processing in depuration facilities.

AC Recommendation

A. Status quo

After discussing the recommendation with the committee, DMF changed its recommendation to Status quo.

MFC Selected Management Strategy

Status quo

9.3.10 Clam Production Units

Should hard clam production units be changed to units used in marketing? This issue originated from the Oyster and Clam PID public hearings.

Background

The majority of hard clam landings are reported as counts of individual clams. MFC rules specify that production and planting effort on shellfish leases and franchises be evaluated by bushel measurements. This dichotomy necessitates the use of conversion factors, which reduces accuracy if no clam size information is given. A conversion of 400 hard clams per bushel is used to convert hard clam production from numbers to bushels. Because of the considerable variation in hard clam shell size and weight along the coast, all hard clam data should be presented in numbers of individuals. This would allow more accurate reporting of hard clams landed from or planted on

leases.

Current Authority

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)
3O.0201 Standards of Shellfish Bottom and Water Column Leases

Discussion

The Shellfish Committee addressed the issue of changing the production requirements from bushels to number of clams in April 1997. After reviewing the proposed rule changes and a lengthy discussion, it was voted to leave the rules on shellfish lease clam production as is. Reasons for leaving the rules unchanged included:

1. An accurate production requirement by number would require establishing a required number of clams by each size category.
2. Many clams are sold ungraded and there is no requirement to grade for trip ticket documentation.
3. Current rules allow leaseholders to report either in bushels or numbers with an average number per bushel that does not reward or penalize large or small clam categories too severely.

Leaseholders are allowed to report their landings in numbers of clams and DMF staff converts the numbers to bushels based on the information provided on the Trip Ticket. Ungraded clams are converted to bushels at the rate of 400 clams per bushel. If clam grade sizes are reported, other conversion factors are used based on average number of clams per bushel for that grade

Management Options/Impacts

A. Status Quo

+ Allows leaseholders to continue to report in numbers of clams
+ Keeps production standards in bushels for all shellfish species
- Introduces a third measure for evaluating clam landings which already include number of clams and pounds of meat

B. Change the production units to number of clams

+ Increase the accuracy of lease data
+ Increases accuracy for comparing shellfish lease with trip ticket data
- Creates separate measures for assessing shellfish lease production
- May require setting production requirements for different clam grades

DMF Management Recommendation

A. Status Quo

AC Recommendation

Agreed with DMF

MFC Selected Management Strategy

Status Quo

9.3.11 Importation of Marine and Estuarine Organisms

Establish criteria for the testing of marine and estuarine organisms prior to introduction into NC waters to ensure safety of native species and habitats. This issue originated from DMF staff, Shellfish Advisory Committee, and Shellfish Growers.

Background

The importation of shellfish seed has become an integral part of many mariculture operations in North Carolina. The few shellfish hatcheries in NC are unable to produce sufficient numbers of seed to meet the demand of shellfish growers. Therefore growers must utilize out-of-state sources for shellfish seed. The importation of shellfish seed into NC was not regulated prior to 1986. The Atlantic States Marine Fisheries Commission (ASMFC) addressed the potential danger of spreading shellfish pests, predators, and disease in their October 1986 meeting. The States of Maine, New Hampshire, Massachusetts, Rhode Island, Virginia, North Carolina, South Carolina, Georgia, and Florida endorsed a cooperative agreement. This agreement which provided primary control of imports would lie with the importing state, and would retain the ultimate authority to accept or reject any shipment of shellfish. The exporter would have the responsibility of proving the health status of shipments. The ASMFC Interstate Shellfish Transport Committee was to draft a plan implementing the Cooperative Agreement for Interstate Transfer of Shellfish. Although the agreement was endorsed by the member states, the implementation of the plan has not been consistent for all states. DMF policy is to follow the guidelines set forth in the ASMFC Cooperative Agreement. DMF requires certification that a shellfish seed shipment is free of shellfish pests, predators, pathogens or parasites, or documentation that the exporting facility uses sterile hatchery procedures that would preclude the above from contaminating the shipment (sterile closed system or treatment of incoming water). A documented history that organisms from the exporting facility have had no incidence of contamination is also required. The responsibility for obtaining the certification lies with the applicant. This policy is consistent with the policies in Maine, Rhode Island and South Carolina although not as restrictive. North Carolina's policy also lacks detailed procedures leaving managers to

make some decisions on a case-by-case basis.

Current Authority

North Carolina Fisheries Rules for Coastal Waters (15A NCAC)

3I .0104 Introduction and Transfers of Marine and Estuarine Organism

Discussion

The intent of this rule is to protect the waters of NC from the introduction of pest species, parasites, pathogens and exotics. Some shellfish growers are concerned over the DMF policy due to the time limitations for holding and shipping shellfish seed and the time necessary to perform the required testing. The applicants view this policy as a burden for the applicant and the hatchery and an unnecessary obstacle to the importation of shellfish seed. However, at least one hatchery maintains disease certifications on each batch of shellfish seed and can send documentation and ship seed within days after the order is placed. Better dissemination of information to other vendors could improve coordination of seed sales between states.

Management Options/Impacts

A. Status Quo

+ Requires no changes in policy or rule
+ Allows flexibility to deal with unforeseen circumstances
- Does not provide adequate detail for new users –
- Causes delays due to lack of clear testing protocols

B. Formalize/amplify policy and send to vendors

+ Gives clear guidance on testing procedures and requirements
+ Allows for preplanning by vendors for NC shipments
+ Increases protection of native NC species
- Unforeseen circumstances and new developments not addressed

C. Develop criteria and recertification schedule for shellfish seed vendors

+ Pre-approved vendors could provide lower costs and faster shipments of seed
+ Less administration required for staff and shellfish growers
- Lack of batch testing increases risk of accidental importation of unwanted species

D. Prohibit importation of all out of state shellfish

+ Provides maximum protection for native species
+ Increases incentive to develop in-state seed suppliers
+ Removes administration and law enforcement burdens
- Does not address current seed supply problems
- Does not allow for improvements in breeding in other states

E. Allow unrestricted importation of shellfish products

+ Reduce costs and speed delivery of shellfish seed
+ Removes administrative and law enforcement burden
- Reduces incentive to develop in-state seed suppliers
- Maximum risk to native species

DMF Recommendation

B. Formalize/amplify policy and send to vendors

AC Recommendation

Agreed with DMF

MFC Selected Management Strategy

Formalize/amplify policy and send to vendors

9.4 Habitat and Water Quality

9.4.1 Water Quality Degradation and Increased Area Closures

Evaluate water quality issues as they relate to the harvest/consumption of shellfish resources. This issue originated from the Oyster and Clam Fishery Management Plan Committee and public comment.

