

Fishery Management Plans

May 2025 Quarterly Business Meeting

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DECISION DOCUMENT

Estuarine Striped Bass Fishery Management Plan Amendment 2 Central Southern Management Area Data Evaluation



This Decision Document provides background information for Amendment 2 to the N.C. Striped Bass Fishery Management Plan and the adaptive management steps prescribed for the Central Southern Management Area stocks.

May 2025

Summary

Estuarine striped bass (*Morone saxatilis*) in North Carolina are managed under Amendment 2 to the North Carolina Fishery Management Plan (FMP) adopted in November 2022 and its subsequent revision (2024). Striped bass stocks in North Carolina are managed jointly by the North Carolina Marine Fisheries Commission (MFC) and the North Carolina Wildlife Resources Commission (WRC). Amendment 2 management for the Tar-Pamlico and Neuse rivers stocks carried forward the Supplement A no-possession measure, maintained the gill net closure above the ferry lines, and maintained the use of 3-foot tied-downs below the ferry lines. The Amendment 2 adaptive management framework for the Tar-Pamlico and Neuse rivers stocks prescribes that in 2025, data through 2024 will be reviewed to determine if populations are self-sustaining and if sustainable harvest can be determined. In addition, the gill net prohibition was maintained to be able to assess its performance”.

Amendment 2 Goal and Objectives

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

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

Background

There are two estuarine striped bass management units and four stocks in North Carolina. The Northern Management Unit includes the Albemarle Sound Management Area (ASMA) and Roanoke River Management Area (RRMA). The striped bass stock in these management areas is the Albemarle-Roanoke (A-R) stock. The A-R stock is also included in the management unit of Amendment 7 to the Atlantic States Marine Fisheries Commission

(ASMFC) Interstate FMP for Atlantic Striped Bass. The Southern Management Unit is the CSMA and includes the Tar-Pamlico, Neuse, and Cape Fear rivers stocks.

CSMA Stock Status

Stock status of the CSMA striped bass is unknown, no stock status determination has been performed, and no biological reference points have been generated. The [CSMA Estuarine Striped Bass Stocks](#) report, completed in 2020, is a collection of 1) all data that have been collected, 2) all management effort, and 3) all major analyses that have been completed for CSMA stocks to serve as an aid in development of Amendment 2. While this report does not determine stock status, it does indicate sustainability of Tar-Pamlico and Neuse rivers stocks is unlikely at any level of fishing mortality, lack of natural recruitment is the primary limiting factor, and without stocking abundance will decline.

Supplement A

At the November 2018 MFC business meeting, the division [recommended development](#) of temporary management measures to supplement the FMP providing for a no-possession provision for striped bass in the internal coastal and joint waters of the CSMA to protect important year classes of striped bass while Amendment 2 to the N.C. Estuarine Striped Bass Fishery Management Plan was developed. [Supplement A](#) to the Estuarine Striped Bass FMP was [adopted](#) by the MFC at their February 2019 business meeting and by the WRC in March 2019. Supplement actions implemented March 29, 2019, consisted of the following:

- Commercial and recreational no possession measure for striped bass (including hybrids) in coastal and inland fishing waters of the CSMA ([Proclamation FF-6-2019](#)). The WRC hook and line closure proclamation had the effect of suspending rules 15A NCAC 10C .0107 (l) and 10C .0314 (g). A no-possession requirement already exists in the Cape Fear River by rule.
- Consistent with [Amendment 1](#), commercial anchored gill-net restrictions requiring tie-downs and distance from shore measures will apply year-round.

Ferry Line Gill Net Closures

See Figure 1 for gill net restrictions in the Pamlico, Pungo, Bay, and Neuse rivers in place prior to implementation of the ferry line gill net closures

Independent of Supplement A but also at the February 2019 MFC business meeting, the following [motion passed](#):

“Ask the director of NCDMF to issue a proclamation, effective in conjunction with the Supplement, that restricts the use of gill-nets that interact with striped bass upstream of the ferry lines and requires attendance of gill-nets that interact with striped bass upstream of the tie-down lines.”

After [careful consideration](#), the director declined the motion request, concluding the scientific data did not support the requested management measure.

On March 13, 2019, the [MFC held an emergency meeting](#) and passed a [motion](#) directing the director to issue a proclamation regarding gill nets, beyond what was contained in Supplement A. [Proclamation M-6-2019](#) implemented the following:

- Prohibits the use of all gill nets upstream of the ferry lines from the Bayview Ferry to Aurora Ferry on Pamlico River and the Minnesott Beach Ferry to Cherry Branch Ferry on the Neuse River.
- Maintains tie-down (vertical height restrictions) and distance from shore restrictions for gill nets with a stretched mesh length 5 inches and greater in the western Pamlico Sound and rivers.

[North Carolina General Statute section 113-221.1\(d\)](#), authorizes the Chair of the MFC to call an emergency meeting (pursuant to the request of five or more MFC members) to review the desirability of directing the fisheries director to issue a proclamation. Once the MFC votes under this provision to direct issuance of a proclamation, the fisheries director has no discretion to choose another management option and is bound by law to follow the MFC decision. In these cases, under existing law, the decision of the MFC to direct the director to issue a proclamation is final and can only be overruled by the courts.

Amendment 2

[Amendment 2](#) management measures for the Tar-Pamlico and Neuse rivers stocks carried forward the Supplement A no-possession measure. Amendment 2 also maintained the gill net closure above the ferry lines and the use of 3-foot tie-downs. The draft of Amendment 2 presented to the MFC at their February 2022 business meeting included discussion of the ferry line gill net closures and options that would have provided limited access for the gill net fishery above the ferry lines while continuing to minimize striped bass discards. However, [at that meeting](#), the MFC approved a [motion](#) to send the draft Estuarine Striped Bass FMP Amendment 2 for review by the public and advisory committees with the change of deleting these options. Therefore, the only option considered by the public, Advisory Committees, and MFC related to the ferry line gill net closure in Amendment 2 was to maintain it.

[The Amendment 2 CSMA adaptive management framework](#) prescribes in 2025, data through 2024 will be reviewed to determine if populations are self-sustaining and if sustainable harvest can be determined. In addition, the approved [motion](#) included language to: “maintain the gill net prohibition through 2024 to allow for assessment of its performance”.

Adaptive Management

Adaptive management allows managers to adjust management measures as new information or data becomes available. Management options which are selected during FMP adoption account for the most up to date data on the biological and environmental factors which affect the stock. After FMP adoption, data through 2024 will be reviewed in 2025. Trends in key population parameters like adult abundance, age structure, natural recruitment, and hatchery contribution will be evaluated to determine the impact of the

2019 no-possession provision on the stocks. Analysis will also consider environmental conditions (e.g., river flow), changes to stocking strategies, and new life history information.

If the data review suggests continuing the no-possession provision is needed for stock recovery, no changes in harvest management measures will be recommended until the next FMP Amendment is developed. Adaptive management may be used to adjust management measures including area, time, and gear restrictions if it is determined additional protections for the stocks are needed.

If analysis indicates the populations are self-sustaining and a level of sustainable harvest can be determined, recommendations for harvest strategies will be developed. Conversely, if analysis indicates biological and/or environmental factors prevent a self-sustaining population, then, consistent with the goal of Amendment 2, alternate management strategies will be developed that provide protection for and access to the resource.

Next Steps and Timeline

Division staff began reviewing Tar-Pamlico and Neuse rivers striped bass data at the beginning of 2025 and will present final data analysis at the August 2025 MFC business meeting. Trends in key population parameters like adult abundance, age structure, natural recruitment, and hatchery contribution will be evaluated to determine the impact of the 2019 no-possession provision on the stocks. Analysis will also consider environmental conditions (e.g., river flow), changes to stocking strategies, and new life history information.

The analysis will address whether the Tar-Pamlico and Neuse rivers stocks are self-sustaining, and dependent on results, will present recommendations for management strategies that provide additional stock protections or alternate management strategies that provide protection for and access to the resource. The analysis will also evaluate effectiveness of the ferry line gill net closures at increasing striped bass abundance.

There is no action for the MFC in May 2025 but there will be actions for the commission to consider regarding Tar-Pamlico and Neuse rivers striped bass management and the ferry line gill net closures at future business meetings.

Timeline

(gray indicates completed step)

Supplement A to Amendment 1 adopted	March 2019
Ferry Line Gill Net Closure implemented	March 15, 2019
Amendment 2 adopted	November 2022
Division begins data review	January 1, 2025
Division provides background to MFC - NO ACTION	May 21 - 23, 2025
Division presents data analysis/conclusions/recommendations to MFC	August 2025

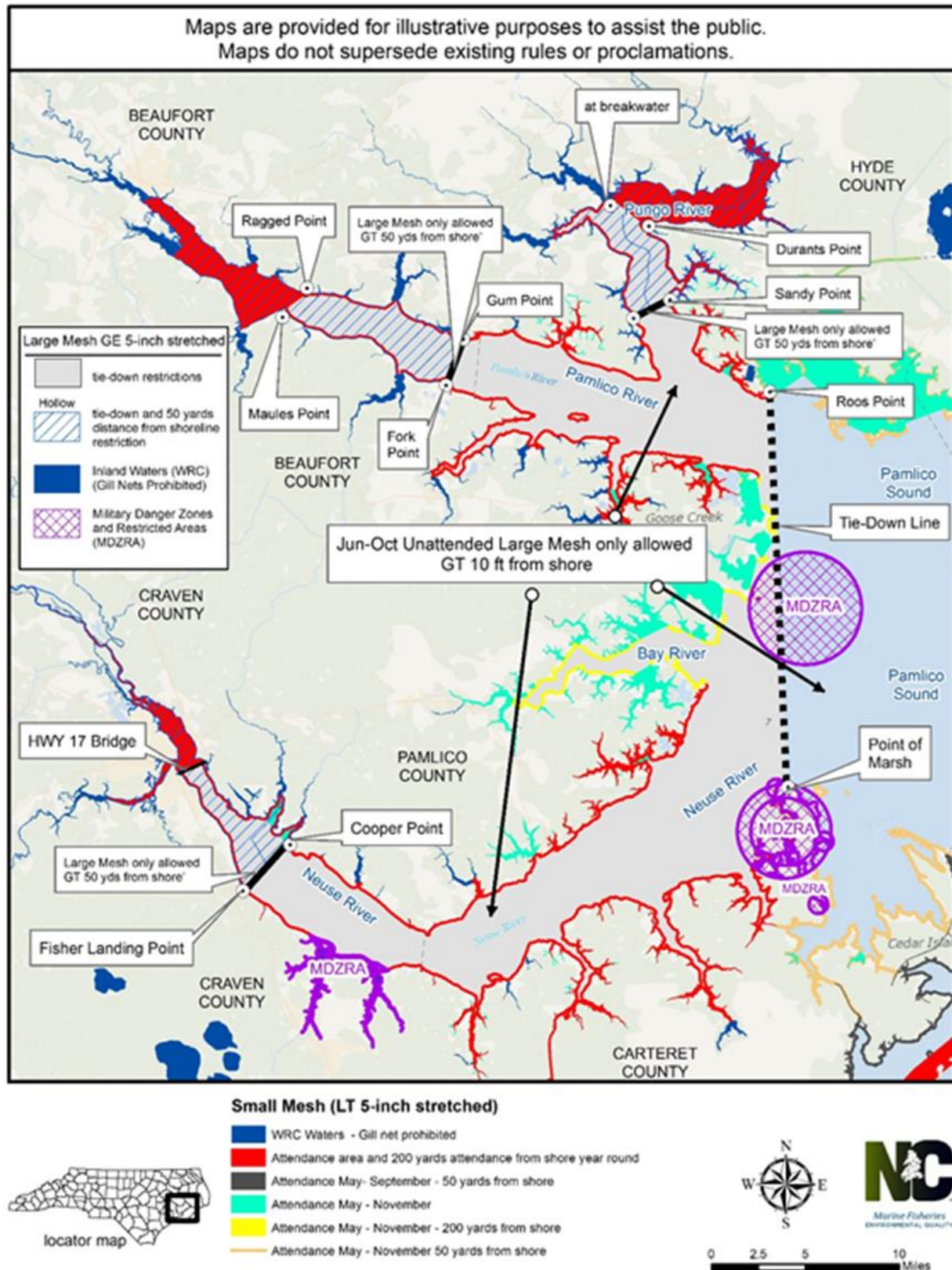


Figure 1. Gill-net regulations for small and large mesh gill nets in the Pamlico, Pungo, Bay, and Neuse rivers.

NC Marine Fisheries Commission

Blue Crab Fishery Management Plan

May 2025 Quarterly Business Meeting

Documents

Blue Crab Decision Document

DECISION DOCUMENT

Blue Crab Fishery Management Plan

Amendment 3 Adaptive Management



This document was developed to help the MFC track previous activity and prepare for upcoming actions for Blue Crab FMP Amendment 3 Adaptive Management.

May 2025

Summary

Amendment 3 to the N.C. Blue Crab Fishery Management Plan (FMP) was adopted in February 2020 and is nearly halfway through the legislatively mandated 10-year stock rebuilding period with little evidence suggesting management measures have been successful in ending overfishing or achieving sustainable harvest. The intent of the Amendment 3 adaptive management framework is to allow for management changes if measures are or are not meeting objectives. Because Amendment 3 management measures have been unsuccessful in ending overfishing or achieving sustainable harvest, the adaptive management framework will be used to implement management measures projected to reduce fishing mortality (F) closer to the F target and rebuild the spawning stock closer to the spawner abundance target with greater than 50% probability of success.

Amendment 3 Background

As part of [Amendment 3 to the North Carolina Blue Crab FMP](#) a benchmark [stock assessment](#) was undertaken using data from 1995–2016. Based on assessment results, the N.C. blue crab stock was overfished and overfishing was occurring in 2016.

The North Carolina Fishery Reform Act of 1997 requires the State specify a time period not to exceed two years to end overfishing and achieve a sustainable harvest within 10 years of the date of adoption of the plan. To meet this requirement, a minimum harvest reduction of 0.4% (in numbers of crabs) was projected to end overfishing and a harvest reduction of 2.2% was projected to achieve sustainable harvest and rebuild the blue crab spawning stock within 10 years with a 50% probability of success (Table 1).

Table 1. Catch reduction projections for varying levels of fishing mortality (F) and the probability of achieving sustainable harvest within the 10-year rebuilding period defined in statute. Bolded row is minimum required harvest reduction.

F (yr-1)	Catch Reduction (%)	Probability of achieving sustainable harvest within 10 years (%)	Comments
1.48	0.0	31	2016 average F from stock assessment
1.46	0.4	45	Catch reduction to meet F threshold and end overfishing
1.40	1.7	46	Catch reduction to meet spawner abundance threshold and end overfished status
1.38	2.2	50	Catch reduction to meet minimum statutory requirement for achieving sustainable harvest
1.30	3.8	67	
1.22	5.9	90	Catch reduction to meet F target
1.10	9.3	96	
1.00	12.3	100	
0.90	15.7	100	
0.80	19.8	100	Catch reduction to meet spawner abundance target
0.70	24.3	100	

At their February 2020 business meeting the MFC adopted Amendment 3 to the FMP with the following management strategies to end overfishing and achieve sustainable harvest in the blue crab fishery:

- North of the Highway 58 Bridge: A January 1 through January 31 closed season.
- South of the Highway 58 Bridge: A March 1 through March 15 closed season.
- A 5-inch minimum size limit for mature female crabs statewide.
- Replacing the current pot closure period and remaining closed in entirety (could not be reopened early).
- Maintain the prohibition on harvest of immature female hard crabs statewide.
- Maintain the 5% cull tolerance established in the 2016 Revision to Amendment 2.
- Adopt proposed adaptive management framework and allow measures to be relaxed if the assessment update indicated the stock was not overfished and overfishing was not occurring and recommend updating the stock assessment once 2019 data is available.

The adopted management provided an estimated 2.4% harvest reduction with a 50% probability of achieving sustainable harvest. This reduction was just above the statutorily required minimum (2.2% reduction), but below the harvest reduction level needed to reduce F to the target (5.9% reduction) and the reduction needed to increase spawner abundance to the target (19.8% reduction; Table 1).

Amendment 3 management strategies have been fully in place since January 2021. Amendment 3 also maintained all measures implemented with the [May 2016 Revision to the Blue Crab FMP](#). A summary of all management measures in place through Amendment 3 can be found in [Amendment 3](#), the annual [FMP Update](#) or in the [Amendment 3 flyer](#).

Amendment 3 Adaptive Management

1. Update the stock assessment at least once in between full reviews of the FMP, timing at the discretion of the division
 - a. If the stock is overfished and/or overfishing is occurring or it is not projected to meet the sustainability requirements, then management measures shall be adjusted using the director's proclamation authority
 - b. If the stock is not overfished and overfishing is not occurring, then management measures may be relaxed provided it will not jeopardize the sustainability of the blue crab stock
2. Any quantifiable management measure, including those not explored in this paper, with the ability to achieve sustainable harvest (as defined in the stock assessment), either on its own or in combination, may be considered
3. Use of the director's proclamation authority for adaptive management is contingent on:
 - a. Consultation with the Northern, Southern, and Shellfish/Crustacean advisory committees
 - b. Approval by the Marine Fisheries Commission

Upon evaluation by the division, if a management measure adopted to achieve sustainable harvest (either through Amendment 3 or a subsequent Revision) is not working as intended, then it may be revisited and either: 1) revised or 2) removed and replaced as needed provided it conforms to steps 2 and 3 above.

Post Amendment 3 Stock Assessment Update

Following full implementation of Amendment 3 management measures in 2021, DMF monitoring programs continued to observe historically low [commercial landings](#), coupled with continued [low abundance of all blue crab life stages](#) (e.g., male and female juveniles, male and female adults, mature females). In response to stock concerns expressed by commercial crabbers and continued poor trends in abundance since adoption of Amendment 3, the DMF began [updating the stock assessment](#) with data through 2022. [Results](#) of the model update indicate the magnitude and trends for estimated recruitment, female spawner abundance, and fishing mortality were similar to the benchmark assessment (Figure 1); however, the Maximum Sustainable Yield (MSY) based reference points used to determine stock status for both female spawner abundance and fishing mortality changed drastically (Figures 2-3).