Background

Laws, regulations, and commissions exist to ensure proper balance among all user groups such as fishermen, swimmers, boaters and developers, along with providing adequate protection of the environment. The federal Clean Water Act, enacted by Congress in 1972 establishes standards to maintain and restore the integrity of the nation's waters. There are provisions that address pollution of shellfishing waters as well as other water quality issues. One of the most powerful provisions is the protection of the existing uses of public waters in order to prevent further degradation of water

quality. Any development permits, dredge and fill permits, or waste water treatment plant permits, issued by the Division of Coastal Management (DCM) must comply with these water quality standards. Within the state of North Carolina, there is a set of water quality classifications for both salt water and fresh water determined by the Environmental Management Commission (EMC) and codified in Classifications and Water Quality Standards Applicable to Surface Waters and Wetlands of North Carolina (15A NCAC 2B .0100 and .0200). These classifications are based on the use that is being protected. Classifications cannot be downgraded if the change eliminates the existing use or the use can be regained (North Carolina Coastal Federation, 1992).

Class SA Waters: suitable for commercial shellfishing and all other tidal saltwater uses [15A NCAC 2B .0101 (d) (3)]. These waters are protected for market purpose shellfishing and have stringent bacteriological standards. Molluscan shellfish, like clams and oysters, are water quality sensitive and are often utilized as environmental indicators because of their sessile lifestyle and ability to concentrate various biological and chemical pollutants many times greater than the concentration of those pollutants found in their surrounding environment. Sewage spills and storm water runoff into shellfish growing areas, which may not adversely affect shellfish, can lead to human illness when shellfish from those areas are consumed. The national standard uses fecal coliform bacteria as an indicator to assess the risk of contracting a human pathogen from consuming raw or partially cooked shellfish. Therefore, fecal coliform bacteria numbers must be low in SA waters. Special requirements for controlling runoff from new development are necessary to insure this standard is met (North Carolina Coastal Federation, 1992).

Class SB Waters: saltwaters protected for primary recreation which includes ona a frequent or organized basis and all Class SC uses [15A NCAC 2B .0101 (d) (2). These waters are classified for swimming, skiing, aquatic life protection and fish propagation. Wastewater treatment plants in these areas must have backup systems to insure no untreated sewage is allowed into these waters (North Carolina Coastal Federation, 1992).

Class SC Waters: : saltwaters protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife. All saltwaters shall be classified to protect these uses at a minimum [15A NCAC 2B .0101 (d) (1)]. These waters are classified for incidental swimming, aquatic life protection, and fish propagation. These waters are safe for swimming but in certain areas there is a higher risk of pollution and human illness than in SB waters. Treated sewage is allowed into these waters if it does not affect the use of the waters. Any treated sewage in SC class waters must not affect SB or SA waters farther downstream (North Carolina Coastal Federation, 1992).

Outstanding Resource Waters (ORW): unique and special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses {15A NCAC 2B .0101 (e) 4)]. This

designation is an addition to the above classifications and provides additional protection for the state's highly valued waters. It was implemented by North Carolina to carry out federal requirements that exceptionally valuable waters be protected (North Carolina Coastal Federation, 1992). This classification allows for protection of waters without significant pollution sources and other special values or uses as specified in 15A NCAC 2B .0225.

Nutrient Sensitive Waters (NSW): waters subject to growths of microscopic or macroscopic vegetation requiring limitations on nutrient inputs [15A NCAC 2B .0101 (e) (3)]. This designation is applied to subject areas in addition to the basic classification and provides for development of nutrient discharge management strategies by the EMC (North Carolina Coastal Federation, 1992).

High Quality Waters (HQW): waters which are rated as excellent based on biological and physical/chemical characteristics through Division monitoring or special studies, native and special native trout waters (and their tributaries) designated by the Wildlife Resources Commission, primary nursery areas (PNA) designated by the MFC and other functional nursery areas designated by the MFC, all water supply watersheds which are either classified as WS-I or WS-II or those for which a formal petition for reclassification as WS-I or WS-II has been received from the appropriate local government and accepted by the DWQ and all class SA waters [15A NCAC 2B .0101 (e) (5)]. This designation includes all SA waters and fish nursery areas and is applicable to streams with biological and chemical characteristics higher than the adopted standards (North Carolina Coastal Federation, 1992).

The Coastal Zone Management Act was also enacted by the federal government in 1972 to encourage states to develop coastal management programs that balance wise development with protection of natural resources. These programs must meet federal requirements in return for funding and a voice in federal actions affecting their coasts. The North Carolina Coastal Area Management Act (CAMA), established in 1974, meets these federal requirements and applies to 20 coastal counties. Through this act, Areas of Environmental Concern (AEC) are established along with local land use plans. This ensures balancing environmental preservation with economic growth. AECs are sensitive valuable areas that require special protection. AECs include estuarine waters and public trust areas, estuarine shoreline, coastal wetlands, ocean hazard areas, public water supplies and natural and cultural resource areas. For any development in AECs that requires land or water disturbance, a permit is required from Division of Coastal management. Exceptions to this permit requirement include some agricultural and forestry activities and maintenance of existing public roads and utilities. Construction of energy facilities and emergency repairs if life or properties are in imminent danger are also exempt from CAMA permitting (North Carolina Coastal Federation, 1992).

Current Authority

North Carolina General Statutes

143B-279.8. Coastal Habitat Protection Plans
143B-289.52. Marine Fisheries Commission - powers and duties

Discussion

In spite of the state's effort to balance economic growth with environmental protection, population growth has resulted in increased land disturbing activities in the coastal areas. This has caused increased closures of a significant amount of shellfish growing waters due to fecal coliform contamination. More than 56,000 acres of shellfish growing waters are regularly closed to shellfishing in North Carolina (DEH unpublished data). Other areas may be temporarily closed during periods of excessive rainfall. As temporary closures have increased in frequency and duration, they have become an area of great concern to shellfishermen and seafood dealers particularly in the southern area of the coast. An additional 1.5 inches of rainfall in a 24-hour period can cause temporary harvesting closures in an additional 50,000 acres and closures may last from several days to more than a month (DEH, Shellfish Sanitation Section, Conditional Opening Management Plans).

One situation that hampers efforts at slowing or reversing the trend toward increased shellfishing closures is the separation of responsibility for activities impacting water quality in the coastal area between three state commissions (Environmental Management Commission, Coastal Resources Commission and Marine Fisheries Commission). However, recently mandated Coastal Habitat Protection Plans (CHPP) will provide an avenue that will bring these three commissions together in order to implement the long term enhancement of coastal fisheries such as the shellfish fisheries associated with each coastal habitat and will include protection of shellfish producing waters. The Habitat and Water Quality Committee of the MFC has already begun to take a proactive role by establishing several recommendations directed at both the CHPPs and the Oyster and Hard Clam FMP.

Stormwater run off accounts for more than 90% of shellfish harvest closures (G. Gilbert, DEH, Shellfish Sanitation, personal comment). Mallin et al. (1998) goes on to state that impervious surfaces account for 95% of the variability in the average amount of fecal coliform in the estuarine systems in New Hanover county. He also found that covering more than 10 percent of an area with pavement, sidewalks, roofs and other hard surfaces induces runoff that will degrade the quality of a stream . Impervious surface in excess of 30 percent is usually devastating to the water body that receives the runoff. Ninety-four percent of the increase in fecal coliform counts in New Hanover County's tidal creeks was attributed to built-upon surfaces.

The Environmental Management Commission has established rules for built upon surfaces in the coastal region. However, these rules have not prevented additional closures of shellfishing waters since they were adopted in the late 1980s. Table 10 lists

closures occurring in ORWs alone. As development activities continue so will the amount of shellfish area closings and because of the extent of coastal development to date, many of the areas closed to shell fishing will be difficult if not impossible to fully reclaim.

The MFC Habitat and Water Quality Committee recently recommended that the EMC place top priority on maintaining and restoring Approved and Conditionally Approved Shellfish waters. This can only be accomplished by preventing increased amounts of surface runoff that carry fecal coliform from natural and human sources into SA waters. In order to more fully protect water quality, the EMC would have to adopt water quality standards that limit the total impervious cover within small watersheds that are immediately adjacent to SA waters to 10 percent. To restore SA waters that are prohibited to shellfishing, the EMC would have to strengthen stormwater rules so that mitigation is required resulting in water quality enhancements from any newly permitted land use activities.

Table 10. Closures of Outstanding Resource Waters.

ORW	**Acres Opened and Closed**
Masonboro Sound	No Change
Topsail and Middle Sound	130 acres closed in Howe Cr (12/6/91) 50 acres closed in Futch Cr (4/27/93) 73 acres closed in Mill Cr (4/27/93) 202 acres closed in Old Topsail Cr (4/27/93) 38 acres opened in Futch Creek (5/30/96 **417 Acres closed**
Stump Sound	25 acres closed in Turkey Creek (5/5/92) 25 acres closed in Galleon Bay (8/4/94) 50 acres closed in Spicer Bay (8/3/95) 20 acres opened in ICWW(1/9/96) **80 Acres Closed**
Western Bogue Sound	20 acres closed in Archer Cr(7/21/95) 77 acres closed in Sanders Cr(3/22/96) **97 Acres Closed**
Roosevelt Natural Area	No Change
Core and Back Sounds	2 acres closed – Marinas (7/30/90) 40 acres closed in Cedar Cr (4/26/94) 25 acres closed in Glover Cr (4/26/94) 2 acres opened in Taylor Harbor(4/26/94) 2 acres closed -Yeomans Fish House(9/8/94)

	67 Acres Closed
Swanquarter and Juniper Bays	405 acres closed in Swanquarter Bay(5/17/90) 155 acres closed in Juniper Bay(7/30/90) 300 acres opened in Swanquarter Bay(11/17/93) 100 acres closed in Swanquarter Bay(4/23/98) **360 Acres Closed**

Source: NC Div. of Shellfish Sanitation

Waters with the SA designation that are classified as conditionally approved open to shellfish harvest can be temporarily closed due to suspected high levels of fecal coliforms based on rainfall events. These waters continue to maintain the SA classification but during closure periods they are not meeting their uses. Section 303(d) of the Clean Water Act requires states to develop a list of impaired waters every two years. For all waterbodies on the list, the source of pollution must be determined and controlled by developing management strategies and numeric Total Maximum Daily Loads (TMDLs). Development of TMDLs for fecal coliforms in impaired estuarine waters has been delayed due to a lack of resources for the sophisticated modeling and monitoring required to characterize the complex water flows, as well as the difficulty in pinpointing the sources. Developing a technically defensible limit for fecal coliforms in estuarine waters may not be feasible at this time.

Historically, conditionally approved open and conditionally approved closed SA waters have been rated as "Support Threatened" a subcategory of "Fully Supporting" and therefore were never targeted by DWQ for protection or restoration because of their inclusion in the "Fully Supporting" category. In 2000, the EPA required "Support Threatened" waters to be treated as impaired. Also during 2000, N.C. Division of Water Quality (DWQ) dropped the "Support Threatened" rating because of conflict between the State's definition of "Support Threatened" meaning fully supporting but threatened and the federal definition of the term meaning impaired. During the early stages of development of this plan there were concerns that conditionally approved open areas would be rated as "Fully Supporting" and conditionally approved closed areas would be rated as "Partially Supporting" in response to the EPA mandate that "Support Threatened" waters be restored. By rating conditionally approved open areas as "Fully Supporting", rather than "Support Threatened", these waters would remain untargeted for protection or restoration. The MFC sent a resolution to EMC that conditionally approved open SA waters be rated as "Partially Supporting" because only through management plans that automatically close these areas after rainfall thresholds are exceeded, are conditionally approved open areas allowed to have a baseline status of open to shellfishing. Without these management plans and diligent monitoring, conditionally approved open areas would be classified as "Restricted" shellfish harvest areas.

DWQ did not change the rating of conditionally approved open waters from

"Fully Supporting" to "Partially Supporting." Instead, DWQ made an agreement with EPA that those waters rated as conditionally approved open would be looked at further and management plans created for those areas by 2002. DWQ and DEH SS are currently developing a database that will allow DWQ to assess extent and duration of closures to make use support determinations of SA waters. However, these tools will not be available for some time. Starting with the 2001 White Oak River basinwide assessment, an interim methodology will be applied using existing databases. This methodology is based on a percentage frequency of closures within a five-year period (1994-1999). Conditionally approved open areas that are closed greater than 10% but less than 25% of the five-year period will be rated as "Partially Supporting." Conditionally approve open areas closed greater than 25% of the time will be rated as "Not Supporting". Once the new database is in place, DWQ will be rating many conditionally approved open waters as "Impaired." The White Oak River Basin Plan is the first to identify any shellfish waters as "Not Supporting" with this methodology. This interim method will also be applied to the 2002 Neuse River basin assessment and the 2003 Lumber River basin assessment (DWQ 2001).