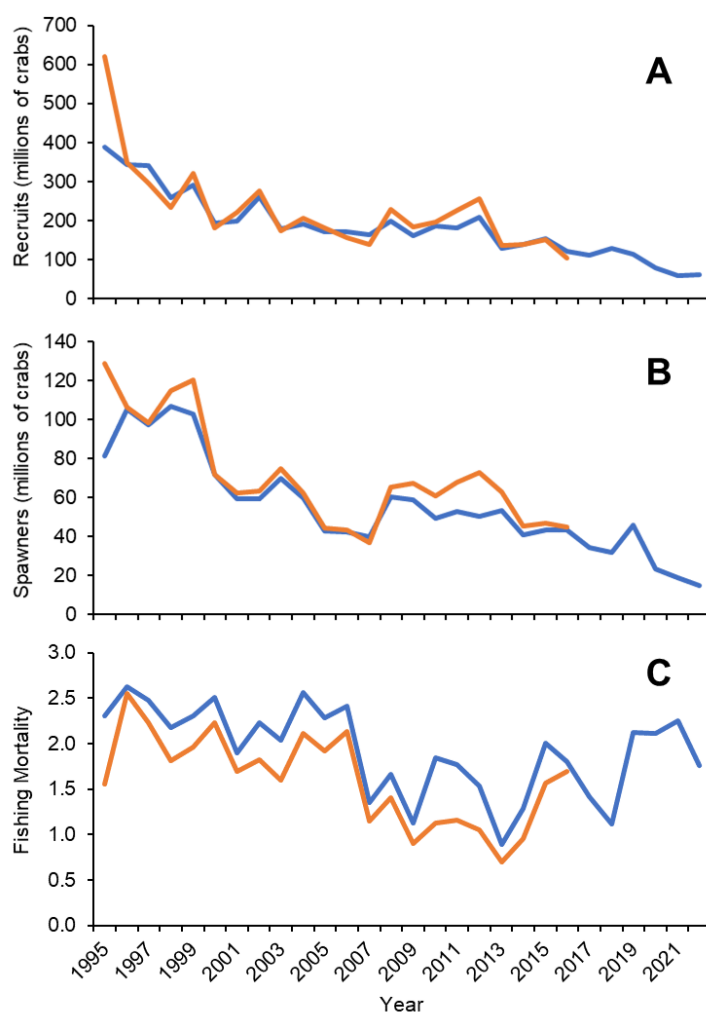


Figure 1. Comparison of estimates of (A) total recruitment, (B) female spawner abundance, and (C) fishing mortality between the 2023 stock assessment update (blue line) and the 2018 benchmark stock assessment (orange line).

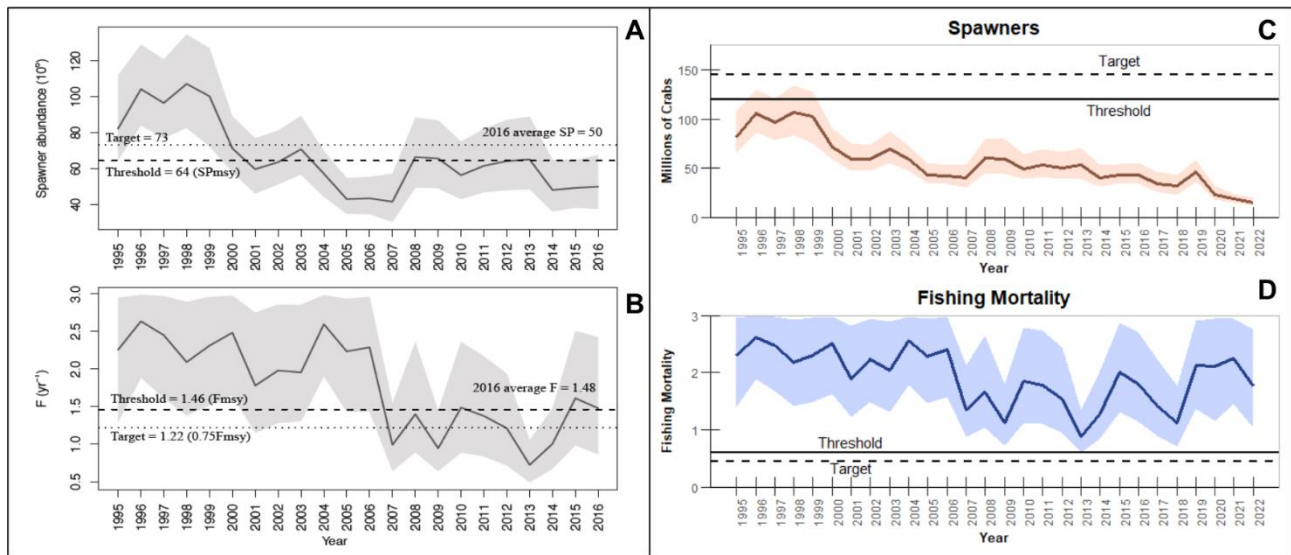


Figure 2. Annual estimates of (A) mature female spawner abundance and (B) fishing mortality relative to associated reference points from the 2018 benchmark stock assessment. Annual estimates of (C) mature female spawner abundance and (D) fishing mortality relative to associated reference points from the 2023 stock assessment update.

Due to the magnitude of the change in reference points, an external review of the assessment update was completed in late December 2023. Reviewers identified concerns with model specifications and results and strongly recommended resolving these issues before basing any management decisions solely on the assessment update. Suggestions provided by reviewers can only be incorporated with a new benchmark stock assessment. Given concerns with the assessment update identified by the DMF and external peer reviewers, **the DMF does not recommend using results of the 2023 stock assessment update to inform management.** Recommending against using the stock assessment update for management purposes does not invalidate the benchmark stock assessment or the data sources used in the model.

Declines in the North Carolina blue crab stock are not unique, as blue crab stocks in other Atlantic coast states have declined similarly. In January 2023 the South Carolina Department of Natural Resources released a [status report](#) for the South Carolina blue crab fishery. The report concluded the South Carolina blue crab stock has been in decline for nearly two decades and provided recommendations to prevent overharvesting, gradually reduce fishing pressure, prevent overexploitation, and strengthen enforcement capabilities. Concerns for the [Chesapeake Bay blue crab stock have also persisted](#). While the Chesapeake Bay blue crab stock is not depleted and overfishing is not occurring, juvenile abundance remains low. Precautionary management, focusing on protecting mature females and juveniles, has been recommended for the Chesapeake Bay stock and a benchmark stock assessment has been started to better understand the population.

Management Measures and Preliminary Recommendations

Size limits are used to rebuild or protect a portion of the spawning stock. Currently, male and mature female hard crabs are subject to a 5-inch minimum carapace width (CW) statewide (harvest of immature females is prohibited).

Because a minimum size limit is already in place for blue crabs, and because achieving necessary harvest reductions through size limit changes alone is unlikely, management options for increasing the minimum size limit or establishing a maximum size limit were not developed.

Prohibiting Crab Trawling prevents harvest from a gear that primarily harvests female crabs prior to the spawning season. Most crab trawl harvest occurs from December through April and is highly variable from year to year. Due to location and time of year crab trawls operate, most crabs harvested by crab trawls are females of lower market value that are caught just prior to spawning. Even at its peak, crab trawls accounted for a small percentage of overall blue crab landings. For example, in 2023 crab trawls accounted for 0.6% of all hard blue crab landings. There is often conflict between the crab trawl and crab pot fisheries and while the crab trawl fishery does not currently have a lot of participants, further growth of this fishery may be detrimental to the crab stock.

Seasonal Closures can be used to reduce overall harvest by restricting harvest during specific times of the year. Amendment 3 implemented a January 1–31 closure in areas north of the Highway 58 bridge to Emerald Isle and a March 1–15 closure in areas south of the Highway 58 bridge to Emerald Isle.

Life Stage Closures and Limits are used to limit harvest of specific life stages (e.g., immature females, sponge crabs, etc.). Amendment 3 maintained the prohibition on harvest of immature female hard blue crabs and harvest of dark sponge crabs from April 1–30. The intent of prohibiting harvest of immature female blue crabs is to allow immature females the opportunity to mature and spawn before being subject to harvest. Prioritizing the reproductive potential of female crabs through life-stage closures serves as a proactive investment to the sustainability of the blue crab population. This strategy not only fosters increased abundance within the crab population but likely contributes to higher recruitment.

Trip or Bushel Limits limit catch while continuing to allow harvest opportunities. Maryland and Virginia each manage blue crab harvest with some form of a trip limit in combination with other measures.

Preliminary Recommendations

Current management of the North Carolina blue crab fishery recognizes the conservation value of protecting mature female crabs by prohibiting harvest of dark sponge crabs from April 1–30 and by establishing crab spawning sanctuaries (CSS) at all coastal inlets. The purpose of the CSS is to protect mature females in these areas prior to and during the spawning season, though limited sanctuary size and other factors limit their effectiveness. Season closures and life stage harvest limits can be used to enhance the effectiveness of the existing CSS by providing broader protections.

The comprehensive blue crab management program in Chesapeake Bay prioritizes protection of mature female blue crabs. Virginia has implemented [extensive blue crab spawning sanctuaries](#) where the harvest of blue crab is seasonally prohibited, and Maryland has implemented [seasonal bushel limits for mature female crabs](#). Preferentially protecting mature female blue crabs in the Chesapeake Bay, allowed for [recovery of the blue crab stock](#) from low levels in the 2000's while allowing for [consistent commercial harvest](#). While the Chesapeake Bay blue crab stock has declined recently, it is [not depleted and overfishing is not occurring](#), though continued protection of mature females as well as immature blue crabs has been recommended.

Given these considerations, initial management options focus on limiting harvest of blue crabs during biologically important times of year (e.g., mating and spawning seasons), and specifically limiting harvest of mature females. Initial management options only included those projected to rebuild spawner abundance to a higher level with a much higher probability of success (Table 1).

Options 1, 2, and 3 implement 10-, 15-, or 20-bushel limits on all hard blue crabs year-round (**Option 1**), from September–December (**Option 2**), or from September–November (**Option 3**; Table 2a). **Option 3** implements seasonal bushel limits in combination with statewide season closures.

Option 4 implements a 10-, 15-, or 20-bushel limit on mature female blue crabs from September–October, a five-bushel limit on mature female mature female crabs from November–December, and no harvest of mature female blue crabs from January–May (Table 2b). **Option 5** is the same as **Option 4** but extends the period for no harvest of mature female crabs from January–May. **Option 6** implements a 10-, 15-, or 20-bushel limit on mature female blue crabs from September–November, a complete closure for all blue crabs from December–January and no harvest of mature female crabs from February–May. **Option 7** implements a 10-, 15-, or 20-bushel limit on mature female crabs from September–December and prohibits harvest of mature female crabs from January–May. **Option 8** is the same as **Option 7** but implements the 10-, 15-, or 20-bushel limit on mature female crabs from June–December.

In consideration of blue crab life history and blue crab fishery characteristics the **preliminary DMF recommendation presented to the Advisory Committees in March 2025 was Option 8.a, 10-bushel limit for mature female blue crabs from June–December and no harvest of mature female blue crabs from January–May** (Table 2b). The DMF also recommended maintaining existing season closures and all other blue crab management measures currently in place. In combination, these management measures should effectively reduce harvest by an estimated 21.7 percent compared to average landings from 2019–2023, increase the spawning stock biomass, and promote increased recruitment.

Table 2a. Season closure and trip limit management options. Unless stated otherwise all options are in addition to existing management including existing season closures. Estimated harvest reductions are calculated from 2016, 2023, and 2019–2023 commercial hard blue crab landings.

Option #	Measures	2016	2023	2019–2023
1	a. 10-bushel hard crab trip limit year-round	48.3	51.6	45.6
	b. 15-bushel hard crab trip limit year-round	34.5	38.3	31.9
	c. 20-bushel hard crab trip limit year-round	25.2	28.5	22.6
2	a. 10-bushel hard crab trip limit Sept–Dec	25.1	32.0	21.6
	b. 15-bushel hard crab trip limit Sept–Dec	20.4	25.2	16.4
	c. 20-bushel hard crab trip limit Sept–Dec	16.6	19.7	12.4
3	a. 10-bushel hard crab trip limit Sept–Nov, closed Dec–Mar	32.8	36.3	27.0
	b. 15-bushel hard crab trip limit Sept–Nov, closed Dec–Mar	28.5	30.2	22.3
	c. 20-bushel hard crab trip limit Sept–Nov, closed Dec–Mar	25	25.2	18.6
	d. 10-bushel hard crab trip limit Sept–Nov, closed Dec–Jan	27.4	34.5	24.0
	e. 15-bushel hard crab trip limit Sept–Nov, closed Dec–Jan	23.1	28.4	19.3
	f. 20-bushel hard crab trip limit Sept–Nov, closed Dec–Jan	19.6	23.4	15.6

Table 2b. Mature female season closure and trip limits management options. Unless stated otherwise all option are in addition to existing management including existing season closures. Estimated harvest reductions are calculated from 2016, 2023, and 2019–2023 commercial hard blue crab landings.

Option #	Measures	2016	2023	2019–2023
4	a. 10-bushel mature females Sept–Oct, 5-bushel mature females Nov–Dec, no mature females Jan–Mar	17.5	19.4	14.4
	b. 15-bushel mature females Sept–Oct, 5-bushel mature females Nov–Dec, no mature females Jan–Mar	15.7	16.9	12.3
	c. 20-bushel mature females Sept–Oct, 5-bushel mature females Nov–Dec, no mature females Jan–Mar	14.3	15.1	10.9
5	a. 10-bushel mature females Sept–Oct, 5-bushel mature females Nov–Dec, no mature females Jan–May	22.1	21.8	18.8
	b. 15-bushel mature females Sept–Oct, 5-bushel mature females Nov–Dec, no mature females Jan–May	20.2	19.2	16.7
	c. 20-bushel mature females Sept–Oct, 5-bushel mature females Nov–Dec, no mature females Jan–May	18.9	17.5	15.3
6	a. 10-bushel hard crabs limit Sept–Nov, complete closure Dec–Jan, no mature females Feb–May	34.8	37.8	29.9
	b. 15-bushel hard crabs limit Sept–Nov, complete closure Dec–Jan, no mature females Feb–May	30.3	31.6	24.2
	c. 20-bushel hard crabs limit Sept–Nov, complete closure Dec–Jan, no mature females Feb–May	26.7	26.4	19.8
7	a. 10-bushel mature females Sept–Dec, no mature females Jan–May	20.6	19.4	17.1
	b. 15-bushel mature females Sept–Dec, no mature females Jan–May	17.6	15.1	13.9
	c. 20-bushel mature females Sept–Dec, no mature females Jan–May	15.3	12.0	11.6
8	a. 10-bushel mature females June–Dec , no mature females Jan–May*	25.0	23.1	21.7
	b. 15-bushel mature females June–Dec, no mature females Jan–May	19.8	17.2	16.4
	c. 20-bushel mature females June–Dec, no mature females Jan–May	16.5	13.2	13.0

*Division preliminary recommendation presented to the MFC Advisory Committees (Northern, Southern, Shellfish/Crustacean) in March 2025

Advisory Committee Review

The Amendment 3 adaptive management framework requires “consultation” with the Northern, Southern, and Shellfish/Crustacean advisory committees before management changes can be approved by the MFC. To fulfill the “consultation” requirement, the advisory committees met the week of March 18–20 to discuss adaptive management and provide recommendations. DMF staff provided background information and the preliminary DMF recommendation. In addition, DMF staff were available prior to each meeting to answer questions and discuss blue crab science and management with the public.

Key takeaways from all meetings included:

- Concern about the economic impact of the preliminary DMF recommendation
- Concern about how the preliminary recommendation would disproportionately impact certain fishery segments and areas and the need for fair management between regions
- Distrust of stock assessment results and data
- Concern about the effects of water quality and predation on the blue crab stock
- Questions about authority to make management changes without an updated stock assessment
- Landings declines are the result of market conditions and participation declines, not a declining blue crab stock
- The need for cooperation with industry for data collection and formulating management
- Some acknowledgement the stock has declined since the 1990’s even if it is not because of fishing
- Some concern about long-term declining trends

Advisory Committee Recommendations

Northern

Motion for the Marine Fisheries Commission to not take final action on Blue Crab Amendment 3 Adaptive Management until August 2025, instead of May 2023 (motion passes 10-0)

Motion for the Marine Fisheries Commission to remain status quo regarding the Blue Crab FMP Amendment 3 Adaptive Management (motion passes 7-2, with 1 abstention)

Southern

Motion to recommend the Marine Fisheries Commission to remain status quo regarding Blue Crab FMP Amendment 3 Adaptive Management and to move the Marine Fisheries Commission action on Blue Crab to the August 2025 meeting (motion passes 6-1, with 1 abstention)

Shellfish/Crustacean

Motion for the Marine Fisheries Commission to not take final action on Blue Crab Amendment 3 Adaptive Management until August 2025, instead of May 2025 (motion passes, 5-0, with 2 abstentions)

Motion to recommend to the Marine Fisheries Commission to remain status quo regarding Blue Crab FMP Amendment 3 (motion passes 4-0, with 3 abstentions)

Amendment 3 Adaptive Management Next Steps and Timeline

Amendment 3 is nearly halfway through the required rebuilding timeline and while an updated stock assessment is not currently available to inform stock status, there is little evidence suggesting overfishing has ended or Amendment 3 sustainability objectives will be met. Because there are strong indicators the stock is not recovering, the **DMF remains concerned about the blue crab stock**. However, in consideration of advisory committee input the DMF intends to:

Bring adaptive management options to the MFC for final action in August 2025

Final MFC adaptive management action will occur in August 2025. Prior to the August meeting, the DMF will consider advisory committee input, re-evaluate the preliminary recommendations and continue to explore additional management options. At the August 2025 meeting, the division will present additional options accounting for public and advisory committee input.

Prioritize completing assessing the stock

Potential avenues for assessing the stock have been explored but there is no anticipated completion date at this time. With the declining trends in all data sources, there is potential a new assessment will not show stock recovery and may indicate the stock requires significant harvest reductions for recovery.

The updated timeline for revision development is:

May 2024	DMF presents results of stock assessment update and adaptive management plan to MFC
May 2024 – August 2024	Outreach and analysis
September 2024	DMF updates Northern, Southern, and Shellfish/Crustacean advisory committees
September 2024 – December 2024	Additional outreach and analysis. DMF drafts Revision to Amendment 3
March 2025	MFC AC (Northern, Southern, Shellfish/Crustacean) review draft
May 2025	DMF updates MFC on advisory committee recommendations and next steps – NO ACTION
August 2025	MFC scheduled to vote on adoption of Amendment 3 Revision

*Gray indicates a step is complete.

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Eastern Oyster Fishery Management Plan

May 2025 Quarterly Business Meeting

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Draft Eastern Oyster FMP Amendment 5

DECISION DOCUMENT

Eastern Oyster Fishery Management Plan Amendment 5



This document was developed by the Division of Marine Fisheries to help the Marine Fisheries Commission track previous activity and prepare for upcoming actions for the Eastern Oyster FMP Amendment 5.

May 2025

Summary

At their March 2025 Business Meeting, the Marine Fisheries Commission (MFC) selected their preferred management options for Amendment 5 to the Eastern Oyster Fishery Management Plan (FMP). The draft FMP was revised to include these selected options and then provided to the Secretary of the North Carolina Department of Environmental Quality. The Secretary submitted the draft FMP to the Joint Legislative Oversight Committee on Agriculture and Natural and Economic Resources (AgNER) for their 30-day review period (N.C. General Statute § 113-182.1(e)). The draft FMP will be provided to the MFC for their vote on final adoption of Amendment 5 at their May 2025 Business Meeting.

This revised Decision Document includes the MFC preferred management options selected at the March 2025 Business Meeting and the suite of management options and rationale behind them that were provided to the MFC for their consideration at that meeting.

Background

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

A joint issue that will also be addressed in Amendment 3 of the Hard Clam FMP is recreational shellfish harvest. Recreational shellfish harvest does not require a license in NC, resulting in the inability of the DMF to adequately collect recreational landings data. This data gap has been cited as a major need in all past FMPs and needs to be addressed to account for all removals from the populations. These data are needed for future stock assessments of Hard Clams and Eastern Oysters. Additionally, shellfish harvest is subject to changing area closures due to human health and safety concerns. Without licensing or permitting requirements, the DMF is unable to ensure that every recreational harvester is informed of shellfish sanitation concerns. The draft FMP contains an issue paper outlining the broad need to capture recreational harvest sector information and have an effective means to provide health and safety information to all recreational shellfish harvesters.

Management strategies are divided regionally by Pamlico Sound and its surrounding bays (generally subtidal, mechanical harvest) and south of Core Sound (mixed subtidal and intertidal, hand harvest) populations. These strategies apply to both natural reefs and cultch reefs. Natural reefs formed with no human intervention and cultch reefs were built by DMF. Both types of reefs are colonized by wild oysters. Oyster reefs are highly susceptible to the

effects of harvest, particularly mechanical, due to oysters being both a fishery resource as well as their own habitat needed to perpetuate their population.

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

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

Amendment Timing

(gray indicates completed step)

DMF holds public scoping period	September 2023
MFC approves goal and objectives of FMP	November 2023
DMF drafts FMP	December 2023 – June 2024
DMF held workshop to review and further develop the draft FMP with the Oyster/Clam FMP Advisory Committee	July 2024
DMF updates draft plan	August – November 2024
MFC Reviews draft and votes on sending draft FMP for public and AC review	November 2024
MFC Advisory Committees meet to review draft FMP and receive public comment	January 2025
MFC selects preferred management options	February 2025
Legislative review of draft FMP	March – April 2025
MFC votes on final adoption of FMP Amendment 5	May 2025
DMF implements management strategies	TBD

You are
here

Goal and Objectives

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

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

Management Measures

Management Carried Forward in Amendment 5

There are management measures from the previous FMP to carry forward into Amendment 5 as listed below:

- A daily limit of two bushels of oysters per person with a maximum of four bushels of oysters per vessel off public bottom for Shellfish License holders statewide.
- A six-week opening timeframe for mechanical harvest in deep bays to begin on the Monday of the week prior to Thanksgiving week through the Friday after Thanksgiving. Reopen two weeks before Christmas for the remainder of the six-week season.
- A 15-bushel hand/mechanical harvest limit in Pamlico Sound mechanical harvest areas outside the bays, 10-bushel hand/mechanical harvest limit in the bays, and 10-bushel hand harvest limit in the Mechanical Methods Prohibited area along the Outer Banks of Pamlico Sound.

MFC Selected Management Measures

Outlined below are the preferred management options by issue selected in March 2025 by the MFC for Amendment 5 to the Eastern Oyster FMP.

Recreational Harvest

- Support the DMF to further explore potential options and develop a solution to estimate recreational shellfish participation and landings, with the intent to move towards a stock assessment and stock level management for both hard clams and oysters; and to establish a mechanism to provide all recreational shellfish harvesters with Shellfish Sanitation and Recreational Water Quality (SSRWQ) health and safety information outside of the FMP process.

Mechanical Harvest

- Adopt the proposed Pamlico and Neuse River Deep-water Oyster Recovery Areas (DORAs), which are bound by existing navigational aids as presented to the MFC Advisory Committees, to protect deep subtidal oyster reefs from continued physical disturbance by mechanical gear. These areas will be closed to mechanical oyster dredging and monitoring efforts will be used to evaluate the effectiveness of closure within the next FMP amendment. The DORAs cover 681 acres of potential oyster habitat (500 acres in Pamlico River and 180 acres in Neuse River), which represents approximately 81% of the vulnerable deep-water oyster habitat.
- Adopt the Cultch Supported Harvest strategy outlined in Appendix 2, which would set the season length based on pre-season sampling aided by industry input on sampling locations with the 10 bushel per day and 15 bushel per day areas considered separately.
- Adopt the inclusion of Rotational Harvest Cultch Sites strategy outlined in Appendix 2. This strategy would create a rotating series of readily available cultch areas available to harvest for the full extent of the mechanical season length each year with the intent of reducing harvest pressure on natural reefs.
- Adopt the proposed adaptive management framework to allow for modification of set season length based on changes to participation in the fishery.

Suite of Management Options Presented

(Options outlined in blue represent MFC's preferred option selected in March 2025 and DMF's recommendation)

Recreational Harvest

Implementing a licensing or permitting requirement for recreational shellfish harvesters would give the DMF the opportunity to adequately collect recreational landings data needed for future stock assessments of Eastern Oysters and Hard Clams, and to inform participants of where to find information on harvest closure boundaries, where to sign up to receive polluted area proclamations or to access temporary closure maps, and where to find information on safe handling practices, particularly as it relates to *Vibrio* bacteria.

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

Option 1: Recreational Harvest

(Refer to pp. 44-51 in the Draft Eastern Oyster FMP Amendment 5, Appendix 1 for additional details)

- a. Status Quo
- b. Support the DMF to further explore potential options and develop a solution to estimate recreational shellfish participation and landings, and to establish a mechanism to provide all recreational shellfish harvesters with SSRWQ health and safety information outside of the FMP process.

Mechanical Harvest

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

1. Deep-Water Oyster Recovery Areas
2. Cultch Supported Harvest
3. Rotational Cultch Sites

Tier/Strategy 1, Deep-Water Oyster Recovery Areas (DORAs):

The remnant deep water natural oyster reefs in the Pamlico River and Neuse River have suffered mass mortality from water quality impacts. These oyster reefs need high vertical relief (height) to be resilient to negative water quality impacts from storm events. However, mechanical harvest reduces the ability of natural oyster reefs in deep water to gain and maintain height as dredging actively removes valuable shell bottom habitat. These reefs have likely not supported much fishery effort since 2018 and have had very few live or legal oysters sampled during DMF monitoring efforts. Past and present permit restrictions do not allow for the enhancement of deep-water reefs in Pamlico Sound with cultch. However, if future permitting could be secured to enhance or restore these deep-water reefs, low-relief

cultch plantings would likely not be sufficient to quickly restore the reef height needed, and large high relief materials would need to be employed. The use of large materials such as boulders may prevent any future mechanical harvest of these sites once restored. Proposed DORAs would not open to the mechanical harvest of oysters to allow these reefs to accumulate shell material to gain the height necessary to be resilient to storm events. Reefs deeper than five meters (~16 ft) have been identified to be most vulnerable to poor water quality events. Two DORAs (Pamlico and Neuse River) with options for varying sizes have been proposed by creating boundaries using existing navigational aids for ease of compliance and enforceability (Appendix 2). Determination of successful recovery and developing sustainable harvest strategies would occur in a future FMP. Future sustainable harvest is defined as a level of harvest that would not result in a net loss of reef height through time and maintain reef height gained through DORA implementation.

Tier/Strategy 2, Cultch Supported Harvest:

The Cultch Supported Harvest strategy seeks to link mechanical oyster harvest management in Pamlico Sound to the DMF's extensive cultch planting effort. The primary changes from previous management in the proposed strategy are that season lengths will be predetermined and based on DMF pre-season sampling of the oyster resource in these areas, and the 10-bushel per day bays and 15-bushel per day open areas will be considered differently for each management area based on the pre-season sampling. This will eliminate the unpredictability experienced by harvesters of how long mechanical harvest will occur in a given season and consider differences in oyster mortality experienced at varying depths of Pamlico Sound. Season lengths will be predetermined based on pre-season sampling of oyster condition. Results of sampling data will be used to set season length as shown in the Mechanical Oyster Harvest Management Issue Paper (Appendix 2). During the harvest season, in-season sampling will occur to determine if the initial season length should be extended. Harvesters will be encouraged to report productive sites, aiding in more accurate in-season assessments. The new approach aims to reduce unpredictability by setting season lengths based on oyster resource conditions and ensuring that harvesting does not overly damage oyster habitats. The goal is to balance sustainable oyster harvests with the preservation of habitat provided by cultch planting

Tier/Strategy 3, Rotational Cultch Harvest Sites:

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

Adaptive Management:

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

Option 1: Mechanical Oyster Harvest – Deep-Water Oyster Recovery Areas (DORAs)

(Refer to pp. 52-84 in the Draft Eastern Oyster FMP Amendment 5, Appendix 2 for additional details)

- a. Status Quo
- b. Adopt larger proposed Pamlico and Neuse River Deep-water Oyster Recovery Areas (DORAs), which are bound by existing navigational aids as presented to the NC MFC regional Advisory Committees, to protect deep subtidal oyster reefs from continued physical disturbance by mechanical gear. These areas will be closed to mechanical oyster dredging and monitoring efforts will be used to evaluate the effectiveness of closure within the next FMP amendment. The DORAs cover 681 acres of potential oyster habitat (500 acres in Pamlico River and 180 acres in Neuse River), which represents approximately 81% of the vulnerable deep-water oyster habitat.
- c. Adopt smaller proposed Pamlico and Neuse River Deep-water Oyster Recovery Areas (DORAs), which are bound by existing navigational aids, to protect deep subtidal oyster reefs from continued physical disturbance by mechanical gear. These areas will be closed to mechanical oyster dredging and monitoring efforts will be used to evaluate the effectiveness of closure within the next FMP amendment. The smaller DORAs cover 271 acres of potential habitat (200 acres in Pamlico River and 71 acres in Neuse River), which represents only approximately 32% of the vulnerable habitat.

Option 2: Mechanical Oyster Harvest – Cultch Supported Harvest

(Refer to pp. 52-84 in the Draft Eastern Oyster FMP Amendment 5, Appendix 2 for additional details)

- a. Status Quo
- b. Adopt the Cultch Supported Harvest strategy outlined in Appendix 2, which would set the season length based on pre-season sampling aided by industry input on sampling locations with the 10 bushel per day and 15 bushel per day areas considered separately.

Option 3: Mechanical Oyster Harvest – Rotational Harvest Cultch Sites

(Refer to pp. 52-84 in the Draft Eastern Oyster FMP Amendment 5, Appendix 2 for additional details)

- a. Status Quo
- b. Adopt the inclusion of Rotational Harvest Cultch Sites strategy outlined in Appendix 2. This strategy would create a rotating series of readily available cultch areas available to harvest for the full extent of the mechanical season length each year with the intent of reducing harvest pressure on natural reefs.

Option 4: Mechanical Oyster Harvest – Adaptive Management for Cultch Supported Harvest Strategy

(Refer to pp. 52-84 in the Draft Eastern Oyster FMP Amendment 5, Appendix 2 for additional details)

- a. Status Quo
- b. Adopt the proposed adaptive management framework to allow for modification of set season length based on changes to participation in the fishery.

Next Steps

The MFC selected their preferred management options at their March 2025 Business Meeting. The draft FMP was revised to include these selected options and then provided to the Secretary of the North Carolina Department of Environmental Quality. The Secretary submitted the draft FMP to the Joint Legislative Oversight Committee on Agriculture and Natural and Economic Resources (AgNER) for their 30-day review period (N.C. General Statute § 113-182.1(e)). At the May 2025 business meeting, the MFC will be presented any comments from the review and will vote on the final adoption of measures for the Eastern Oyster FMP Amendment 5. After adoption, the DMF will immediately begin implementation of the adopted management measures.

DRAFT, 2025

North Carolina Eastern Oyster Fishery Management Plan Amendment 5

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EXECUTIVE SUMMARY

The Eastern Oyster is a commercially and recreationally important molluscan shellfish harvested from North Carolina's estuarine waters. In fact, the oyster fishery was the first regulated fishery in North Carolina. Hand harvest and mechanical dredges are the primary commercial methods for harvesting oysters, while hand harvest methods are the sole means used in the recreational fishery.

Stock status, including population size, rate of removals and sustainable harvest metrics, is unknown due to insufficient data to conduct a traditional stock assessment. Data available for the stock include commercial landings and fishing effort (i.e., trips) reported to the Trip Ticket Program, biological data collected from the commercial catch, and voluntary responses to an annual recreational survey. Commercial landings trends reflect population abundance to an extent, but other factors like market demand, regulations, changes in effort, closures from rainfall events, and gear technology also affect harvest. Recreational landings and fishing effort in North Carolina is currently unknown and cannot be quantified from the voluntary recreational survey.

The mechanical oyster fishery is limited to subtidal open water regions of Pamlico Sound and its surrounding bays. To balance the value of oysters as both a fishery resource and essential habitat for oysters and other estuarine species, a three-tiered management strategy is proposed for the Pamlico Sound oyster mechanical harvest management. The first tier prioritizes the ecological value of oysters with the designation of Deep-water Oyster Recovery Areas (DORAs) at the mouth of the Pamlico and Neuse rivers that will be closed to mechanical harvest. The closures protect 81% of the identified deep-water oyster habitat, preventing further height loss and damage to recovering oyster reefs. The second tier is a Cultch Supported Harvest strategy that incorporates industry input to guide NCDMF sampling locations to assess the percentage of legal-sized oysters. This approach uses data to set fixed season lengths by proclamation, which may only be extended, balancing habitat and fishery value and providing harvesters with greater certainty on the season length. Additionally, the NCDMF's extensive cultch planting program will continue to support the fishery by replenishing material lost through mechanical harvesting. To evaluate the effectiveness of the second tier, an adaptive management framework is included to evaluate fixed season lengths if participation in the mechanical harvest fishery changes by more than 25%. The third tier is the Rotational Cultch Site strategy, which uses rotational openings for 10-acre planting sites across four management areas in Pamlico Sound to further strengthen the integration of the NCDMF's Cultch Planting Program into management of the oyster fishery, prioritizing the fishery value of these sites.

Identification of a strategy to quantify recreational harvest continues as a need outlined in Amendment 5. The number of recreational shellfish harvesters in North Carolina is currently unknown, which prevents reliable estimates of total recreational harvest of shellfish. Because there is no license or permit required for recreational shellfish harvest, there is no mechanism for communicating with recreational harvesters regarding human health and safety information related to shellfish harvest like there is for commercial

harvesters when they acquire their license. Instituting a recreational shellfish license or permit provides a mechanism for distributing human health and safety information and allows the NCDMF to quantify the number of recreational shellfish harvesters to aid in future stock assessments. This issue is shared with the Hard Clam FMP Amendment 3.

The goal of Amendment 5 to the N.C. Eastern Oyster FMP is to manage the oyster resource in such a way as to enhance oyster populations that provide long-term harvest and continue to offer protection and ecological benefits to North Carolina's estuaries. The following objectives will be used to achieve this goal: use the best available biological, environmental, habitat, fishery, social, and economic data to effectively monitor and manage the oyster fishery and its environmental role, support and implement the restoration and protection of oyster populations as both a fishery resource and an important estuarine habitat through the actions of the Cultch Planting and Oyster Sanctuary programs, coordinate with DEQ and stakeholders to implement actions that protect habitat and environmental quality consistent with the Coastal Habitat Protection Plan (CHPP) recommendations, manage oyster harvesting gear use to minimize damage to habitat, and promote stewardship of the resource through public outreach to increase public awareness regarding the ecological value of oysters and encourage stakeholder involvement in fishery management and habitat enhancement activities. To meet the goal and objectives of Amendment 5, the N.C. Marine Fisheries Commission (NCMFC) selected their preferred management options at their March 2025 business meeting as follows:

Mechanical Oyster Harvest

1. Deep-Water Oyster Recovery Areas
 - Adopt the proposed Pamlico and Neuse River Deep-water Oyster Recovery Areas (DORAs), which are bound by existing navigational aids as presented to the NC MFC regional Advisory Committees, to protect deep subtidal oyster reefs from continued physical disturbance by mechanical gear. These areas will be closed to mechanical oyster dredging and monitoring efforts will be used to evaluate the effectiveness of closure within the next FMP amendment. The DORAs cover 681 acres of potential oyster habitat (500 acres in Pamlico River and 180 acres in Neuse River), which represents approximately 81% of the vulnerable deep-water oyster habitat. ([Appendix 2](#))
2. Cultch Supported Harvest Management
 - Adopt the Cultch Supported Harvest strategy outlined in [Appendix 2](#), which would set the season length based on pre-season sampling aided by industry input on sampling locations with the 10 bushel per day and 15 bushel per day areas considered separately.
3. Rotational Harvest Cultch Sites
 - Adopt the inclusion of Rotational Harvest Cultch Sites strategy outlined in [Appendix 2](#). This strategy would create a rotating series of readily available cultch areas available to harvest for the full extent of the mechanical season length each year with the intent of reducing harvest pressure on natural reefs.

4. Adaptive Management

- Adopt the proposed adaptive management framework to allow for modification of set season length based on changes to participation in the fishery ([Appendix 2](#)).

Recreational Harvest

- Support the DMF to further explore potential options and develop a solution to estimate recreational shellfish participation and landings, with the intent to move towards a stock assessment and stock level management for both hard clams and oysters; and to establish a mechanism to provide all recreational shellfish harvesters with Shellfish Sanitation and Recreational Water Quality health and safety information outside of the FMP process.

Additionally, the following management measures from the previous FMP are carried forward into Amendment 5:

- A daily limit of two bushels of oysters per person with a maximum of four bushels of oysters per vessel off public bottom for Shellfish License holders statewide.
- A six-week opening timeframe for mechanical harvest in deep bays to begin on the Monday of the week prior to Thanksgiving week through the Friday after Thanksgiving. Reopen two weeks before Christmas for the remainder of the six-week season.
- A 15-bushel hand/mechanical harvest limit in Pamlico Sound mechanical harvest areas outside the bays, 10-bushel hand/mechanical harvest limit in the bays, and 10-bushel hand harvest limit in the Mechanical Methods Prohibited area along the Outer Banks of Pamlico Sound. Areas as defined and adopted in Amendment 2 of the Oyster FMP.

INTRODUCTION

This is Amendment 5 to the Oyster Fishery Management Plan (FMP). FMPs are the ultimate product that brings all information and management considerations into one document. The North Carolina Division of Marine Fisheries (NCDMF) prepares FMPs for adoption by the North Carolina Marine Fisheries Commission (NCMFC) for all commercially and recreationally significant species or fisheries that comprise state marine or estuarine resources. The goal of these plans is to ensure long-term viability of these fisheries. By law, each FMP must be reviewed at least once every five years (G.S. 113-182.1). The NCDMF reviews each FMP annually and a comprehensive review is undertaken approximately every five years. The last comprehensive review of the plan (Amendment 4) was approved by the NCMFC in 2018. All management authority for the North Carolina Eastern Oyster fishery is vested in the State of North Carolina. The NCMFC adopts rules and policies and implements management measures for the Eastern Oyster fishery in Coastal and Joint Fishing Waters in accordance with G.S. 113-182.1. Until Amendment 5 is approved for management, Eastern Oysters are managed under Amendment 4 of the Oyster FMP (NCDMF 2018).

There are insufficient data to conduct a traditional stock assessment to determine population size and the rate of removals for the eastern oyster in North Carolina. Without a stock assessment, management is focused on habitat protection and enhancement measures that maintain harvestable oyster populations.

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

Fishery Management Plan History

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

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

Management Unit

The management unit of this FMP includes the Eastern Oyster (*Crassostrea virginica*) and its fisheries in all public coastal fishing waters of North Carolina. This FMP pertains only to oysters from wild stocks and does not address managing farmed oysters originating from private aquaculture leases and franchises.

Goal and Objectives

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

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

DESCRIPTION OF THE STOCK

Biological Profile

DISTRIBUTION

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

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



Figure 1. Distribution of the Eastern Oyster (*Crassostrea virginica*) represented by the red line (adapted from Bahr and Lanier 1981; Amaral and Simone 2014).