Conditionally approved closed SA waters are seldom, if ever open for shellfishing. The MFC recommendation included that these waters be rated as "Not Supporting" their intended uses. These waters were listed by DWQ as impaired and rated as "Partially Supporting" their intended uses. Under the interim plan, conditionally approved closed SA waters will be rated as "Not Supporting" based on the duration of their closures (DWQ 2001).

Several projects are listed in the draft 2000 list of impaired waters which are aimed at controlling some of the sources of fecal coliform impairment, such as best management practices to reduce stormwater runoff in coastal areas. However, as mentioned previously, coastal development is projected to increase in the upcoming years, and is the overriding source of the problem. North Carolina does not appear to have an effective strategy for addressing the impacts of coastal development on water quality, particularly since the CAMA land-use planning process has been halted pending reevaluation by DCM.

Point source discharges from municipal or community wastewater treatment plants can degrade water quality in or near shellfish waters. The Clean Water Act requires states to establish anti-degradation policies. North Carolina's anti-degradation policy sets three tiers of protection from degradation of water quality. Under the policy, Tier 1 protects existing uses that were attained or for which water quality was suitable to be attained on or after November 28, 1975. Tier 2 protects the levels of water quality that are higher than required to support propagation of fish, shellfish and wildlife, and recreation. Tier 3 protects the quality of outstanding national resources, such as waters of exceptional recreational or ecological significance. Closure of waters to shellfishing is a clear discrete event that contravenes the anti-degradation policy.

The MFC's Habitat and Water Quality Committee also recommended that prior to the construction of any new or expanded wastewater treatment plants within 10 miles upstream or downstream of a shellfish area that was or could have been productive at any time after November 28, 1975, Phase II NPDES (National Pollutant Discharge Elimination System) stormwater permits shall be required within the area serviced by the new or expanded sever systems. Permits issued should require the implementation of stormwater management plans that will protect SA waters form fecal coliform pollution. They also recommended that the current ban on allowing discharges of treated sewage to SA waters also be maintained.

Because the loss of wetlands can also contribute significantly to the degradation of shellfish areas, the MFC's Habitat and Water Quality Committee also recommended that Army corps of Engineers' nationwide permits that would cause further loss of wetlands, including nationwide permits #39 for residential and commercial activities, # 41 for reshaping existing drainage ditches, #42 for recreational facilities like golf courses, #43 for stormwater management facilities; and #44 for mining activities not be certified. Nationwide permits should not be certified if they do not control cumulative impacts. Nationwide permits are "general" permits issued by the Corps that allow small acreage wetland impacts for activities deemed to have a minimal adverse effect on the aquatic environment. The recommendations on use of Phase II NPDES stormwater permits and certification of nationwide permits represent increased use of statutory authority to comment on activities that affect water quality.

Other strategies for coping with shellfish harvesting closures involve acceptance of the fact that closures are going to continue to occur and that different standards could be adopted concerning oyster consumption. The present National Shellfish Sanitation Program standard for bacteriological water quality of shellfish harvest areas assumes that all shellfish could be consumed raw. This assumption requires a very high standard for the waters where shellfish are harvested. In Japan there are standards for cooked consumption and raw consumption. Even though Japan is heavily populated and highly developed in many areas, they are able to utilize almost all of their waters for shellfish production. Most of these waters would be closed to harvest if they occurred in the United States.

There has also been discussion of researching different indicator organisms to assess the contamination of shellfish harvest waters. While fecal coliform bacteria are found in the intestinal tract of all warm blooded animals and indicate the presence of fecal contamination from those animals, they are not specific to the organisms of primary concern to human health which are viral disease pathogens. More specific indicators of potential human health risks could lead to a reduction in the area of closed shellfishing waters. However, early attempts at locating such an organism have failed and the present system provides a risk averse approach to protecting human health.

Studies have been conducted indicating actions that can be initiated now which can reduce the extent of some closed harvesting areas, or at least slow or halt the overall

increase in closures. By developing an assessment of water quality and shellfish resources in different growing areas, management strategies could be developed in order to protect the designated uses of each growing area (Robinson and Horzepa, 1988). In order to do this, all available information on water quality and shellfish resources in a growing area must be gathered and evaluated. The results of this assessment would be used to establish management goals and objectives for each growing area. This would insure a consistent and defendable framework for use by the various state agencies as they comment on permit applications that may affect coastal water quality.

Reilly and Kirby-Smith (1999) assessed a polluted area in a tributary of North River, Carteret County and developed management strategies to reopen the area. By identifying the sources of pollution and any correlation between fecal coliforms and the physical parameters of the tributary, four different management strategies were considered. These included no action, remove the shellfish from the area, control the sources of fecal coliforms and control the flow of fecal coliforms. It was concluded that controlling the amount of fecal coliform deposited and where it was deposited can be addressed. Increasing exposures of fecals to sunlight and salt along with increasing the amount of time it takes for a fecal coliform to get to the shellfish source can also be addressed.

Management Options/Impacts

A. Status quo

+ No additional funds or staff needed to implement
- Continued degradation of water quality and increased shellfishing closures

B. Increase use of existing statutory authority (permit comments, CHPP development)

+ Makes use of increased authority to protect water quality
+ Ensures coordination with sister agencies
+ Utilizes existing procedures and information
- Based on a system that has failed in the past
- No defined mechanism for restoration of water quality

C. Accept closures and develop new standards for shellfish consumption **(Recommend changes through the Interstate Shellfish Sanitation Conference)**

+ Places little burden on the public
+ Could potentially reopen many areas to shellfish harvest
- Greatly increases potential for water quality problems other than shellfish harvesting closures

- Requires vast modifications to harvesting and marketing rules and enforcement
- Requires a substantial public education effort
- May increase public health risk especially until new consumption habits are learned

D. Develop strategies to restore water quality of Conditionally Approved harvest areas and maintain water quality of Approved harvest areas by:

1. Rating Conditionally Approved Open shellfish waters as Partially Supporting

2. Rating Conditionally Approved Closed shellfish waters as Not Supporting

3. Adopting standards that limit total impervious cover immediately adjacent to SA waters to 10 percent

4. Requiring mitigation that results in water quality enhancements in permanently closed areas

Recommend specific changes to DWQ and the EMC

\+ Would decrease number of acres of shellfish areas closed because of pollution.

\- Would require large amounts of funding and manpower to perform assessments and implement strategies.