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

North Carolina's oysters are composed of both subtidal populations (below the mean low tide water level, up to 26 ft deep) and intertidal populations (between the mean high and low tide levels; MacKenzie et al. 1997). Throughout the Croatan, Roanoke, and Pamlico sounds, oyster resources are almost exclusively subtidal. This region is primarily influenced by wind-driven tides, with intertidal oysters found occasionally near the inlets. Scattered subtidal populations may be found in larger systems farther south (Newport, White Oak, and New River systems). Conversely, intertidal populations are predominantly observed south of Cape Lookout and throughout estuaries extending to the state's southern border. The horse or crested oyster (*Ostrea equestris*) may be confused with small Eastern Oysters and can be locally abundant in both intertidal and subtidal habitats in southeastern North Carolina (Markwith et al. 2009).

MORPHOLOGY

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

REPRODUCTION AND RECRUITMENT

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



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

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

Under normal conditions, male oysters spawn first in response to various physical stimuli and environmental conditions. Female oysters are stimulated to spawn specifically by the presence of oyster sperm. Fertilization must take place shortly thereafter in the surrounding waters, or the unfertilized eggs lose their viability. Fertilized eggs develop into a free-swimming larva, which can migrate vertically in the water column in response to temperature and salinity changes (Hopkins 1931; Galtsoff 1964). Oyster larvae have

also been documented to travel up to 30 miles, with dispersion strongly dependent on prevailing winds (Bahr and Lanier 1981; Andrews 1983). Patterns of larval distribution in North Carolina estuaries remain relatively unstudied; however, predictive models of Pamlico Sound larval dispersal from oyster sanctuaries have been developed (Haase et al. 2012).

An oyster larva may visit several sites before it cements itself to the substrate (Kennedy et al. 1996). Several environmental factors, including light, salinity, temperature, acoustic signature, and current velocity may influence the setting of larvae (Hidu and Haskins 1971; Lillis et al. 2013). Oyster larvae also respond positively to a protein on the surface of oyster shells as well as other recently set spat (Kennedy et al. 1996). Larval oysters tend to settle in the intertidal zone where salinities are above 20 ppt whereas in subtidal areas they settle when salinities are below 20 ppt (Mackin 1946; Loosanoff 1952; Menzel 1955). Generally, spatfall is higher in intertidal areas and in areas boasting salinities in the upper range of tolerance (Bahr and Lanier 1981).

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

GROWTH

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

Stock Unit

For the purposes of this fishery management plan, the unit stock is considered to be all wild oysters occurring within North Carolina coastal fishing waters, excluding oysters produced via private aquaculture leases or franchises.

Assessment Methodology

Data are not available to perform a traditional assessment, so it was not possible to estimate population size or fishing mortality rates.

Stock Status

Data limitations prevent the NCDMF from conducting an Eastern Oyster stock assessment and calculating sustainable harvest metrics. Data available for the stock include commercial landings and fishing effort (i.e., trips) reported to the Trip Ticket Program, biological data collected from the commercial catch, and voluntary responses to an annual recreational survey. For information on the methodology used in previous stock assessment attempts, see [Amendment 4 of the Oyster FMP](#).

While the oyster is managed by 18 other states along the Atlantic Coast and Gulf of Mexico, it is worth noting that only Louisiana, Maryland, and Virginia have complete stock assessments. Louisiana's most recent stock assessment in 2023 utilized 1,700 dredge samples and 1,000 diver quadrat samples collected during summer months. Their results suggested a 118% year-over-year increase in the stock of oysters, with most of the stock occurring in the west. Maryland conducts a stock assessment within the northern region of Chesapeake Bay and its tributaries (north of Smith Island, following the state-boundary); while Virginia's stock assessment of oysters includes the southern portion of the Chesapeake and its tributaries, including the James River. Maryland's stock assessment, which involves a stage-structured model integrated with various fishery-independent data, recently reported increases in their adult and spat populations but regional overfishing occurring within the fishery (MDDNR 2021). The Virginia Marine Resources Commission and the Virginia Institute of Marine Science collect data during the fall using tongs to extract samples of one square-meter (See graphic summaries on the [Virginia Oyster Stock Assessment and Replenishment Archive - VOSARA](#)). The most recent evaluation found the oyster stock in the southern Chesapeake was at its best condition in a generation, extending the fishery season for the first time since 1987. In addition to a stock assessment, Virginia employs a rotational harvest management system for the oyster.

In the absence of a formal stock assessment, Delaware and New Jersey use other metrics to inform their management strategies. Delaware conducts a population survey to set quotas; New Jersey does an annual assessment of Delaware Bay. For more information on how other states manage their fisheries, see Appendix 5.

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

DESCRIPTION OF THE FISHERY

Additional in-depth analyses and discussion of North Carolina's commercial oyster fishery can be found in earlier versions of the Oyster FMP, Revisions, Amendment 1, Amendment 2, Supplement 2A, Amendment 3, and Amendment 4 (NCDMF 2001b, 2003, 2008, 2010, 2014, 2017); all FMP documents are available on the [NCDMF Fishery Management Plans website](#) and commercial landings can be found in the License and

Statistics Annual Report (NCDMF 2022) produced by the NCDMF and available on the [NCDMF Fisheries Statistics website](#).

Commercial Fishery

HISTORICAL OVERVIEW

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

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

However, oyster landings saw a drastic decline soon after the 1902 peak, reaching 171,090 bushels in 1918. Around this time, the state recognized the value of recycling shells for rebuilding oyster beds. From 1915 to 1920, the state began funding the Cultch Planting Program, resulting in 10,000–12,000 bushels of shell being planted each year for the aimed benefit of the fishery. After initial success and apparent rebound in harvest, additional state funding allowed the program to scale up and plant around 100,000 bushels of seed oysters and substrate in the early 1920s. Harvest statistics show a rebound in landings from 1923 to around 1931. For a more comprehensive history of the Cultch Program, see Appendix 1.

All oyster landings prior to 1931 were accomplished using hand methods and sail-powered oyster dredge boats. The 1940s saw restrictions on powerboats lifted, likely due to heightened demand and the price of oysters during World War II. The distinction between power and sailboat dredging disappeared altogether by 1955.

Throughout the remainder of the 20th century, oyster landings fluctuated between 650,000 to less than 50,000 bushels per year. Even with the switch from sailboat to power dredging, the overall trend of oyster landings in North Carolina was that of gradual decline through 2000 with a notable exception in 1987. There are several factors contributing to the continued decline in landings. For instance, taking oysters for personal consumption was allowed year-round until 1966, which may have been exacerbated by the fact that hand gear for oyster harvest has been largely unregulated in shallow subtidal (hand

tongs) and intertidal areas (hand rakes and by hand). Furthermore, a lack of adequate enforcement seemed to allow the harvest and sale of undersize oysters; it was not until 1981 that the three-inch size limit was applied throughout the state (Chestnut 1951; Thorsen 1982). Modern commercial shellfishing continues in North Carolina and these fisheries include mechanical dredging and hand harvest methods, which are further detailed in the following sections. For a more thorough history of the oyster fishery including changes in regulations for commercial gear, length of seasons, and openings and closures of bays, refer to [Amendment 4 of the Oyster FMP](#) (NCDMF 2017)

MECHANICAL HARVEST METHODS

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

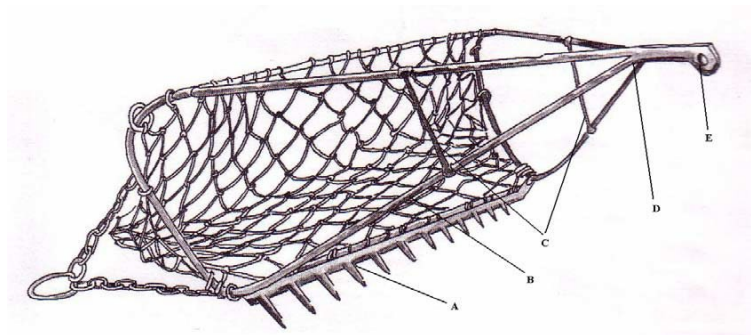


Figure 3. Sketched illustration of a dredge used in North Carolina's mechanical oyster fishery (from Shefi 2007, adapted from Heddeen 1986).

DRAFT SUBJECT TO CHANGE

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

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

The current mechanical oyster fishery is limited to greater Pamlico Sound and adjacent bays and tributaries, including the Neuse and Pamlico rivers, with a maximum season beginning on the Monday of the week prior to Thanksgiving week, which is typically the third Monday in November, and running through March 31. Mechanical harvest gear is restricted to the deeper portions (more than 6 ft) of the Sound, including deeper areas of rivers and bays (see Appendix 2, Figures 2.8 & 2.9). There are currently four oyster

management areas for mechanical harvest: Northern Dare, Northern Hyde, Pamlico River, and Neuse River (see Appendix 2, Figure 2.3). Throughout these areas, mechanical harvest is limited to 15 bushels per fishing operation in the open sound and the Neuse and Pamlico rivers. Conversely, mechanical harvest in some larger bays and tributaries is limited to 10 bushels per fishing operation. These areas and limitations are based on recommendations and criteria established in the original Oyster FMP (NCDMF 2001b) with areas prohibited to take oysters by mechanical methods are designated in the N.C. Marine Fisheries Commission Rule 15A NCAC 03R .0108.

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

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

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

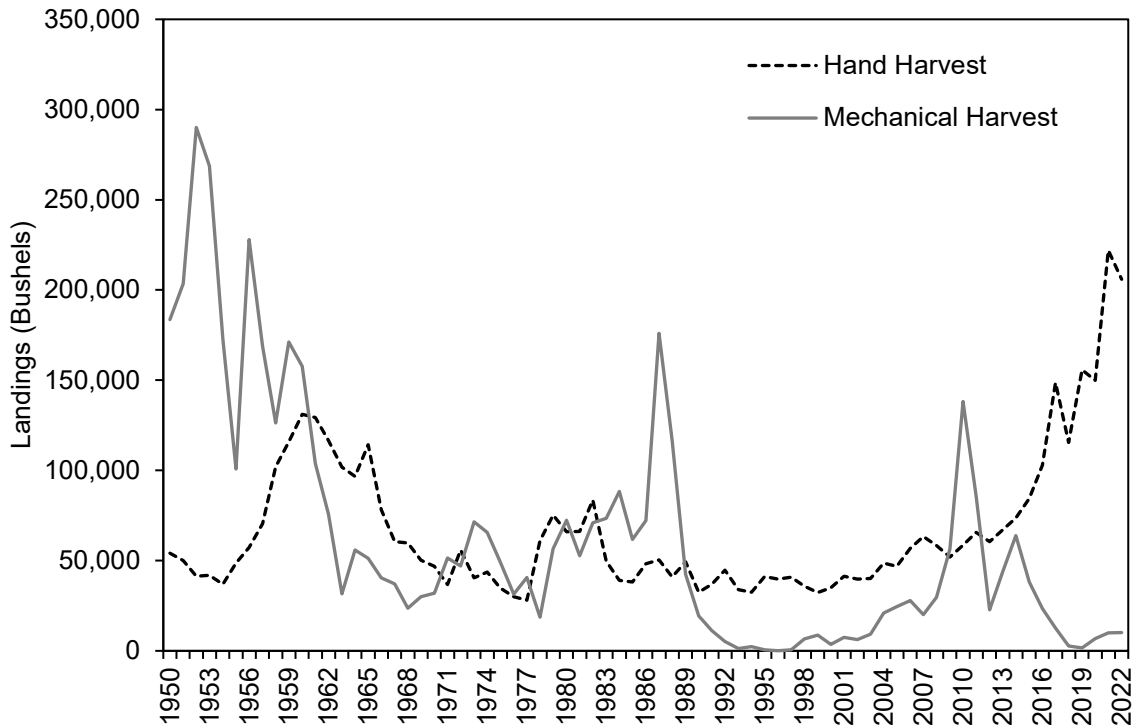


Figure 4. Commercial oyster landings by gear, 1950–2022. Landings for both gear types include both public (wild) and private bottom (farmed oysters). Landings data for farmed oysters are included in this figure as historically it contributed an insignificant portion of the overall oyster landings, and prior to 2010 the distinction between wild and farmed was not recorded in landings data. (Sources: Chestnut and Davis 1975; National Marine Fisheries Service unpublished data; NCDMF Trip Ticket Program).

Recent Changes to Mechanical Harvest Methods

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

From 2009 to 2012, many inexperienced oyster dredgers came into the fishery and several new restrictions were required to maintain traditionally accepted harvest and culling techniques. One of these restrictions was a 2 PM time limit on dredging; this limit resulted in harvesters culling their entire catch after 2 PM rather than on-site, often depositing cultch where it could no longer function as oyster habitat. Additionally, during this time, many vessels were not rigged with towing points over the side of the vessel that work best for circular dredging patterns or for short tows. As a result, restrictions were put in place between the Adoption of Supplement A and before the development of the Oyster FMP Amendment 3 in 2014. The purpose of these restrictions was to encourage circular dredging patterns, which are viewed as less damaging to oyster reef habitat, and shorter tows, which encourage culling onsite and between each deployment of the gear. These restrictions include the following: 1) It is unlawful for the catch container (bag, cage) attached to a dredge to extend more than 2 ft in any direction from the tooth bar; and 2) it is unlawful to tow a dredge unless the point where the tow line or cable is in the water is on the port or starboard side of the vessel forward of the transom. The North Carolina Marine Fisheries Commission established additional measures to further protect oyster habitat, such as Rule 15A NCAC 03K .0202, which requires that oysters be culled on site. As a result of this rule, it is unlawful to possess more than five bushels of uncultured catch onboard a vessel. Only material on the culling tray is exempt from culling restrictions. It is unlawful to possess uncultured catch or culled cultch material while underway and not engaged in mechanical harvesting.

Trends and Impacts to Mechanical Harvest

In the past two decades, the mechanical oyster fishery has experienced two relative peaks, one during 2009–2010 and 2010–2011, and another during 2014–2015 (Figure 5). During the 2009–2010 mechanical harvest oyster season, the Great Island Narrows area between Great Island and mainland Hyde County experienced intensive oyster harvest. NCDMF staff observed approximately 50 oyster dredge boats intensively working in this small area with some returning with new crews to fish the 15-bushel limit twice in one day. Further investigation indicated substantial shell damage was occurring to the remaining oysters and the area was closed after six weeks of harvest. Deeper waters of western Pamlico Sound and areas of Middle Ground also contributed to increased landings in the 2009–2010 and 2010–2011 seasons.

Fishing effort in 2010 was influenced by an increase in market demand due to the closure of oyster harvest areas in the Gulf of Mexico following the Deepwater Horizon oil spill. In response to this market demand, the North Carolina's mechanical harvest season opened earlier than usual, on November 1, 2010. Supplement A to the Eastern Oyster FMP Amendment 2 (adopted November 3, 2010) provided for a variable mechanical harvest limit of up to 20 bushels per day from November 18–24, 2010, and March 16–31, 2011, which likely increased landings. The Neuse River area was closed to dredging from January 7 to February 14, 2011, because samples failed to meet the minimum 26% legal size criterion set in [Supplement A \(NCDMF 2010\)](#). Effort in the Neuse River area appeared to be much lower after the re-opening of the area to oyster harvest in February 2011.

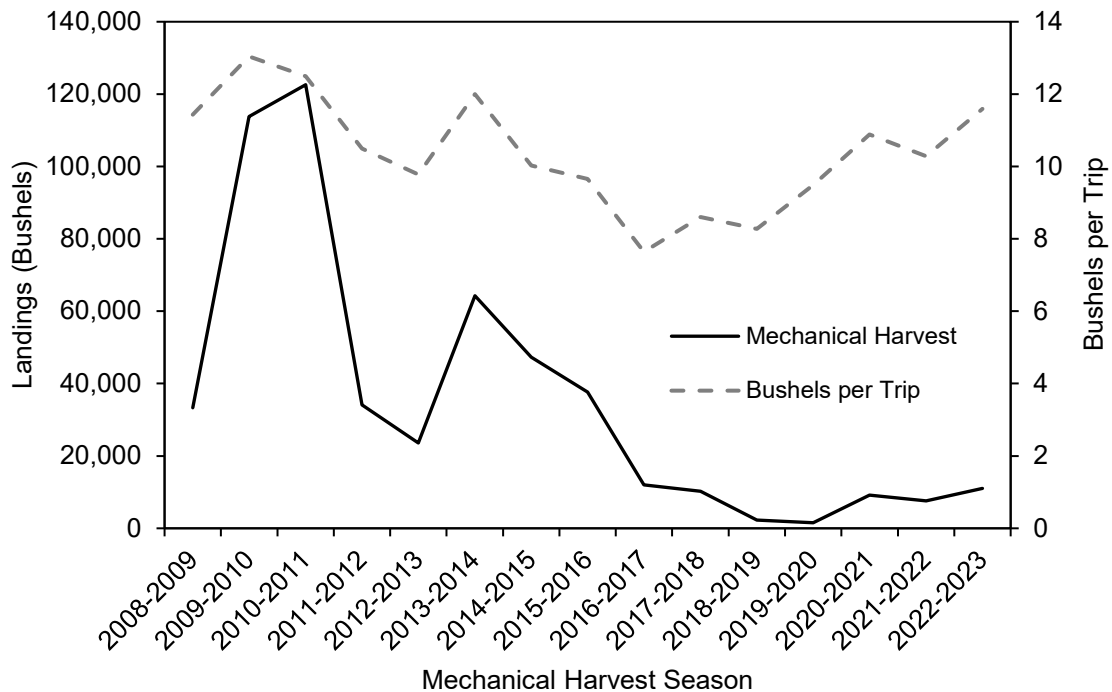


Figure 5. Mechanical harvest oyster landings on public bottom by season 2008–2009 through 2022–23. A monitoring system for determining the closure of mechanical harvest areas began in the 2010–11 season (Source: NCDMF Trip Ticket Program).

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

Prior to the 2012–2013 mechanical harvest season, NCDMF oyster sampling indicated an apparent severely low dissolved oxygen event in the Neuse River that caused virtually 100 percent mortality of the oyster resources at 18 ft or greater depths. A few oyster rocks in shallower waters between Maw Point Shoal and Light House Shoal were spared as well as some NCDMF oyster habitat enhancement projects in other shallow areas. The Pamlico River area also had not recovered from the effects of Hurricane Irene at this time. The Neuse River area was available for mechanical harvest until the adjacent bays closed on December 21; however, there was no harvest activity in the river during the time it was open. The Pamlico River area closed to mechanical harvest on February 1 based on

failure to meet the 26% trigger even though effort was much reduced since early January. The 2012–2013 mechanical harvest oyster landings declined further to 23,566 bushels (Figure 5).

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

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

Overall, participation in the mechanical oyster fishery has declined rapidly since 2010 according to trip ticket data (Figure 6). There was a high of 503 participants in 2010, wherein 74.8% of landings (bushels) were brought in by the top quartile (25%) of participants (Figures 6 & 7). Between 2012 and 2016, participation declined and fluctuated around 200 fishers (Figure 6). During the same period, the top quartile of participants contributed 62–70% of total landings (Figure 7). However, in the last five years (2018–2023) there were 60 or fewer participants in the mechanical oyster fishery, and the top quartile of participants contributed 48–61% of bushels landed (Figures 6 & 7).

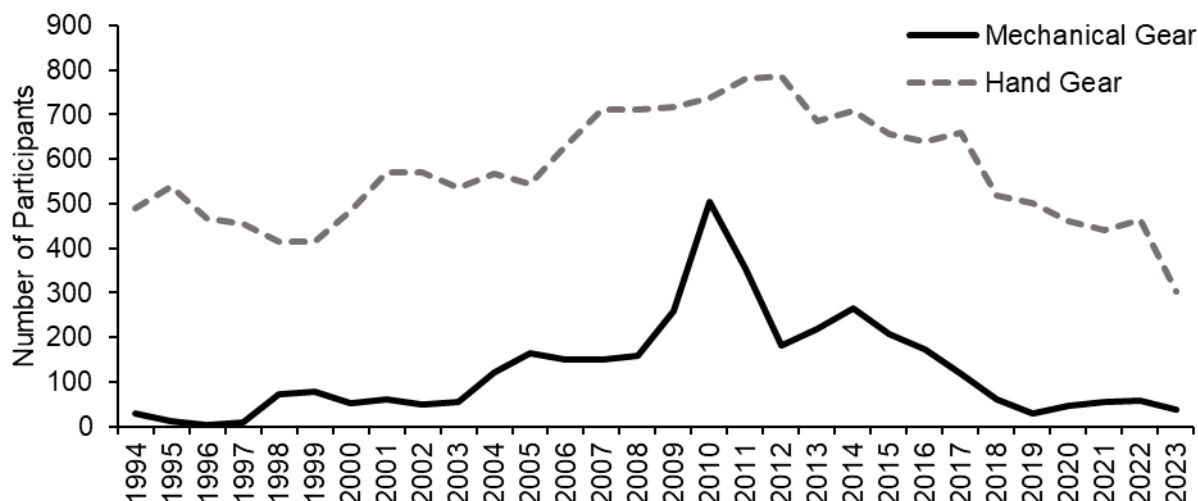


Figure 6. Participation in North Carolina's wild oyster fisheries between 1994 and 2023. Two separate fisheries are distinguished by the two types of gear that may be used to harvest oysters from wild populations: mechanical (dredge) and hand gear (rakes, tongs, etc.). For additional data, see NCDMF License and Statistic's Annual Report.

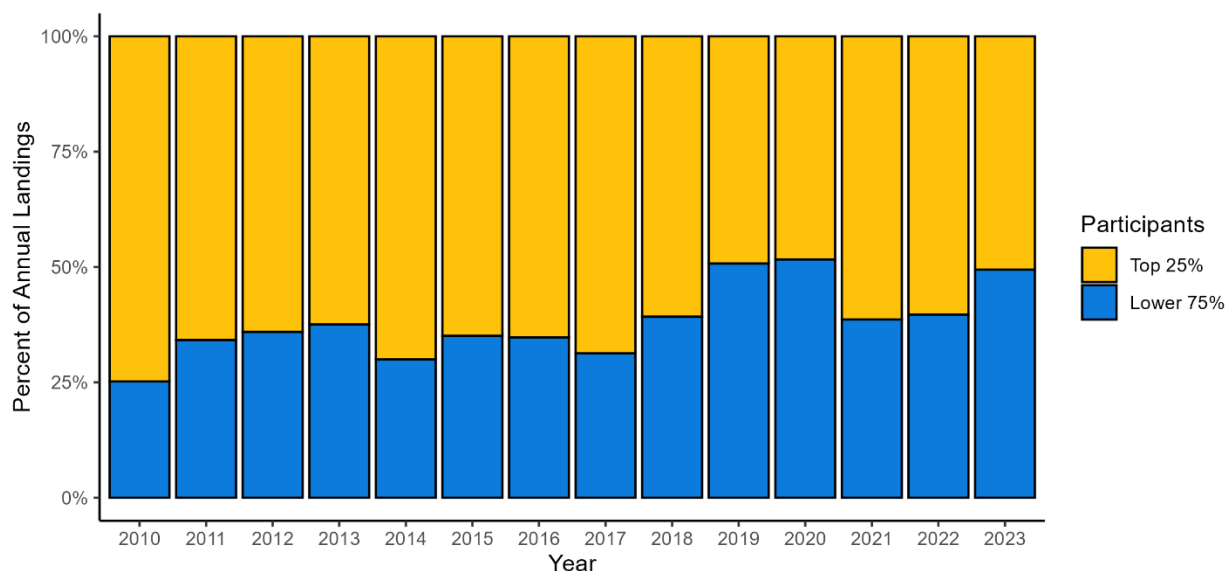


Figure 7. Relative contribution to annual landings from public bottom (wild harvest) by the top quartile of participants in North Carolina's mechanical oyster fishery, 2010–2023 (Source: NCDMF Trip Ticket Program).

HAND-HARVEST METHODS

In North Carolina, hand harvest methods include hand tongs, hand rakes, and by hand (Figure 8). Hand tongs are generally used in shallow subtidal areas. Hand rakes and

actual picking up by hand are normally used in intertidal areas. Some specialized uses of rakes and modified tongs occur in subtidal areas. Hand-harvest methods are allowed in all areas found suitable for shellfish harvest by the Shellfish Sanitation and Recreational Water Quality Section of the NCDMF.

The hand-harvest season for commercial and recreational harvest is October 15 through March 31 each year (15A NCAC 03K .0201 (a)). Commercial harvest is limited to Monday through Friday each week. Some locations may close early due to perceived excessive harvest or pollution concerns. Brunswick County is the only area that frequently closes early due to excessive harvest and typically is closed by proclamation on March 15 annually.



Figure 8. An illustration of several different designs for hand tongs and rakes that may be used for harvesting oysters (from Shafi 2007, reproduced from von Brandt 1964).

Since the 1990s, hand harvest has accounted for most of the commercial landings each season and has been the dominant harvest gear for oysters in North Carolina (See Appendix 3: Intertidal Oyster Harvest Management Information Paper). This trend may be the result of hand harvest landings being less variable than mechanical harvest landings. For instance, southern intertidal oyster resources did not suffer the same long-term mortality from Dermo, an easily transmittable parasitic disease, that affected subtidal oyster beds in the northern part of the state (for more information, see Biological Stressors section).

These higher and more consistent hand-harvest landings come primarily from intertidal oyster reefs between Core Sound and the North Carolina-South Carolina state line (Coastal Fishing Waters in Brunswick, New Hanover, Pender, Onslow, and portions of Carteret counties). This trend is despite the fact that this southern portion of the coast only accounts for five percent of the total area open to shellfish harvest in the state. Additionally, the harvest limit in this area is five bushels per person per day, not exceeding

10 bushels per vessel per day for Standard and Retired Commercial Fishing License holders.

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

Hand-harvest oyster landings from areas north of Core Sound accounted for less than 2% of total hand-harvest landings prior to 2005 (Figure 9). In 2005, the percentage began to climb, reaching a peak near 11% in 2009. The highest percentages occurred in 2015 and 2017, with landings north of Core Sound reaching almost 20% of the total hand-harvest landings. Since 2019, the percentage has remained under 5%.

Across the state, hand-harvest oyster landings generally increased from 1994 to 2017 (Figure 10). This is likely due to increased effort as reflected by the number of trips, mirroring the trend in landings (Figure 9). Hand harvest landings peaked in 2017 at 61,574 bushels, and despite some decline, have remained steady around 41,000 bushels since 2017.

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

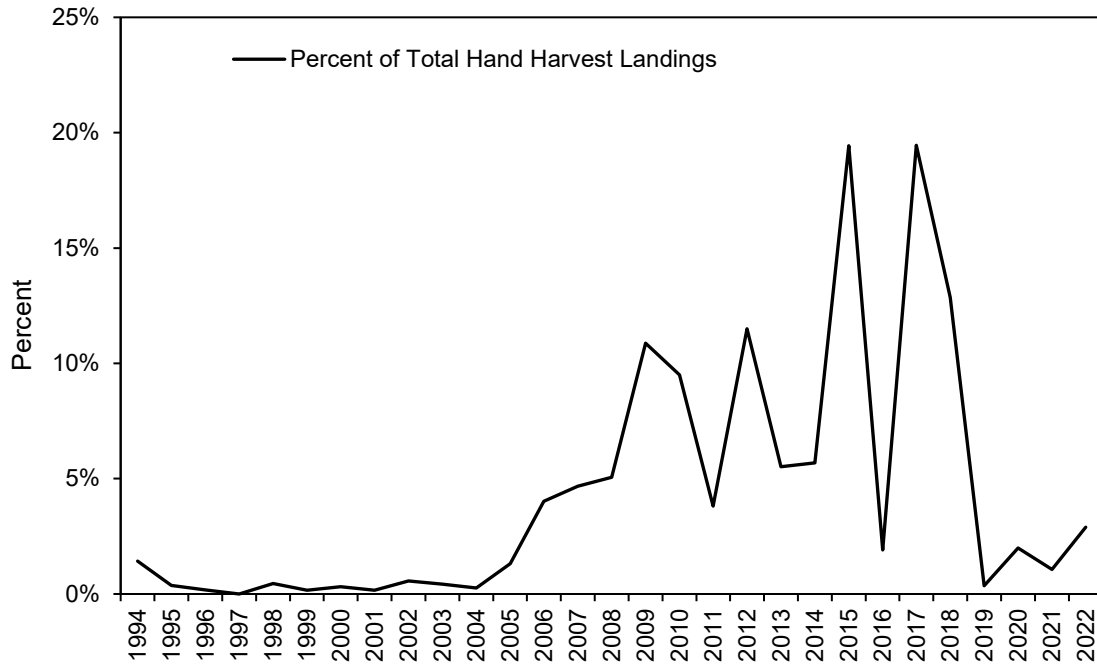


Figure 9. Public bottom commercial hand harvest oyster landings north of Core Sound as a percentage of total public bottom hand harvest oyster landings, 1994–2022 (Source: NCDMF Trip Ticket Program).

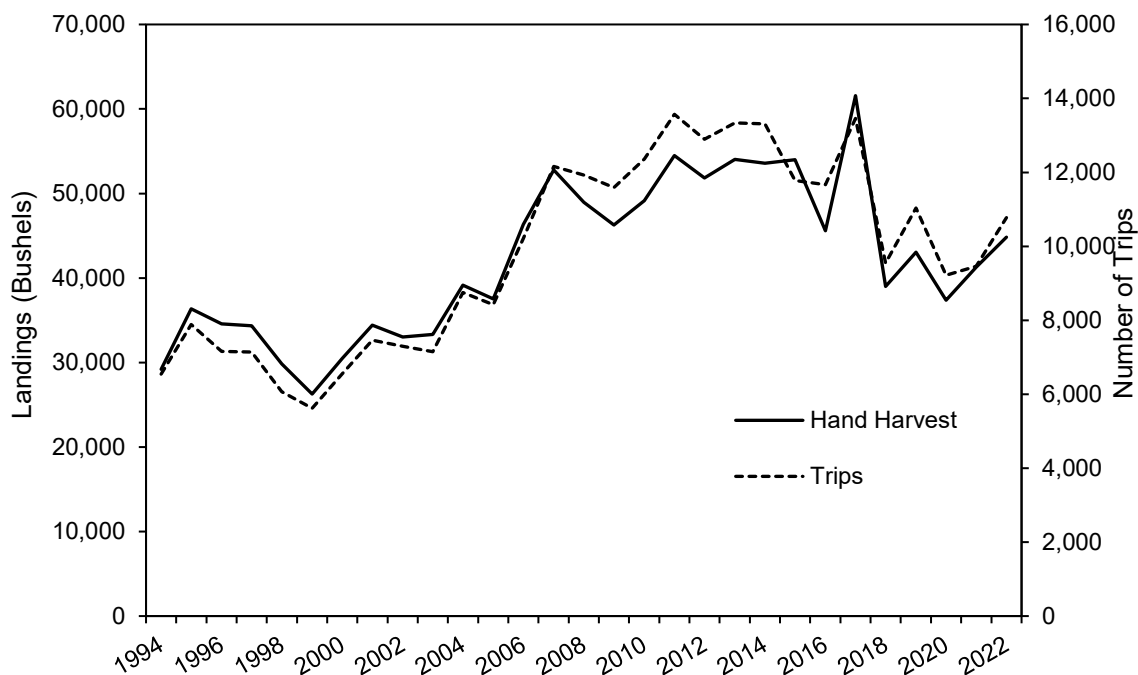


Figure 10. Commercial oyster hand harvest landings and number of dedicated trips in public bottom waters of North Carolina, 1994–2022. (Source: NCDMF Trip Ticket Program).

Recreational Fishery

Oysters are commonly harvested recreationally in North Carolina from October to March by hand, rake, and hand tongs. The limit allowed for personal consumption is one bushel of oysters per person per day, not to exceed two bushels per vessel with a minimum shell length of 3-inches. The NCDMF has limited data on recreational oyster fishing, including the number of participants and the extent of their economic activity. Efforts to accurately quantify the impact of recreational fishing on shellfish (mollusks and crustaceans) have been met with limited success in North Carolina. The NCDMF collects data on recreational fishing in conjunction with the Marine Recreational Information Program (MRIP). However, MRIP collects information on finfish only. The Marine Recreational Fishery Statistics Survey (MRFSS), which was a survey used prior to 2008, reported that more than one million recreational fishing trips targeted shellfish in 1991 in the state; however, estimates of shellfish harvest were not reported.

Based on recommendations by the original Oyster and Hard Clam FMPs, House Bill 1427 was introduced before the general assembly in 2004 to establish a recreational shellfish license on a three-year trial basis (NCDMF 2001b). However, House Bill 1427 was not passed. In the same year, House Bill 831 sought to create a saltwater fishing license

requiring individuals recreationally fishing for finfish and shellfish to obtain a license, but this bill did not pass. The state legislature revisited the issue in 2005 and passed a bill to create the Coastal Recreational Fishing License (CRFL). When CRFL was implemented in 2007, it was only required when harvesting finfish and did not include shellfish.

To fill this data gap, the NCDMF implemented a Saltwater Activity Mail Survey during November 2010 to collect monthly data on the harvest of crabs, oysters, clams, and scallops from the CRFL pool. The survey sample initially included approximately 650 randomly selected CRFL holders that held a valid license for at least one day during the survey period and answered “yes” to the harvest of at least one of the following species: crabs, oysters, clams, or scallops. In September 2014, the sample size doubled to approximately 1,300 CRFL holders. The Saltwater Activity Mail survey continued through July 2023 and is set to resume in 2025.

Each survey sent to selected CRFL holders included an explanation letter outlining methods to return the paper survey or to fill it out online. The survey obtained information on the number of trips taken during the survey period, average length of the trip, average party size, number of species kept and discarded, gear used, location information (water access), waterbody, and county of harvest. Data from this survey were limited in scope but could potentially be used to estimate catch and effort in the recreational shellfish fishery for those people who purchased a CRFL license. One limitation, however, is that the survey did not have the means to include individuals who fish exclusively for shellfish as they would not need to purchase a CRFL.

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

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

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

PRIVATE CULTURE

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

Landings from farmed raised oysters have shown a consistent upward trend since around 2014, surpassing wild harvest landings since 2017 (Figure 11). This shift marked a notable change in the primary methods and scale of production, with farm-raised oysters becoming a dominant component of overall oyster landings in the state. This growth was facilitated by advancements in aquaculture technology, increased investment in oyster farming infrastructure, and favorable market conditions for farmed oysters. Additionally, initiatives supporting aquaculture and the expansion of shellfish leasing programs further contributed to the industry's expansion during this period.

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

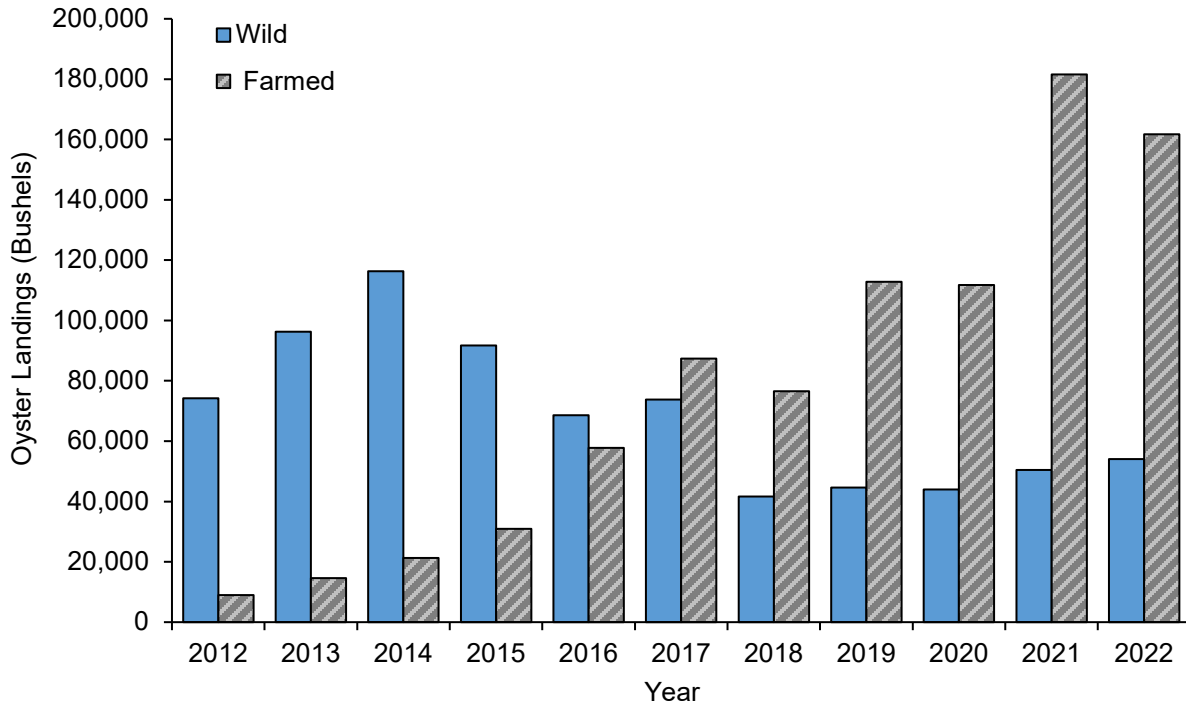


Figure 11 Annual commercial landings of wild harvest and farm-raised (aquaculture) oysters in North Carolina. Wild harvest includes oysters landed by either mechanical (dredge) or hand (e.g., tong, rakes) methods on public bottom.

Summary of Economic Impact

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

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

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

¹As reported by the North Carolina Division of Marine Fisheries (NCDMF) Trip Ticket Program.

²Represents both full-time and part-time jobs.

³Economic impacts calculated using the NCDMF commercial fishing economic impact model.

RECENT ECONOMIC TRENDS

The inflation-adjusted value of North Carolina oysters increased in the early 2010s, reaching a peak of about \$6.7 million in 2010. Since then, the value of the wild oyster fishery has trended downwards (Figure 12). The nominal ex-vessel price per bushel for oysters exhibited an overall steady increase from 1994 to 2022. When corrected for inflation the price per bushel for oysters has increased by \$10 over the last thirty years.