DMF Management Recommendation

B. Increase use of existing statutory authority (permit comments, CHPP development).

D. Develop strategies to restore water quality of Conditionally Approved harvest areas and maintain water quality of Approved harvest areas by:

1. Classifying Conditionally Approved Open shellfish waters as Partially Supporting

2. Classifying Conditionally Approved Closed shellfish waters as Not Supporting

3. Adopting standards that limit total impervious cover immediately adjacent to SA waters to 10 percent

4. Requiring mitigation that results in water quality enhancements in permanently closed areas

AC Recommendation

Agreed with DMF (Note: D was changed after the AC made its recommendation)

MFC Selected Management Strategies

Increase use of existing statutory authority (permit comments, CHPP development).

Develop strategies to restore water quality of Conditionally Approved harvest areas and maintain water quality of Approved harvest areas by:

1. Rating Conditionally Approved Open shellfish waters as Partially Supporting

2. Rating Conditionally Approved Closed shellfish waters as Not Supporting

3. Adopting standards that limit total impervious cover immediately adjacent to SA waters to 10 percent

4. Requiring mitigation that results in water quality enhancements in permanently closed areas

9.4.2 Minimizing Effects of Mechanical Clam Harvest

What are the effects of mechanical clam harvest on the habitat and fisheries resources in North Carolina and how do we minimize them? This issue originated from the Oyster and Clam FMP Committee, and DMF staff.

Background

The use of mechanical gear to harvest clams began in 1949 in Core Sound. This dredging method involved loosening and washing bottom sediments with the boat prop and towing an oyster dredge to harvest the clams that were uncovered. By the 1970s, this method of harvest had evolved into today's clam trawling or "kicking" where kick boats utilize deflector plates attached to the bottom of the boat to deflect prop wash toward the bottom. In order for a kick boat to operate efficiently, the propeller must be within a few inches of the bottom. Instead of an oyster dredge, small, heavily chained trawls are towed. Another mechanical gear used to harvest clams is the hydraulic escalator dredge. The use of this gear began in 1968 and utilizes jets of water provided by a high-pressure

pump to remove bottom sediments covering the clams and to move the clams onto a conveyor, which brings the catch to the harvest vessel.

The harvest of clams by these methods is both effective and efficient because it allows the harvest of clams that would otherwise not be harvested by hand because of water depth, weather, or bottom type. However, the ecological impacts of these gears on the bottom and their effects on hard clam recruitment, seagrass biomass, and benthic macroinvertebrates such as scallops and pink shrimp have been questioned. Fisheries regulations prohibit the use of mechanical gear for the harvest of clams in grass beds and live oyster beds because of the destructive nature of these gears. Fisheries regulations also limit mechanical harvest season to the time period between December 1 and March 31 and only allow it in designated harvest areas between Cedar Island and Topsail Beach that do not contain significant grass beds or oyster resources.

Current Authority

North Carolina Fisheries Rules for Coastal Waters
15A NCAC 3K .0302. Mechanical Harvest Season

Discussion

Numerous studies have been conducted on the effects of mobile fishing gear on the benthos. These studies include effects of gear such as otter trawls, beam trawls, scallop dredges, oyster dredges, hydraulic clam dredges and clam trawls. The impacts of these different gears have been studied on habitat types ranging from flat sand and mud bottoms to structured habitats such as piled boulders, live bottom, seagrass, kelpbeds and coral reefs (Dorsey and Pederson 1998; Auster 1998). These studies have shown that mobile fishing gear reduces habitat complexity by smoothing the bottom and removing structures provided by different benthic fauna. Benthic populations that provide food are also removed (Dorsey and Pederson, 1998).

One study of the effects of the otter trawl on a sandy-bottom habitat showed no detectable effect on sediment size. Physical effects of trawling on the sediment and habitat structure were moderate with recovery occurring within a year. In this particular study, the bottom showed an increase in surface relief and roughness (Schwinghamer et al. 1998).

The environmental effects of a hydraulic clam dredge on intertidal beaches on Vancouver Island showed that clam mortality associated with the dredge was estimated to be as high as the harvest itself. Harvesting also resulted in deep trenches, mounds of side castings, a redistribution of substrate material along with an overall instability of the beach (Adkins et al. 1983).

Peterson et al. (1987) tested the impact of clam raking and two different

intensities (light and intense) of clam trawling in a seagrass bed and in a sand flat. An obvious result from their study was that clam harvest caused an immediate reduction of seagrass biomass with an increase in harvest intensity. Seagrass biomass was reduced 25% in the raking and light clam kicking matrix, but full recovery occurred within a year. However, in seagrass beds where "intense" kicking was tested, seagrass biomass decreased by 65%. Recovery of seagrass in this matrix did not begin to occur until two years later. After four years, biomass was still 35% lower than predicted. Bay scallop densities declined with declining seagrass biomass across all harvest treatments. There were fewer scallops than predicted, in the intense kicking matrices, probably due to the increase in patchiness of the remaining seagrass, because juvenile bay scallops attach themselves to seagrass. Adult bay scallops also depend on seagrass beds. There were no effects on densities or species composition of other macroinvertebrates in either the sand flat or the seagrass bed. This is because polychaetes that dominate both habitats have short life spans and can recover rapidly from disturbances. Effects on clam recruitment were somewhat ambiguous although recruitment in the sand flats was lower in the intense clam kicking matrices than in controls. There was no clear response of clam recruitment in the seagrass beds. It was concluded that hard clam fisheries should be managed to minimize the intensity of harvest within seagrass beds.

Current knowledge of fishing gear impacts from the previously mentioned work indicates that mechanical clam harvest gear does have an effect on habitat and some fisheries such as bay scallops. Current management of this fishery, by prohibiting the use of mechanical harvest gear on oyster rock, in seagrass beds, and nursery areas is supported by previous studies. More research is needed to better understand the affects of the use of mechanical gear on sand bottom and clam recruitment.