In the 2000s the proportion of landings by mechanical versus hand harvest was consistent before reaching a peak in 2010 when it made up 74% of landings (Figure 13). Since then, mechanical harvest has steadily decreased, comprising a small percentage of total landings. This decrease in mechanical landings is likely a result of changes in licensing requirements for mechanical harvest and waterbody closures from management actions, as well as greater participation in the private lease aquaculture program. While many water bodies have accounted for a steady portion of the overall harvest value, the oyster fishery in Pamlico Sound has decreased in market share from 34% in 2004 down to 16% in 2022. Conversely, Topsail Sound, Masonboro Sound, and Newport River have increased their market shares in the same time span.

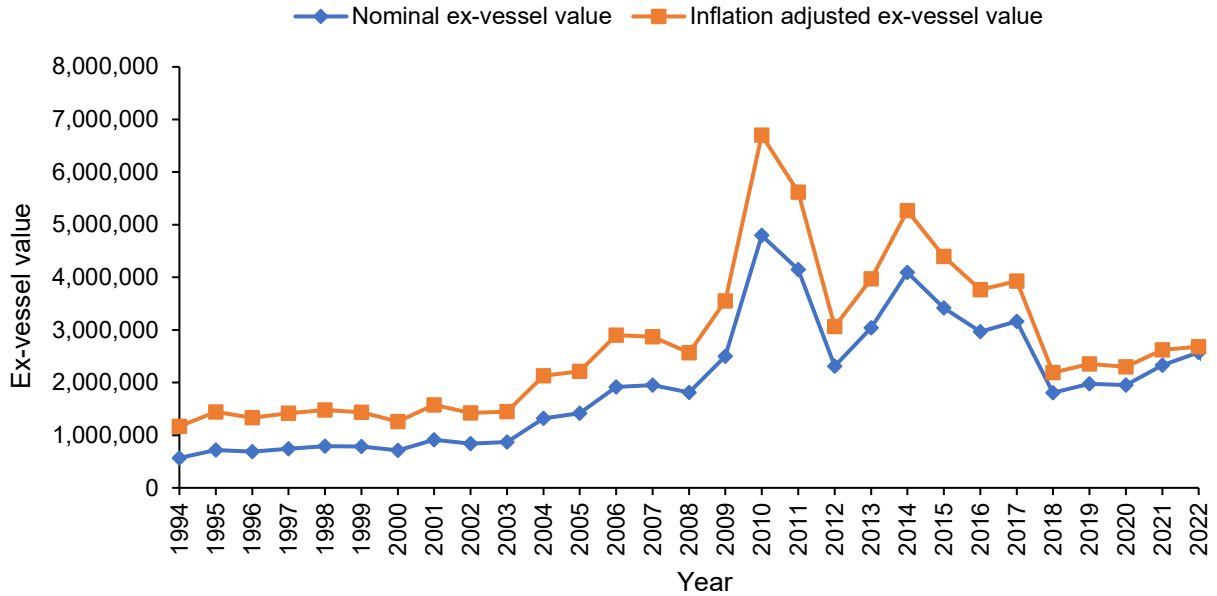


Figure 12. Annual ex-vessel value within North Carolina's wild oyster fisheries, 1994–2022. Inflation adjusted values are in 2023 dollars (Source: NCDMF Trip Ticket Program).

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

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

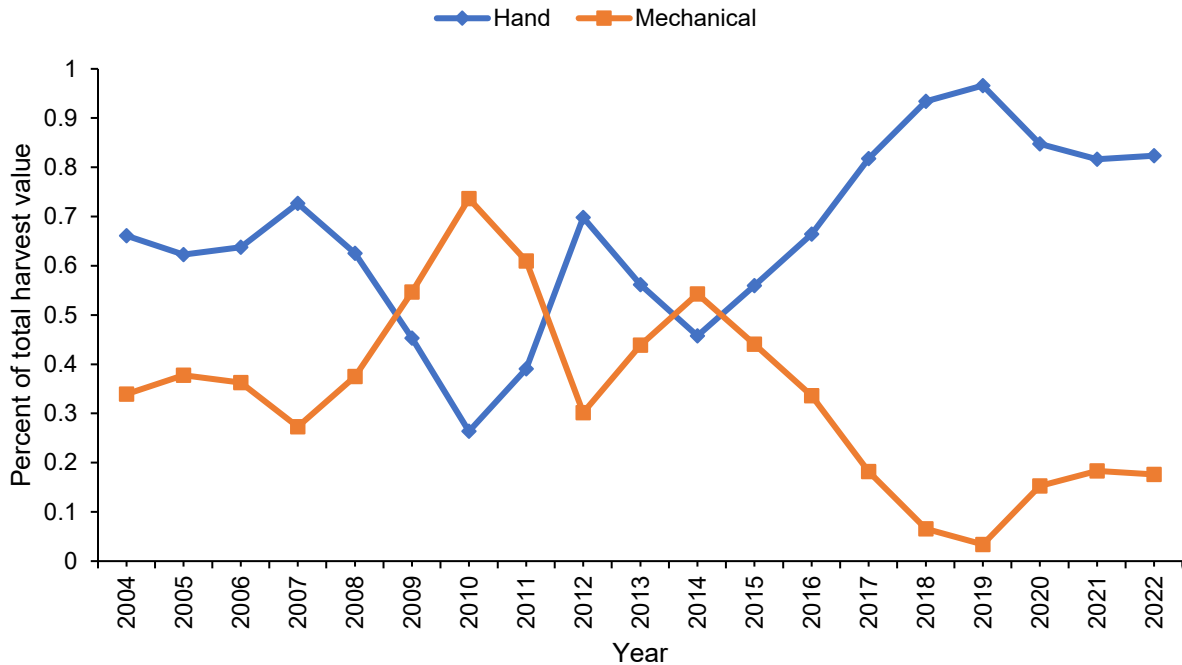


Figure 13. Annual percent of total landings value by gear types used in North Carolina's hand and mechanical oyster fisheries, 2004–2022 (Source: NCDMF Trip Ticket Program).

SOCIAL IMPORTANCE OF THE FISHERY

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

As of the 2017 survey, the greatest number of commercial oyster fishers lived in Sneads Ferry, followed by Newport, Beaufort, and Wilmington. Active participants in the oyster fishery were characterized as white males, with an average age of 50 and 28 years of commercial fishing experience. On average, commercial fishing accounted for 68% of the personal income for these fishers, and 46% reported commercial fishing was their sole source of personal income. Most (77%) commercial fishers that targeted oysters fished year-round. Respondents indicated commercial fishing held extremely high historical and economic importance within their communities.

The most important issue to these fishers was low prices for seafood, which is also related to competition from imported seafood. Another key issue for oyster fishers was coastal development. With several areas of coastal North Carolina having undergone intense

development in recent decades, associated water quality impairments have often impacted opening/closure of shellfish areas. Additionally, coastal development is associated with losing working waterfronts, another top five concern of respondents. Conversely, the bottom ranked issues according to 168 commercial oyster harvesters were keeping up with rule changes/proclamations, overfishing, bag limits, size limits and quotas.

ECOSYSTEM PROTECTION AND IMPACT

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

Coastal Habitat Protection Plan

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

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

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

ESSENTIAL HABITAT

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

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

In North Carolina, over 70 species of fish and crustaceans have been documented using natural and restored oyster reefs (Table 3; ASMFC 2007; Coen et al. 1999; Grabowski et al. 2005; Lenihan et al. 2001; Peterson et al. 2003). The list includes 12 species managed by the Atlantic State Marine Fisheries Commission and seven species managed by the South Atlantic Fishery Management Council, highlighting the importance of this habitat for recreational and commercial fisheries. Many of the state's economically important

fishery species are estuarine dependent at some point in their life cycles as oyster reefs serve as nursery habitat for numerous marine and estuarine species during key phases of their life cycles (Ross and Epperly 1985; Pierson and Eggleston 2014). Fish that utilize oyster reefs can be classified into three groups: residents, facultative residents, and transients. Residents depend on oyster reefs for breeding, feeding, and shelter. Facultative residents primarily use the reefs for food. Transients, on the other hand, visit the reefs for food and shelter but do not rely on them long-term (NCDEQ 2016).

Oyster reefs also host large abundances of small forage fishes and crustaceans, such as pinfish, gobies, grass shrimp, and mud crabs, which are important prey for larger recreationally and commercially important fishes (Minello 1999; Posey et al. 1999; Plunket and La Peyre 2005; ASMFC 2007). The structural complexity of oyster reefs provides safe refuge from disturbance events, thereby offering stability to both shell-bottom and soft-bottom habitats. A diversity of invertebrates and microalgae that have key food web roles inhabit these microenvironments, such as polychaetes, crabs, clams, and amphipods, and those species rely on the interstitial spaces in the shell matrix of oyster reefs to improve survival from foraging by predators like oyster toadfish, blue crabs, and birds (NCDEQ 2016).

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

WATER QUALITY

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

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

DRAFT SUBJECT TO CHANGE

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

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

*NCDMF state managed species

** ASMFC federally managed species

† Most recent stock assessment suggests population is overfished as of 2025

‡ Most recent stock assessment suggests overfishing is occurring as of 2025

Habitat and Enhancement Programs

In 2007, a National Oceanic and Atmospheric Administration biological review team found that east coast oyster harvest was 2 percent of peak historical volume, and suggested oyster restoration and enhancement efforts are “necessary to sustain populations” (EOBRT 2007). One example in North Carolina is the Neuse River Estuary, which has experienced widespread loss of oyster habitat, as oyster beds have been “displaced downstream roughly 10–15 miles” since the late 1940s (Jones and Sholar 1981; Steel 1991). Natural expansion of healthy oyster reefs is not expected in this area because adjacent bottom lacks attachment substrate (Lenihan 1999; Lenihan and Peterson 1998).

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

Additionally, NCDMF’s Habitat & Enhancement Section oversees the construction of no-take reserves with the goal of creating and maintaining a self-sustaining network of subtidal oyster reefs. Protected oyster sanctuaries have the potential to supply approximately 65 times more larvae per square meter than non-protected reefs (Puckett and Eggleston 2012; Peters et al. 2017). This heightened reproductive output potential further benefits naturally occurring reefs and cultch sites as wind patterns distribute oyster larvae to historical oyster fishing areas for grow-out and future harvest (Haase et al. 2012; Puckett et al. 2014). A 20-acre protected oyster reef could provide an annual commercial fish value of \$33,370 and have a larval oyster supply functionally equivalent to 1,300 acres of non-protected oyster reef (adapted from Grabowski et al. 2012; Peters 2014; Peters et al. 2017). Oyster Sanctuaries also provide recreational hook-and-line fishing and diving opportunities for the public. Sanctuary and cultch sites are planned with the aim of improving larval connectivity within the network of restoration sites. To date there are 17 sanctuaries (Figure 4.2), and a total of 789 acres of protected habitat placed in effect by proclamation (see Appendix 4 for more information on Enhancement Programs).

Secondary to improving oyster populations, enhancement programs also provide valuable reef habitat for many estuarine species (Table 3). Both cultch sites and sanctuaries offer oysters and other species refuge from hypoxia events via the construction of high relief habitat using alternative substrates. Additionally, artificial reefs may serve as nursery habitat to commercially valuable finfish. The estimated commercial fish value supported by a hectare of oyster reef is \$4,123 annually (Grabowski et al. 2012). Peterson et al. (2003) conducted a meta-analysis that indicated every 10 m² of newly constructed oyster reef in the southeast United States is expected to yield an additional 2.6 kg of fish production per year for the lifetime of the reef.

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

Threats and Alterations

Oysters are unique in their status as an ecosystem engineer in that they not only have a disproportionate impact on their surrounding environment, but they are also a global commodity. Declining oyster populations have been observed, especially on sub-tidal reefs along the US East Coast (Rothschild et al. 1994; Hargis and Haven 1988; NCDMF 2001b; EOBRT 2007). The declining trend has been noted for oyster harvest in North Carolina (Street et al. 2005; Deaton et al. 2010).

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

PHYSICAL DISTURBANCE FROM HARVEST METHODS

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

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

but that oyster harvesting had little effect on clam populations. Further discussion of the impacts of hand harvest is included in Appendix 3.

BIOLOGICAL STRESSORS

Introduced Species

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

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

Dermo Disease

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

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

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

Staff observed in southern estuaries during late summer months that moderate and high Dermo infection levels did not reduce oyster populations. It is suspected that small, high salinity estuaries may inhibit mortality by flushing out parasites at a higher rate or by exceeding the salinity tolerance of the Dermo parasite, allowing for a higher survival rate compared to Pamlico Sound. The link between low dissolved oxygen, increased availability of iron, and increased parasite activity may also be a factor in the different mortality rates as the smaller, high salinity estuaries are less prone to low dissolved oxygen events than Pamlico Sound (Leffler et al. 1998). Dermo infection intensity levels since 2005 have remained low and have likely not resulted in large scale mortality events, resulting in NCDMF discontinuing the routine annual monitoring program in 2017 (NCDMF unpublished data).

Other Harmful microbes

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

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

consume raw shellfish in the warm-water months. Humans can also contract *Vibrio* infections through open wounds on the skin and contact with brackish or saltwater.

Neurotoxic Shellfish Poisoning is a disease caused by consumption of molluscan shellfish contaminated with brevetoxins primarily produced by the dinoflagellate, *Karenia brevis*. Blooms of *K. brevis*, sometime referred to as Florida red tide, occur frequently along the Gulf of Mexico (Watkins et al. 2008). Red Tide events have been documented to cause impacts to shellfish fisheries in North Carolina (NCDMF 2001a).

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

Boring Sponge

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

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

WATER QUALITY THREATS

Marine bivalves, including oysters, have been shown to accumulate chemical contaminants, such as hydrocarbons and heavy metals, in high concentrations. Reductions in growth and increased mortality have been observed in soft-shelled clams (*Mya arenaria*) following oil spill pollution events (Appeldoorn 1981). Impaired larval

development, increased respiration, reduction in shell thickness, inhibition of shell growth, and general emaciation of tissues have been attributed to adult bivalve exposure to heavy metal contamination (Roesijadi 1996). High concentrations of organic contaminants also result in impairment of physiological mechanisms, histopathological disorders, and loss of reproductive potential in bivalves (Capuzzo 1996). As shellfish can easily accumulate chemical pollutants in their tissues, consumption of impaired shellfish creates a health risk. Subsequently, shellfish closures occur due to chemical contamination, commonly associated with industry, marinas, and runoff.

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

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

Low Oxygen

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

Shellfish Sanitation

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

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

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

Climate Change

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

For instance, Paerl et al. (2020) investigated the impact of tropical cyclones on nutrient delivery and algal bloom occurrences in the Neuse River Estuary and Pamlico Sound. They found high-discharge storm events, such as high-rainfall tropical cyclones, can double annual nutrient loadings to the estuary, leading to increased nutrients and dissolved organic carbon. Phytoplankton response to moderate storm events is immediate, while during high-rainfall events like Hurricanes Floyd (1999), Matthew

(2016), and Florence (2018), phytoplankton growth is diverted downstream to Pamlico Sound, where it can persist for weeks. Additionally, increased organic matter and phytoplankton biomass from heavy rainfall events contribute to oxygen depletion, exacerbating hypoxic and anoxic conditions in the Neuse River and Pamlico Sound.

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

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

Protected Species

A "protected species" is defined as any organism whose population is protected by federal or state statute due to the risk of extinction. In North Carolina, these species are primarily protected by the following federal statutes: the Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), and the Migratory Bird Treaty Act. The primary marine mammal that occurs in North Carolina estuaries is the common bottlenose dolphin (*Tursiops truncatus*; Hayes 2018) though the West Indian Manatee (*Trichechus manatus*) seasonally occurs during warm water months (Cummings et al. 2014). The NMFS has designated oyster fisheries as Category III, with no known gear interactions with marine mammals. More information on the MMPA List of Fisheries and fisheries categorizations can be found on the National Oceanic and Atmospheric Administration (NOAA) MMPA [website](#).

North Carolina estuaries are also home to multiple ESA-listed species including the Green Sea Turtle (*Chelonia mydas*), Kemp's Ridley Sea Turtle (*Lepidochelys kempii*), Loggerhead Sea Turtle (*Caretta caretta*), Leatherback Sea Turtle (*Dermochelys coriacea*), Hawksbill Sea Turtle (*Eretmochelys imbricata*), Atlantic Sturgeon (*Acipenser oxyrinchus*), and Shortnose Sturgeon (*Acipenser brevirostrum*). These species are unlikely to be impacted as harvest methods employed largely exclude any potential for direct interactions. Due to the lack of recorded interactions and the unlikelihood of any interactions between these ESA-listed species and the oyster industry, it can be assumed any potential impacts of oyster harvest on protected species populations would be indirect and at the ecosystem-level.

A diverse array of migratory bird species occurs in North Carolina estuaries (Potter et al. 2006). Little evidence exists to suggest birds are directly impacted by oyster harvest.

However, as oysters are a primary prey species of the American Oystercatcher (*Haematopus palliatus*; Tuckwell and Nol 1997), oyster harvest may result in secondary interactions with the species. For example, overharvest of oyster reefs has been found, in some cases, to contribute to a decrease in overall reproductive success of nearby nesting Oystercatchers (Thibault et al. 2010).

FINAL AMENDMENT 5 MANAGEMENT STRATEGY

The NCMFC selected management measures

APPENDIX 1: RECREATIONAL SHELLFISH HARVEST ISSUE PAPER

Option 1: Recreational Harvest

- b. Support the NCDMF to further explore potential options and develop a solution to estimate recreational shellfish participation and landings, with the intent to move towards a stock assessment and stock level management for both hard clams and oysters; and to establish a mechanism to provide all recreational shellfish harvesters with SSRWQ health and safety information outside of the FMP process.

APPENDIX 2: MECHANICAL OYSTER HARVEST MANAGEMENT ISSUE PAPER

Option 1: Deep-water Oyster Recovery Areas (DORAs)

- b. Adopt the proposed Pamlico and Neuse River Deep-water Oyster Recovery Areas (DORAs), which are bound by existing navigational aids as presented to the NC MFC Advisory Committees, to protect deep subtidal oyster reefs from continued physical disturbance by mechanical gear. These areas will be closed to mechanical oyster dredging and monitoring efforts will be used to evaluate the effectiveness of closure within the next FMP amendment. The DORAs cover 681 acres of potential oyster habitat (500 acres in Pamlico River and 180 acres in Neuse River), which represents approximately 81% of the vulnerable deep-water oyster habitat.

Option 2: Cultch Supported Harvest

- b. Adopt the Cultch Supported Harvest strategy outlined in Appendix 2, which would set the season length based on pre-season sampling aided by industry input on sampling locations with the 10 bushel per day and 15 bushel per day areas considered separately.

Option 3: Rotational Cultch Site Strategy

- b. Adopt the inclusion of Rotational Harvest Cultch Sites strategy outlined in Appendix 2. This strategy would create a rotating series of readily available cultch

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areas available to harvest for the full extent of the mechanical season length each year with the intent of reducing harvest pressure on natural reefs.

Option 4: Adaptive Management

- b. Adopt the proposed adaptive management framework to allow for modification of set season length based on changes to participation in the fishery.

MANAGEMENT FROM PREVIOUS PLANS

The following management measures from the previous FMP are carried forward into Amendment 5.

- A daily limit of two bushels of oysters per person with a maximum of four bushels of oysters per vessel off public bottom for Shellfish License holders statewide.
- A six-week opening timeframe for mechanical harvest in deep bays to begin on the Monday of the week prior to Thanksgiving week through the Friday after Thanksgiving. Reopen two weeks before Christmas for the remainder of the six-week season.
- A 15-bushel hand/mechanical harvest limit in Pamlico Sound mechanical harvest areas outside the bays, 10-bushel hand/mechanical harvest limit in the bays, and 10-bushel hand harvest limit in the Mechanical Methods Prohibited area along the Outer Banks of Pamlico Sound. Areas as defined and adopted in Amendment 2 of the Oyster FMP (NCDMF 2008).

RESEARCH NEEDS

The research recommendations listed below are offered by the NCDMF to improve future management strategies for the Eastern Oyster fishery. They are considered high priority as they will help to better understand the oyster fishery and meet the goal and objectives of the FMP. A more comprehensive list of research recommendations is provided in the [Annual FMP Review](#) and [NCDMF Research Priorities](#) documents.

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

APPENDICES

Appendix 1: Recreational Shellfish Harvest Issue Paper

ISSUE

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

ORIGINATION

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

BACKGROUND

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

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

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

estimates were not reported. The current extent of coastal households in North Carolina that recreationally harvest shellfish is unknown at this time.

The Marine Fisheries Commission in the original Bay Scallop, Hard Clam, and Oyster FMPs recommended developing a mechanism to obtain data on recreational harvest of shellfish (DMF 2007). The need for a mechanism to be able to accurately quantify recreational effort and harvest has been a consistent area of concern in all subsequent North Carolina shellfish and crustacean FMPs. The Hard Clam Fisheries Management Plan FMP (NCDMF 2001a) and Eastern Oyster FMP (NCDMF 2001b) supported adoption of a mechanism to provide data on recreational shellfish harvest. As a result, House Bill 1427 was introduced before the General Assembly in 2003 to establish a recreational shellfish license. This license would have been for shellfish only and would have been instituted on a trial basis for three years. However, the bill was never passed. In 2004, House Bill 831 did pass a saltwater fishing license mandating those individuals recreationally fishing for both finfish and shellfish to obtain a license. However, the state legislature revisited the issue in 2005 and replaced the saltwater fishing license with the Coastal Recreational Fishing License (CRFL). The CRFL, which was implemented January 1, 2007, is only required when targeting finfish. When the CRFL legislation was originally drafted in 2007, it also included shellfish. However, the inclusion of shellfish was removed from the draft bill was removed before it was finally legislated.

To fill this data gap, the NCDMF implemented a Saltwater Activity Mail Survey during November 2010 to collect monthly data on the harvest of crabs, oysters, clams, and scallops from the CRFL pool. The survey sample initially included approximately 650 randomly selected CRFL holders that held a valid license for at least one day during the survey period and answered “yes” to the harvest of at least one of the following species: crabs, oysters, clams, or scallops. In September 2014, the sample size doubled to approximately 1,300 CRFL holders. The Saltwater Activity Mail survey continued through July 2023 and is set to resume in 2025.

Each survey sent to selected CRFL holders included an explanation letter outlining methods to return the paper survey or to fill it out online. Those that did not respond by the end of the month were sent a second copy of the survey. The survey obtained information on the number of trips taken during the survey period, average length of the trip, average party size, number of species kept and discarded, gear used, location information (water access), waterbody, and county of harvest. Despite good response rates, few responses contained oyster and clam activity. One limitation to the survey, however, is that the survey did not have the means to include individuals who fish exclusively for shellfish as they would not need to purchase a CRFL. So, while the data are a useful representation of shellfish harvest by CRFL holders, they do not cover the entire population of potential recreational shellfish harvesters and probably represent a minimum estimate of effort and harvest.

The Fisheries Reform Act of 1997 (FRA) created a Recreational Commercial Gear License (RCGL) to allow recreational fisherman to use limited amounts of commercial gear to harvest recreational limits of seafood for personal consumption; however, shellfish gear (including hand, rakes, and tongs) was not authorized under this license. Since these

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gears are not covered by RCGL, recreational shellfishers can use these gears to harvest recreational bag limits of oysters and clams without a license. Therefore, recreational harvest data are not captured by past RCGL surveys.

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

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

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

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

- Prohibited Shellfish Harvest Boundaries – SSRWQ establishes permanent closure boundaries that prohibit the harvest of shellfish in areas where there may be consistent contamination exceeding the standards for safe human consumption. These permanently closed areas are described and established via proclamation.
- Polluted Area Proclamations and Temporary Closure Maps – In addition to the permanently closed areas described above, studies have found that water quality in certain areas can be negatively impacted by stormwater runoff, and shellfish can become temporarily unsafe for harvest under certain conditions. SSRWQ has developed management plans describing rainfall thresholds that can generate negative impacts and require temporary closures of these impacted areas. Temporary closures are put in place via proclamation and shown visually on the NCDMF website through a [web map](#) updated as closed areas change.
- Articles and Fact Sheets on Safe Handling Practices – Temperature abuse or improper handling practices can render shellfish unsafe to eat. To provide the public with information on how to safely store and handle shellfish, SSRWQ has prepared articles, fact sheets, and pamphlets available through the NCDMF [website](#).
- Information on *Vibrio* Bacteria – *Vibrio* bacteria are naturally occurring bacteria that can be found in North Carolina waters and can cause severe illness in certain susceptible populations if consumed or through exposure to open wounds. Notably, these bacteria can proliferate within harvested shellfish even after they've been removed from the water, if the shellfish are held in warm/hot temperatures for extended periods of time. Proper handling/cooling of harvested shellfish is a critical step towards avoiding illness. SSRWQ has made available pamphlets and articles describing risks associated with these types of bacteria, and best practices for shellfish handling.

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

AUTHORITY

N.C. General Statute

113-134	Rules.
113-169.2	Shellfish license for NC residents without a SCFL.,
113-174.2	Coastal Recreational Fishing License.
113-182	Regulation of fishing and fisheries.
113-182.1	Fishery Management Plans.

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- 113-201 Legislative findings and declaration of policy; authority of Marine Fisheries Commission.
- 113-221.1 Proclamation; emergency review.
- 143B-289.52 Marine Fisheries Commission – powers and duties.

Session Law 2023-137

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

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

DISCUSSION

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

License requirements for recreational shellfish harvesting varies by state along the United States east coast (Table 1.1). Most states require some type of license while in Maine, Massachusetts, New York, and Connecticut individual towns and cities require a license to recreationally harvest shellfish. North Carolina and Virginia are the only states without some form of license, local permitting, or residency requirements.

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

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Table 1. 1. Recreational shellfish harvest license requirements for east coast states.

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

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

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

Another way to obtain data on recreational shellfish activity would be through the MRIP. The MRIP does capture some non-fish activity, but those data are broad and not available to shellfish at the species level and MRIP agents rarely encounter those types of recreational fishing trips. Most recreational shellfishing effort is by coastal residents using private docks and access points as opposed to public access points. Because MRIP is a nationwide program, any changes to methodology designed to intercept more recreational shellfishing activity would need to undergo extensive review process and if implemented could take away from intercepts in other target fisheries.

Personal consumption by participants holding commercial fishing licenses (either a SCFL with a shellfish endorsement or a Shellfish license without a SCFL) would not be covered

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under any type of recreational shellfish license or permit. In the fall of 2023, the North Carolina General Assembly passed Session Law 2023-137. Section 6 of this legislation requires anyone holding a commercial fishing license who is engaged in a commercial fishing operation to report all fish (including shellfish) harvested to NCDMF, regardless of if the fish are sold or kept for personal consumption. Currently, this legislation is effective December 1, 2025. The NCDMF is working on draft rules to implement this law and to develop the reporting mechanism for these participants. Implementation of this law should fill this data gap.

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

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

Option 1: Recreational Harvest

a. Status Quo

- Does not provide reliable estimates of recreational shellfish harvest or effort.
- Does not provide a mechanism to ensure recreational shellfish harvesters are provided with SSRWQ health and safety information and links to harvest area closures.

- #### b. Support the NCDMF to further explore potential options and develop a solution to estimate recreational shellfish participation and landings, with the intent to move towards a stock assessment and stock level management for both hard clams and oysters; and to establish a mechanism to provide all recreational shellfish harvesters with SSRWQ health and safety information outside of the FMP process.

RECOMMENDATIONS

The DMF recommends that the NCMFC support the NCDMF to further explore potential options and develop a solution to quantify recreational shellfish participation and landings, with the intent to move towards a stock assessment and stock level management for both hard clams and oysters; and to establish a mechanism to provide all recreational shellfish harvesters with SSRWQ health and safety information outside of the FMP process.

Advisory Committee Recommendations and Public Comment: see [Appendix 7](#)

NCMFC Selected Management Options

Option 1: Recreational Harvest

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

Appendix 2: Mechanical Oyster Harvest Management Issue Paper

ISSUE

Addressing management for the mechanical fishery for subtidal oysters in Pamlico Sound, North Carolina.

ORIGINATION

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

BACKGROUND

The North Carolina Eastern Oyster Fishery Management Plan (FMP) Amendment 5 focuses on management of wild oysters, and this issue paper does not include farm raised or private cultured oysters.

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

Currently, large scale abundance estimates or a traditional stock assessment for the Eastern Oyster in North Carolina is not possible. Without a stock assessment the Division of Marine Fisheries (hereafter, DMF) is unable to assign a stock status or determine sustainable harvest limits. Oysters pose a unique management problem as they are simultaneously a stock that is harvested as a fishery resource, and the essential habitat for that same fishery resource. Oysters need suitable hard substrate (cultch) for juvenile oyster (spat) to settle on and grow. Shells of living or dead oysters provide the appropriate hard substrate for juvenile oysters to settle on, creating self-sustaining oyster reefs. If living oysters or dead shell material is removed from a reef through fishery effort at a rate faster than it can naturally replenish, both the oyster resource and habitat required for oysters to successfully reproduce will eventually disappear. An approach to manage oyster fisheries that considers this balance of shell gain and loss (Shell Budget Model) has been developed and employed in the Gulf of Mexico (Soniat et al. 2022; Soniat 2016).

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

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

The mechanical harvest season has the potential to occur between the Monday of the week prior to Thanksgiving week, which is typically the third Monday in November, to 31 March in areas designated open to mechanical harvest; however, the actual season length is ultimately determined by a harvest monitoring program. In bays where harvest is allowed, the season is capped to a total of six possible weeks. If the area in which the bay is located is closed due to harvest monitoring the season may be shorter than six weeks.

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

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

The current harvest monitoring program which serves as a habitat protection framework to manage fishery effort in the Pamlico Sound mechanical oyster fishery was developed as Supplement A to Amendment 2 of the Oyster FMP and has been in place since 2010. In this framework, the sound is divided into four Management Areas based on geographic region: the Neuse River Area, Pamlico River Area, Northern Hyde Area, and Northern Dare Area (Figure 2.3). The NCDMF samples oyster reefs in each management area once before the opening of the mechanical harvest season, and then biweekly once mechanical harvest is open. Sampling sites are chosen based on the current (or previously known) presence of commercial harvesting in the area. Areas are selected where commercial harvest occurs with the goal of assessing localized depletion and addressing habitat protection concerns. A threshold of 26% legal-size live oysters (3 inches shell length or greater) in pooled samples for each sampling event and Management Area was established as the management trigger. In developing this management framework, the effect of the effort required to harvest a limit of legal oysters on reef habitat was considered. When an area oyster population reaches 26% or lower legal oysters, it was determined that impacts to reef habitat through the removal of shell material outweighed the fishery benefit from harvest. If the pooled samples collected across a management area for a sampling event show 26% or less legal oysters, the management trigger is tripped for that area. If two consecutive sampling events result in the management trigger being tripped, the entire management area is closed to mechanical harvest. An area may re-open if two additional consecutive sampling events show above 26% legal oysters.

There is no minimum threshold for percent legal in the initial opening of an area to mechanical harvest. A management area will open even if pre-season sampling shows the area is below the 26% legal threshold. Biweekly sampling begins the first week of the mechanical harvest season, meaning areas that start below the 26% legal threshold can take three weeks to trip the management trigger twice before closing.

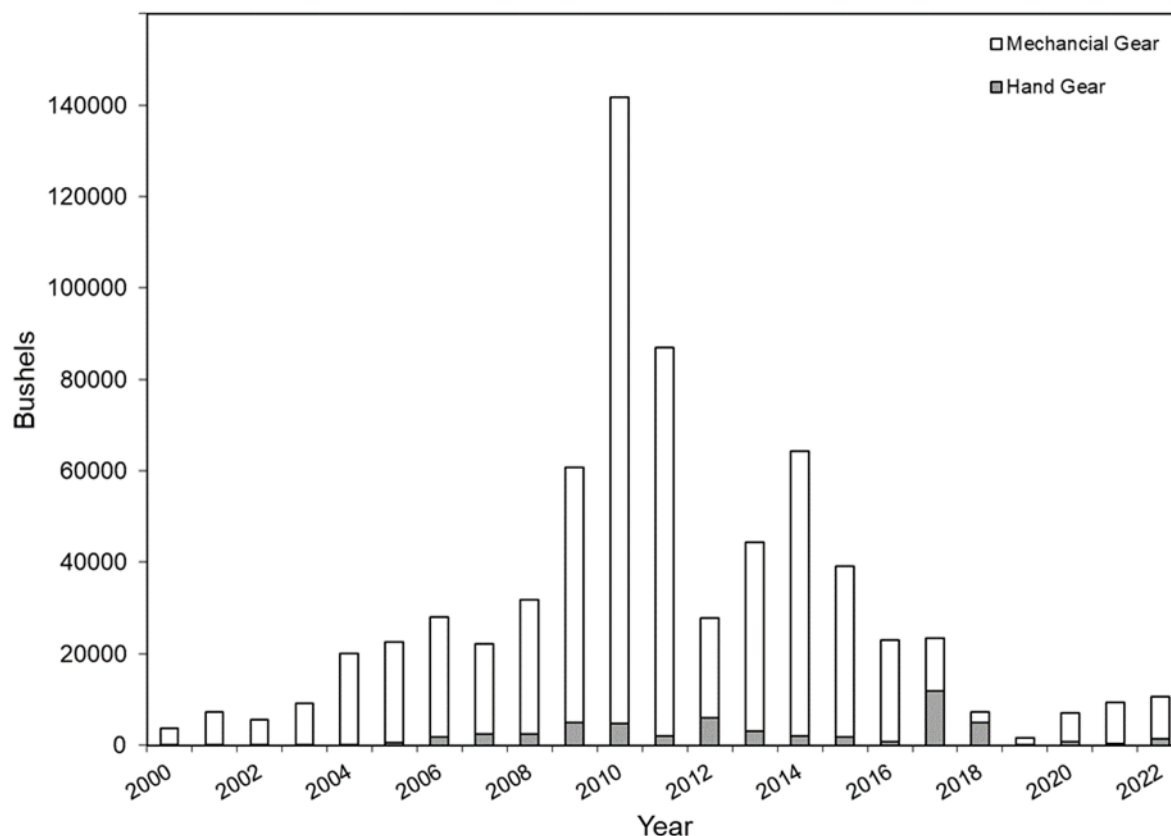


Figure 2.1. Commercial landings of wild oysters from greater Pamlico Sound, adjacent bays and tributaries in North Carolina from 2000 to 2022, showing annual landings in bushels harvested by hand gear (rakes, tongs, hand) as dark gray bars and mechanical gear (dredges) as white bars.

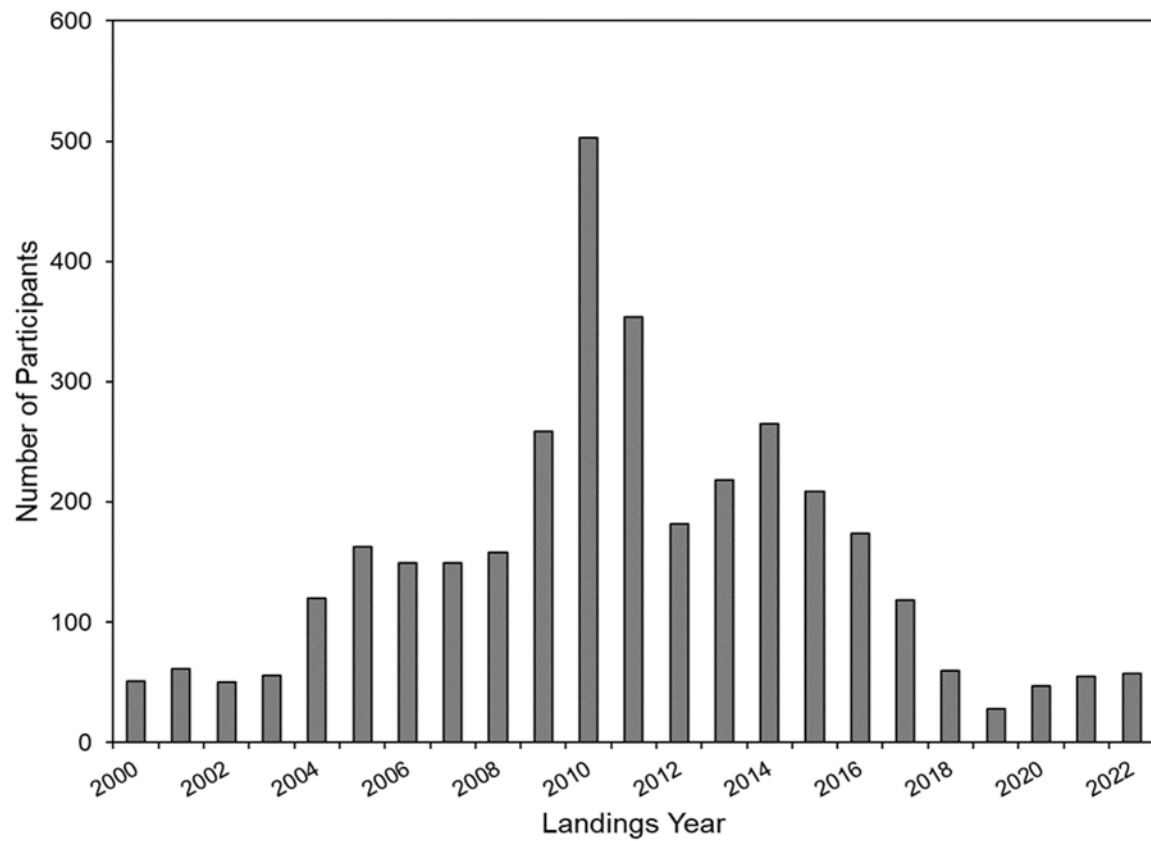


Figure 2.2. Annual number of participants with landings of wild oyster using mechanical gear, 2000–2022.