Management Options/Impacts

A. Status Quo

+ No additional regulation
- Unknown impacts on habitat function of sand bottom along with possible impacts on species diversity of benthic fauna in sand bottom habitat

B. Decrease the amount of area open to mechanical harvest

+ Decrease in amount of habitat affected by mechanical harvest
+ Reduced fishing effort on clam stocks
- Larger number of boats in a reduced area could increase impacts on benthos

C. Shorten mechanical harvest season

+ Shorter amount of time habitat is impacted

+ Longer amount of time habitat can recover
+ Reduced fishing effort on clam stocks
- Reduced income for mechanical harvest fishermen

D. Increase rotation of mechanical harvest in existing sites

+ Decrease amount of habitat affected by mechanical harvest at one time
+ Ability for closed portions of area to recover from harvest impacts
- Larger number of boats in a reduced area could increase impacts on benthos

E. Rotation of current mechanical harvest areas with previously unopened areas (**Rule change required)**

+ Increase in use of underutilized clam resources
+ Ability for closed portions of area to recover from mechanical harvest impacts
+ Unique research opportunity to study impacts of mechanical harvest
- Increase in overall amount of area impacted by mechanical harvest
- Create conflicts between hand harvesters and mechanical harvesters

F. Close all mechanical harvest areas

+ No further impacts by harvest gear on benthos
+ Reduced fishing effort on clam stocks
- Loss of income to mechanical harvest fishermen

DMF Recommendation

B. Increase rotation of mechanical harvest areas within existing sites

After exploratory sampling of the area proposed, DMF changed its recommendation to add SE Pamlico Sound area and rotate with Core Sound.

AC Recommendation

E. Rotation of current mechanical harvest areas with previously unopened areas. **Rule change required**

MFC Selected Management Strategy

Add SE Pamlico Sound area and rotate with Core Sound

9.4.3 Restrict Clam Harvest in Oyster Habitat

Public comments from oyster harvesters indicate that additional restrictions on clam harvest are necessary to protect oyster habitat. This issue originated from the Oyster and Clam FMP Committee, and oyster harvesters.

Background

The effects of harvesting clams by hand methods on and around oyster rocks have been an issue among shellfishermen and the Division for many years. The perception of many oyster harvesters is that clamming on oyster rocks damages oyster habitat. This has been a problem where oysters and hard clams co-exist, principally around the inlets in the northern part of the state and on oyster rocks in the south. The competition for these two resources increased with the beginning of a significant market for North Carolina hard clams in the 1970s which put more pressure on these stocks and, as other areas were depleted of clams harvesters moved to less desirable harvest areas such as oyster rocks. Concurrently, more shellfishing areas, primarily in the southern portion of the state, were closed to harvest because of bacterial contamination in the waters. Additionally, the incidence of dermo and its associated mortality has caused significant decrease in oyster harvest in some years. These factors have combined to compress the harvest of these two species of shellfish into smaller and smaller areas increasing the occurrence of clamming in oyster habitat. There is no current estimate of the magnitude of the impact of the clamming on oyster rocks

The North Carolina General Assembly and the MFC both recognize that clamming can negatively impact oyster habitat. They have adopted statutes and rules that prohibits clam harvest on posted oyster rocks and restricted the harvest of areas and gear which can be used to take clams and oysters. Natural oyster rocks have never been posted on a large scale because of the large number of rocks and the lack of sufficient resources to maintain markers. Difficulties in posting oyster rocks led the Division to create Shellfish Management Areas in which enhancement activities are conducted and clamming is either restricted or prohibited. The MFC has also passed rules regarding the types of equipment that can be used to take both oysters and clams in any live oyster bed as well as prohibiting the taking of oysters and clams by mechanical methods in some areas of the state.

Current Authority

<u>North Carolina Fisheries Rules for Coastal Waters (15 NCAC)</u>

3I.0101 Shellfish Producing Areas defined
3I.0101 Intertidal Oyster Bed defined

3K.0101 Prohibited Shellfish Areas/Activities
3K.0102 Prohibited Rakes
3K.0103 Shellfish/Seed Management Areas
3K.0204 Dredges/Mechanical Methods Prohibited
3K.0304 Prohibited Taking

North Carolina General Statutes

G.S. 113-207 Clamming on posted oyster rocks forbidden; penalty.

Discussion

The harvest of clams by hand methods, rakes, tongs, and by hand on oyster habitat can cause mortality of oysters by turning over and burying live oysters. Studies by Noble (unpublished data) and Lenihan and Micheli (2000) have confirmed and quantified the effects of both oyster and clam harvest on oyster rocks. Lenihan recommended that "both clamming and oyster harvesting should be permitted on some reefs, but maintaining large populations of oysters and clams on intertidal oyster reefs will require protection of some reefs from both types of harvesting".

The ecological merits of oyster habitat are discussed in the Oyster FMP (NCDMF 2001). Large areas of the southern part of the state are closed to the shellfish harvest and the oysters in these areas provide spawning stock as well as fulfill an ecological function of habitat and filtering water in some of these smaller systems. Clams are more economically valuable than oysters and some have questioned the wisdom of closing additional areas to clamming. DMF has reservations about being able to effectively mark and maintain additional oyster habitat given the constraints of time and materials. The closing of additional area to either oyster or clam harvest will further compress these fisheries into a smaller area and increase the social conflicts that currently exist.

Management Options/Impacts

A. Status quo

+ No statutory or rule changes required
+ No additional impact on clam fishery
- Continued damage to oyster rocks from clamming

B. Implement additional experimental closures of oyster areas based on habitat value for both oysters and clams.

+ No statutory or rule changes required
+ Positive effect on oyster and clam populations
+ Positive effect on oyster habitat

- Negative impact on oyster and clam fisheries

C. Provide additional protection of oyster rocks from clamming by modifying allowable gear, seasons and/or closing additional area. **(Rule changes required)**

+ Reduction or elimination of damage to oysters from clamming activities
+ Positive impact on oyster fishery
+ Positive impact on habitat value
- Negative economic impact on clam fishery
- Increased enforcement problems
- Lack of funds to mark and maintain these areas

DMF Recommendation

B. Implement additional experimental closures of oyster areas based on habitat value for both oysters and clams.

This would be initiated as a pilot project because of personnel and budget constraints and to test the concept.

AC Recommendation

Agreed with DMF recommendation

MFC Selected Management Strategy

Implement additional experimental closures of oyster areas based on habitat value for both oysters and clams.

This would be initiated as a pilot project because of personnel and budget constraints and to test the concept.

9.4.4 Increasing Clam Production by Stock and Habitat Enhancement, and the Creation of Spawning Sanctuaries to Increase Clam Production

Should DMF create hard clam spawning sanctuaries, enhance hard clam stock, and/or enhance habitat for hard clams in order to increase hard clam production? This issue originated from the oyster and Clam FMP Committee.

Background

Enhancing shellfish resources has been a popular method for increasing abundance of oysters and clams on public bottom. Oyster enhancement practices have

occurred since the mid 1800s when oystermen would transplant seed oysters to 'growout' areas and plant cultch to attract oyster spat. Planting seed clams to increase hard clam abundance was first considered in the early 1900s. Enhancing shellfish resources is a popular management strategy in several northern states such as New York and New Jersey. It is supported by the public because it is seen as an active solution to low stock abundance and is favored by the fishermen over restrictive harvest limits (Kassner 1994). North Carolina began practicing habitat enhancement for oysters in 1915 and on an annual basis since 1947.

Shellfish enhancement is based on the theory that the environment is not at carrying capacity because of different factors affecting the clam stock. These factors include biological conditions and environmental conditions. Enhancement increases the population by counter-acting or eliminating these conditions. Unfortunately, those factors that may be causing low stock abundance could also affect the enhancement measure being used. When natural abundance is high, enhancement may be successful, but when natural abundance is low and enhancement is needed most, enhancement may not be successful (Kassner 1994).

There are several different methods of enhancement. These include spawning sanctuaries, spawner relays and transplants, planting seed clams and habitat enhancement.

Current Authority

General Statutes of North Carolina
G. S. 113-204. Propagation of shellfish

Discussion

The concept of "spawning sanctuaries" has been around since the early 1960s when spawning sanctuaries were established in Long Island Sound, New York. Sanctuaries have also been established in New Jersey. Because clams from cooler waters spawn later than those in warmer waters, the practice of establishing spawning sanctuaries by transplanting adult clams from cooler waters and placing them in warmer waters will increase the length of time larvae are in the water. This rationale is based on the fact that reproductive success of the hard clam is dependent on the co-occurrence of larvae and suitable environmental conditions. Therefore the longer larvae are in the water, the greater the chance it will find suitable conditions (Kassner and Malouf 1982; McCay 1988; Kassner 1994). Because of their high fecundity and low value, chowders are best suited for transplanting to spawning sanctuaries. Selecting a site suitable for a spawning sanctuary is also crucial, in that the success of a spawning sanctuary is dependent on the settling ability of the larvae. However, there are several things to consider when establishing a spawning sanctuary. These include the ability to predict when clams are ready to spawn, in order to transplant at the appropriate time. Other things to consider are the selection of a suitable site that will insure settlement is also

very difficult because of the lack of knowledge of circulation and dispersal of larvae. It is also difficult to determine whether the quantitative contribution from a spawner transplant is worth the time, effort and money. Because of high mortality of larvae and an inconsistent relationship between number of larvae and number of clams that survive to recruitment, contribution to the overall abundance of the clam population is possibly very low (Kassner and Malouf 1882; McCay 1988).

Stock enhancement by seeding public bottom is another possible method for increasing the abundance of hard clams in North Carolina. Predation is the biggest cause of mortality in the culture of hard clams. In order to exclude predators that occur in an aquaculture operation, materials such as shell, rock, or mesh covers are placed over the culture site. This is a major expense for the aquaculturist. Even then, high mortality may still occur. However, it may be feasible to stock public bottom if the following variables are considered. These include the size of the seed clams, time of the plantings, density of the plantings and planting in proper habitat in traditionally productive sites. It may then be possible to minimize predation of the seed. Peterson et al. (1995) demonstrated 35% seed clam survival by stocking public bottom with large seed clams during the fall/winter at low densities (1 clam/meter^2) in shell hash or seagrass beds in traditionally productive areas.

Habitat enhancement may also be considered to increase hard clam abundance. Increasing the amount of favorable clam habitat by planting shell could increase the amount of productive clam bottom. It is well known that clams prefer sandy shell bottom and seagrass beds. The North Carolina Oyster Rehabilitation Program (now the Shellfish Rehabilitation Program) has been planting different shell types for oyster enhancement since 1947. Although the program was initially designed for oyster enhancement, clams have also benefited from the program. Surf clam shell (*Spisula solidissima*) appeared to increase hard clam abundance in Newport River (Mike Marshall, NCDMF, pers. com.). A pilot study comparing oyster cultch and surf clam cultch has been initiated to document this observation. Preliminary results from year one of this study are inconclusive because of low regional spatfall in Core Sound (NCDMF, unpublished data).

Management Options/Impacts

A. Status Quo

+ No additional expenditure of state funds.
- No possibility of increasing hard clam stocks in North Carolina
- No possibility of increasing production by the fishery

B. Create Spawner Sanctuaries

+ Protects spawning individuals
+ Increases the abundance of spawning individuals

+ Increases the chance of reproductive success
+ Possibility of increasing stock abundance
- Site selection is difficult
- Possibility of not increasing stock abundance because of poor environmental conditions may offset the gains from increased spawning

C. Stock enhancement by planting seed clams

+ Possibility of increasing stock abundance
- Expensive
- Site selection may be difficult until procedures are established
- Possibility of not increasing stock abundance because of high predation

D. Habitat enhancement by planting shell and other material

+ Possibility of increasing stock abundance
+ Popular with the public
+ Creates additional habitat for other commercially and recreationally important species
+ Already has established enhancement program for oysters using similar methods
- Site selection may be difficult until procedures are established
- Possibility of not increasing stock abundance due to variability in larval settlement/environmental conditions

E. Examine methodologies to potentially enhance clam populations by planting seed clams in combination with habitat enhancement

+ Possibility of increasing stock abundance
+ Popular with the public
+ Create additional habitat for other commercially and recreationally important species
- Expensive
- Site selection may be difficult
- Possibility of not increasing stock abundance because of poor environmental conditions
- Still may have high predation of seed

DMF Recommendation

D. Habitat enhancement by planting shell and other materials; and progress to

E. Examine methodologies to potentially enhance clam populations by planting seed clams in combination with habitat enhancement.

AC Recommendation

Agreed with DMF

MFC Selected Management Strategies

Habitat enhancement by planting shell and other materials; and progress to Examine methodologies to potentially enhance clam populations by planting seed clams in combination with habitat enhancement

10.0 RECOMMENDED MANAGEMENT STRATEGIES AND RESEARCH NEEDS

The following recommended management program for hard clams in North Carolina are based on the recommendations of the DMF, the Oyster and Clam AC and the MFC. Each proposed action is followed by a reference to the section where it is discussed (9.1.1) and the objective(s) listed in section 4.2.5 that each action addresses.

Research needs are also listed in this section. All new work and expansion of programs will require additional personnel and operating funds.

10.1 Optimum Yield

Based on the discussion in section 5.2 Stock Status, it is recommended that the hard clam fishery be allowed to harvest at current catch/trip limits with the exception of Core Sound. It is recommended that Core Sound mechanical bag limits be lowered from 25 bags to 20 bags per vessel per day. It is also recommended that Core Sound be closed to mechanical harvest and rotated with the proposed area in Southeast Pamlico Sound. This proposed area would also have a bag limit of 20 bags per vessel per day. This rotation scheme will allow Core Sound hard clam populations to recover while allowing harvest of an underutilized clam resource in Southeast Pamlico Sound.

It is also recommended that a harvest cap **not** be put in place until regional populations can be ascertained and available data indicate such a change is necessary.

10.2 Insufficient Data

This issue deals with the lack of fisheries data on the hard clam. Because trip ticket data alone can be biased by market demand, water quality, and gear efficiency, more detailed data are needed

10.2.1 Proposed Actions

- Expand Shellfish Mapping Program (5.3.1) [1,3]
- Expand catch/effort sampling of hard clam catches. (5.3.1) [1,3]
- Develop a fishery independent sampling program to determine population abundance. (5.3.1) [1,3]
- Support adoption of a mechanism that would provide data on recreational shellfish harvest and add “pleasure” category to the existing shellfish license (9.1.1) [3,6,8].

10.2.2 Research Needs

- Determine which regions in North Carolina have discreet populations.

10.3 Management Strategies

10.3.1 Proposed Actions

- Continue to relay oysters as normal and increase the intensity of the recent clam relay schedule. (9.2.1)[6,7].
- Rotate Southeast Pamlico Sound area with Core Sound and lower the bag limit in Core Sound to 20 bags. Pamlico Sound area bag limit would also be 20 bags. (9.2.2, 9.2.3, 9.4.2)[1, 2, 3, 4, 6]
- Continue to allow all NC residents to purchase a shellfish license. (9.2.4)[3, 8]
- Leave unloading rule as is. (9.2.5)[6]

10.3.2 Research Needs

- Evaluate the amount of harvest that can occur without affecting spawning stock in areas harvested with mechanical gear.
- Evaluate effects and recovery of areas opened to mechanical gear.
- Analysis of trends in the license universe and trip ticket data to indicate increases in effort

10.4 Private Culture

10.4.1 Proposed Actions

- Retain the statutory shellfish lease program (9.3.1) [6,8]
- Increase public bottom shellfish relay (9.3.1) [5,6,8]
- Utilize user coordination plans for shellfish lease issuance. (9.3.2) [3,6,8]
- Recommend adoption of a statutory policy statement supporting shellfish culture. (9.9.3) [6]
- Require harvest and sale of 10 bushels of shellfish per acre per year AND planting effort of 50 bushels of cultch or 25 bushels of seed per year to maintain lease production. (9.3.3) [1,6,8]
- Set fees for water column leases at four times bottom lease fees. (9.3.3) [6,8]
- Require shellfish culture training certification for new lease applicants. Grandfather existing leaseholders that meet production requirements. (9.3.3) [6,8]
- Apply FRA requirements to an organized, upgraded permit system and reconsider license/permit system specifically for shellfish at scheduled FMP review which will coincide with the new license system implementation schedule. (9.3.4) [3,6,8]
- Affirm recommendations of the State Auditor [$200 Application fee; $100

renewal fee; $10 rental fee]. (9.3.5) [6,8]

- Change shellfish lease contract expiration date and recommend same to the Joint Legislative Commission on Seafood and Aquaculture. (9.3.5) [6,8]
- Designate and plant managed seed bed areas for subsequent relay to leases (9.3.6) [1,5,6,8]
- Request funding for research, disease, and education centers for shellfish culture. (9.3.6) [2,5,9,10]
- Change operational policy and rules to increase lease use of marginal polluted areas.(9.3.7) [6,8]
- Inform the public about agency roles concerning aquaculture. (9.3.8) [6]
- Continue to not allow harvested shellfish to be processed in a depuration plant unless clams will be lost to the fishery due to dredging. (9.3.9) [1,6]
- Continue to record clam production units as bushels. (9.3.10) [6]
- Formalize/amplify policy and send to vendors. (9.3.11) [6]

10.4.2 Research Needs

- Quantify effects of shellfish habitat and the benefits of establishing shellfish sanctuaries.
- Examine the cost:benefit ratio of relaying shellfish to public
- Examine recovery rates of harvested relay areas for different areas of the coast.
- Determine the effects of relay on hard clam mortality.
- Expand human use mapping and shellfish mapping to provide coastwide data.
- Determine areas for block leasing by user coordination studies in various areas.
- Develop a protocol for defining BMP's among water bodies with differing production capacities and differing hydrological dynamics.
- Determine ecological benefits from shellfish mariculture activities. Develop an Internet or correspondence training course for certification or re-certification of shellfish culturists.
- Determine most effective seedbed shell planting areas, timing of plants and protocol for shellfish larvae and spatfall.
- Research and develop appropriate extensive and intensive shellfish culture methods, improve genetics and disease resistance of cultured stocks and perform biological monitoring and support services to growers
- Stock assessments of clams located in polluted areas geographically to determine if a depuration operation would be feasible and aid in sizing the facility.
- Review current depuration programs in other states.

10.5 Habitat and Water Quality

10.5.1 Proposed Actions

- Increase use of existing statutory authority (permit comments, CHPP development). (9.4.1)[6,7]
- Develop strategies to restore water quality of Conditionally Approved harvest areas and maintain water quality of Approved harvest areas by:
  - Rating Conditionally Approved Open shellfish waters as Partially Supporting
  - Rating Conditionally Approved Closed shellfish waters as Not Supporting
  - Adopting standards that limit total impervious cover immediately adjacent to SA waters to 10 percent
  - Requiring mitigation that results in water quality enhancements in permanently closed areas. (9.4.1) [1,6,7]
- Recommend specific changes to DWQ and the EMC. (9.4.1) [1,6,7]
- Implement additional experimental closures of oyster areas based on habitat value for both oysters and clams. (9.4.3) [2,4]
- Enhance clam habitat by planting shell and other material. (9.4.4) [5,9]
- Examine methodologies to potentially enhance clam populations by planting seed clams in combination with habitat enhancement. (9.4.4) [2,5]

10.5.2 Research Needs

- Continue research on means and methods for reduction of non-point source pollution and mitigation of pollutant effects in the estuary.
- Develop better data bases and database management to enable to quantify use ratings
- Determine impacts of clam trawls and escalator dredges on sandy bottom environments.
- Determine effects of clam recruitment and clam mortality by mechanical harvests.
- Determine water circulation in different waterbodies studies.
- Evaluate site selection protocols for best planting sites
- Determine effects of transplanting spawners.
- Determine contribution of different enhancement strategies
- Examine methodologies to reduce predation, increase seed planting efficiencies
- Perform cost analyses as needed.

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12.0 ATTACHMENTS