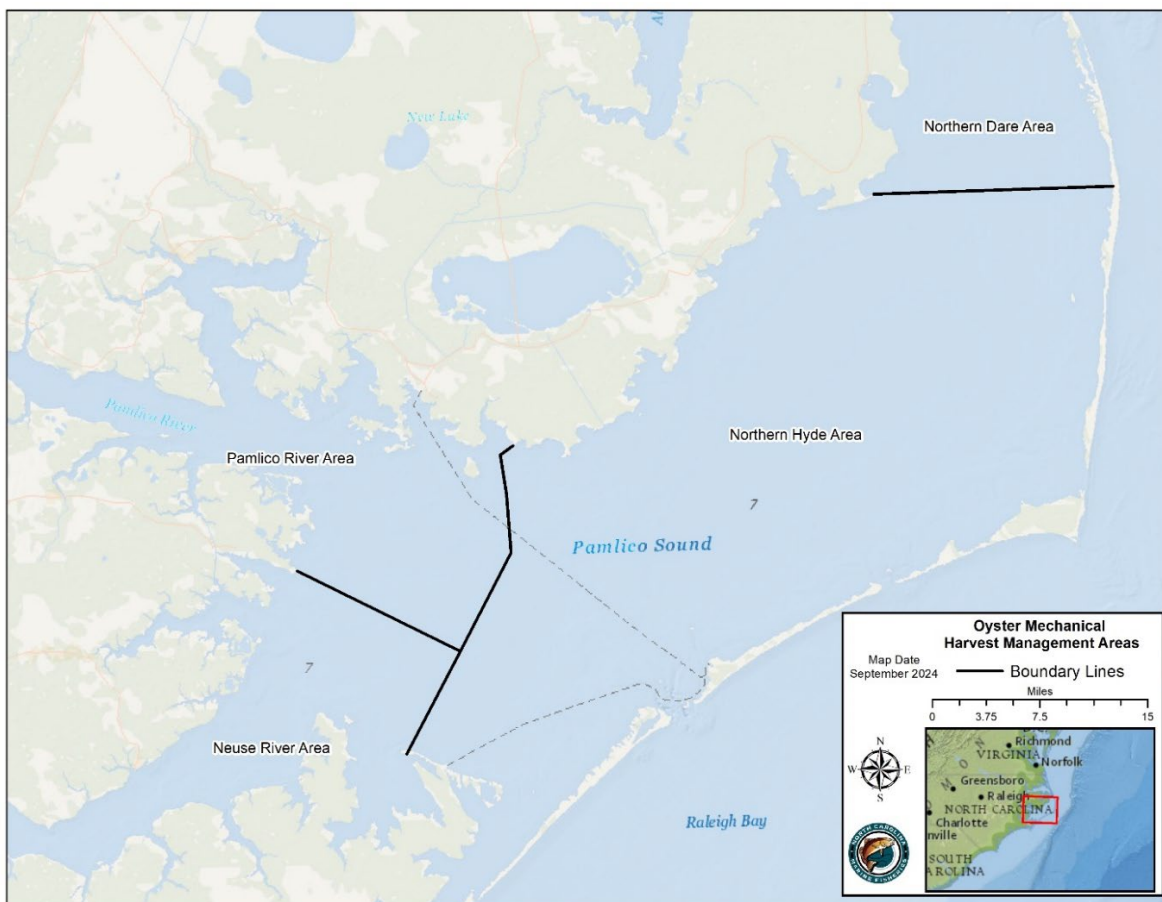


Figure 2.3. Pamlico Sound Oyster Mechanical Harvest Management Areas from south to north: the Neuse River Area, Pamlico River Area, Northern Hyde Area, and Northern Dare Area.

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

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When the bays are examined separately from the deep waters, they have averaged above the management trigger (Table 2.2).

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

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

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

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

The NCDMF has one of the longest running and expansive oyster restoration and enhancement programs in the United States. North Carolina's Cultch Planting Program began in 1915 to replace shell material removed by harvest. Since its inception, over 21 million bushels of cultch material have been planted in the form of small-scale, low-relief, harvestable oyster reefs. Today, the NCDMF Cultch Planting Program creates oyster reefs that provide both habitat restoration and alleviation of public harvest pressure from natural reefs. Over the last ten years, 624 acres of harvestable oyster reefs have been created on public bottom through this program, with the ongoing goal of creating an additional 50 acres per year into the future. In addition, 789 acres of protected oyster reef have been permitted and constructed across 17 separate no-take Oyster Sanctuaries in Pamlico Sound. For more detailed information about these two programs see Appendix 4: Habitat Enhancement Programs. In areas open to mechanical harvest, cultch planting efforts have been focused primarily in the bays of the Neuse and Pamlico River Areas as well as in the eastern portion of the sound in the Dare and Hyde areas (Figure 2.4).

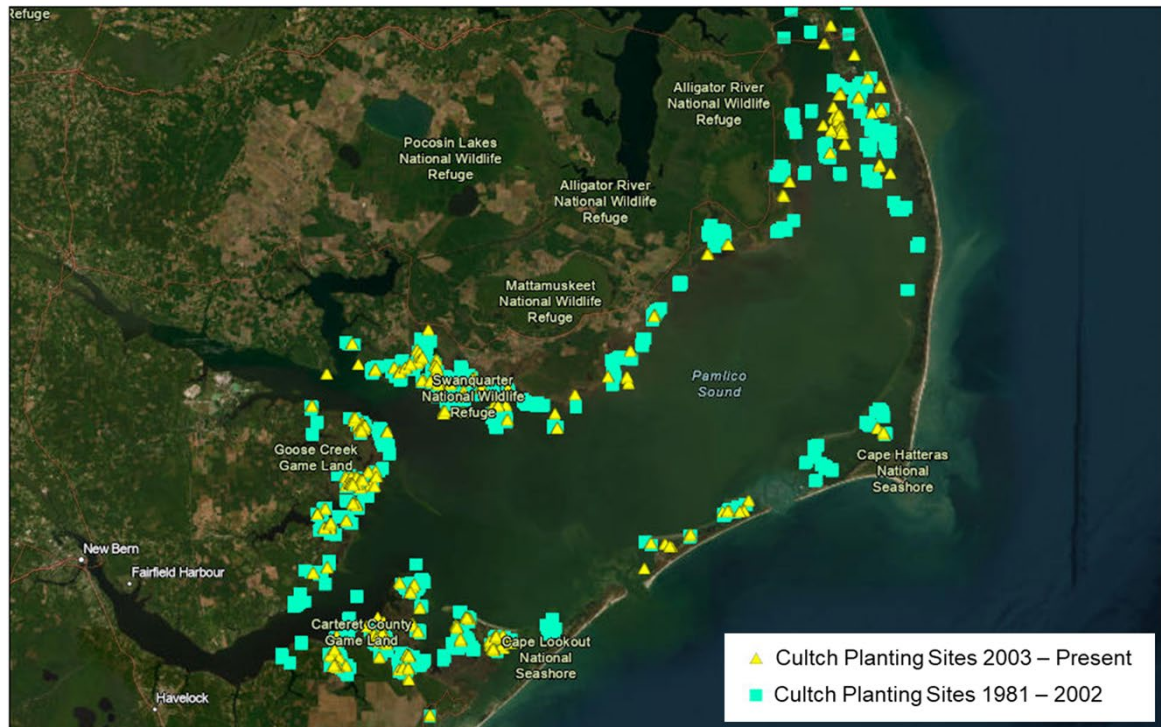


Figure 2.4. Map of cultch planting sites in the greater Pamlico Sound, 1981 to present.

Between 2000 and 2022, a total of 2,167,638 bushels of cultch material were planted in the mechanical harvest areas of Pamlico Sound, and 452,112 bushels of oyster were mechanically harvested. This resulted in 4.8 times more bushels of cultch being planted than oysters mechanically harvested over this time. Since 2018, 36 times more bushels of cultch have been planted compared to bushels of oysters commercially harvested and removed (Figure 2.5). The return in commercial harvest per unit of cultch planted in North Carolina remains unknown and likely varies across different planting sites. The impact of cultch plantings on oyster landings is not immediate, as it typically takes between one and three years after planting for new cultch material to yield legal-sized oysters. While some cultch planting sites have relatively short lifespans, others have been observed to continue yielding harvests for decades. Current management of oyster harvest in North Carolina does not distinguish between harvest from constructed cultch planted reefs and wild naturally occurring reefs.

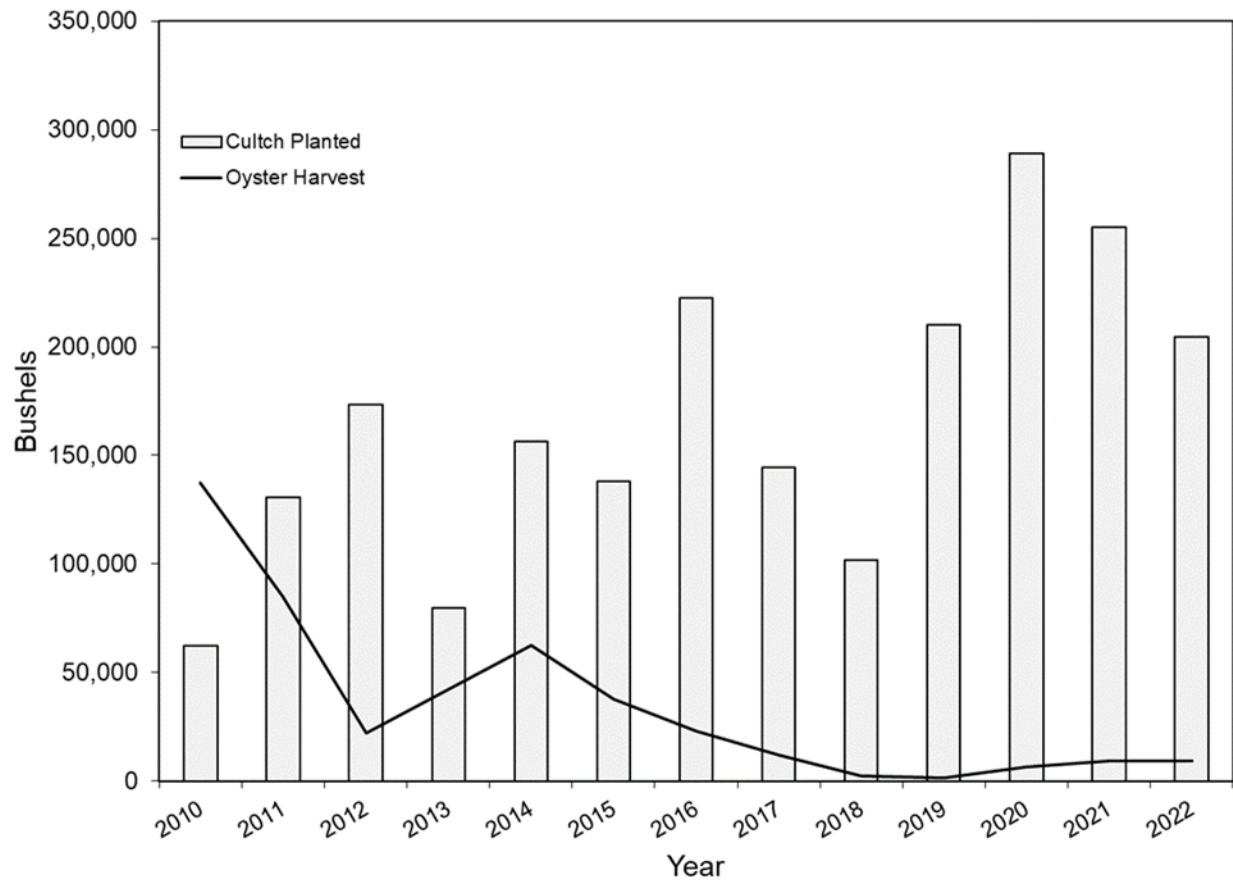


Figure 2.5. Annual bushels of cultch planted (shown as light gray bars) and bushels of oysters mechanically harvested (shown as black line) from the mechanical harvest areas of Pamlico Sound.

AUTHORITY

N.C. General Statute

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

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

- 03K .0201 Oyster Harvest Management

DISCUSSION

The existing mechanical harvest management strategy for oysters in Pamlico Sound aims to monitor in real time the habitat conditions of oyster reefs where mechanical harvest is actively occurring, and then close broad management areas once the condition of the oyster resource reaches a point where the effort required to harvest legal oysters causes excessive damage to the reef habitat. When this reactive management strategy was developed and adopted in 2010, participation in this fishery was approximately five times greater than participation has been in recent years. This drop in participation has often made it problematic for NCDMF staff to find areas where there is active fishing activity to sample, particularly in the bays of the Neuse and Pamlico River Areas. When active mechanical harvest areas are not encountered by staff, knowledge of past harvesting areas or localized areas of current oyster abundance are chosen for trigger sampling locations using their best judgment. Additionally, during pre-season sampling events, or when areas are either closed due to the management trigger being tripped or the break in the 6-week season for the bays and there is no mechanical harvest occurring, staff are again required to make judgment call decisions on where to sample. Given the sometimes-varying conditions between oyster reefs in the region, mechanical harvesters may view sampling locations selected by the NCDMF as not representative of areas they fish.

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

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

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

Historically deep-water reefs of western Pamlico Sound were reported to reach up to 13 feet (4 m) in height. In the Neuse River, high relief deep-water oyster reefs were shown to suffer mass mortality at water depths greater than 16.4 ft (below 5 meters) due to low oxygen, while low relief reefs in shallow waters (between 9.8 to 13 ft in depth) did not experience such die offs (Lenihan and Peterson 1998). The historical mounded structure of reefs in Pamlico Sound provided increased habitat complexity for a wide variety of invertebrates and fish and the upper portion of the mounds provided refuge for benthic organisms when lower portions of the reef were hypoxic. Research has shown that oysters at the base of subtidal reefs have a greater proportion of oyster mortality, significantly lower abundance of associated organisms, and higher incidence of disease occurrence, compared to the crest of reefs (Lenihan and Peterson 1998; Lenihan et al 1999). The survival and recovery of deep-water oyster reefs is contingent on their ability to gain vertical height.

Mechanical oyster harvest using dredges significantly impacts subtidal oyster reefs by reducing their vertical relief, which leads to several negative habitat effects (Lenihan and

Peterson 1998; Lenihan et al. 1999). This harvest method causes the scattering of shells and oysters into less suitable substrates, destabilizing the reef structure and increasing its vulnerability to storm damage. The process also decreases the reef's resistance to disease. The removal of live and dead oysters, along with portions of the upper shell layers, leads to a reduction in the potential number of spawning adults (spawning stock biomass) and diminishes the area available for oyster larvae settlement. Furthermore, newly settled oysters are subjected to lower oxygen levels and increased sedimentation due to the reduced depth in the water column. Additionally, it reduces the availability of small spaces within the reef that serve as crucial refuge and foraging areas for juvenile fish. For more information on the ecosystem importance of oyster reefs see the Ecosystem Protection and Impact section of this current FMP, Amendment 4 to the Eastern Oyster FMP (NCDMF 2017) and Chapter 3 of the 2016 CHPP (NCDEQ 2016).

To investigate the impacts of mechanical harvest methods on oyster reef heights, NCDMF and the University of North Carolina Institute of Marine Science researchers created restored reefs in the Neuse River in 1993, which were experimentally harvested in 1995 and 1996 (Lenihan and Peterson 1998, 2004). The 1995 experimental dredge harvest (designed to approximate the minimum seasonal dredge effort a reef would experience) removed an average of 11.4 in of height from the reefs that were 3.28-ft tall (Lenihan and Peterson 1998). The 1996 experimental harvest included dredge, tong, and diver hand harvest methods, which reduced the heights of the 3.3-ft reefs by averages of 13.2 in., 9 in., and 2.4 in., respectively, illustrating that dredge harvest has the greatest impact to reef height out of the harvest methods examined (Lenihan and Peterson 2004). While oyster growth rates can vary based on site conditions, Oysters monitored by NCDMF cultch planted reefs in the Greater Pamlico Sound take approximately three years to reach 3 in in shell length. Considering this observed oyster growth rate, it could take approximately 12 years for an oyster reef in this area to re-grow 1 ft of height.

In Pamlico Sound, changes in abundance of historic oyster reefs since the 1880s were documented by Ballance (2004). Using new technologies to locate subtidal reefs reported by Winslow (1889), Ballance (2004) found many formerly productive high-profile reefs now consisting of low-profile shell rubble, low density reefs, or buried reefs. Ballance (2004) also found the larger shallow reefs had less live oysters, which he attributed to the ease of locating those reefs by fishers. Similarly, Lenihan and Peterson (1998) re-surveyed natural oyster reefs in the deeper (>16.4 ft depth) portions of the Neuse River Estuary that had been marked in an 1868 US Coast and Geodetic Survey, finding that reefs that were 5.9 to 7.9 ft tall in 1868 were only 1 to 3 feet tall in 1993, and that no reefs in the 1993 survey were taller than 4 feet. Lenihan and Peterson (1998) reported that it was “probable that reduction in reef heights in the Neuse River estuary is due to decades of fishery-related disturbances caused by oyster dredging” and suggested reefs in heavily fished North Carolina waters would need to be restored every 3–4 years.

The NCDMF oyster restoration and enhancement program has focused significant effort into creating cultch reefs in areas open to mechanical oyster harvest in Pamlico Sound, with the volume of cultch material planted into the sound greatly exceeding the volume of oysters commercially harvested. Cultch plantings form low relief harvestable reefs and are not planted over areas of existing oyster to prevent the destruction of present natural

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

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

Deep-water Oyster Recovery Areas (Tier 1)

The remnant deep-water natural oyster reefs in the Pamlico and Neuse rivers have been recognized by the NCMFC as a habitat requiring protection due to their ecological importance and vulnerability. These reefs have suffered from excessive historical harvest, disease outbreak, and mass mortality from water quality impacts. Sites which contain these deep-water natural oyster reefs have been nominated by the NCMFC as Strategic Habitat Areas for the Pamlico Sound System (Figure 2.6) (NCDMF 2011). Strategic Habitat Areas (SHAs) are priority habitats identified for protection because of their exceptional condition or the imminent threats to their ecological functions, which support estuarine and coastal fish and shellfish species. Additionally, the NCMFC has directed the NCDMF to develop habitat protection measures through the adoption of the CHPP. Goal 3 of the 2016 CHPP is to “enhance and protect habitats from adverse physical impacts”, which includes reducing the impacts of mobile bottom disturbing fishing gear, the negative effects of which are described in Section 8.1.1 of the 2016 CHPP. Under Goal 3, the relevant recommended actions are 3.3 “Protect habitat from adverse fishing gear effects through improved compliance” and 3.8 “Develop coordinated policies including management adaptations and guidelines to increase resiliency of fish habitat to ecosystem changes.” (NCDEQ 2016)

Monitoring of the oyster resource in this area has indicated that these reefs have likely not supported much fishery effort between the 2018–19 and 2023–24 oyster seasons, due to few live or legal oysters sampled during NCDMF efforts. Past and present permit restrictions do not allow for the enhancement of deep-water reefs in Pamlico Sound with cultch. However, if future permitting could be secured to enhance or restore these deep-

water reefs, low-relief cultch plantings would likely not be sufficient to quickly restore the reef height needed, and large high relief materials would need to be employed. The use of large materials such as boulders may prevent any future mechanical harvest of these sites once restored. To meet the NCMFC goals adopted in the CHPP and recognize the nomination of these areas as SHAs, Tier 1 proposes Deep-water Oyster Recovery Areas (DORAs) where mechanical harvest would not be opened. The long-term goal of DORAs would be to allow deep-water oyster reefs to grow and accumulate living oysters and dead shell material to gain the height necessary to better function as habitat and therefore be resilient to low dissolved oxygen events. Mechanical harvest can quickly remove oysters and shell material at a faster rate than it can naturally replenish, potentially resulting in no net vertical growth of any mechanically harvested reefs in these areas.

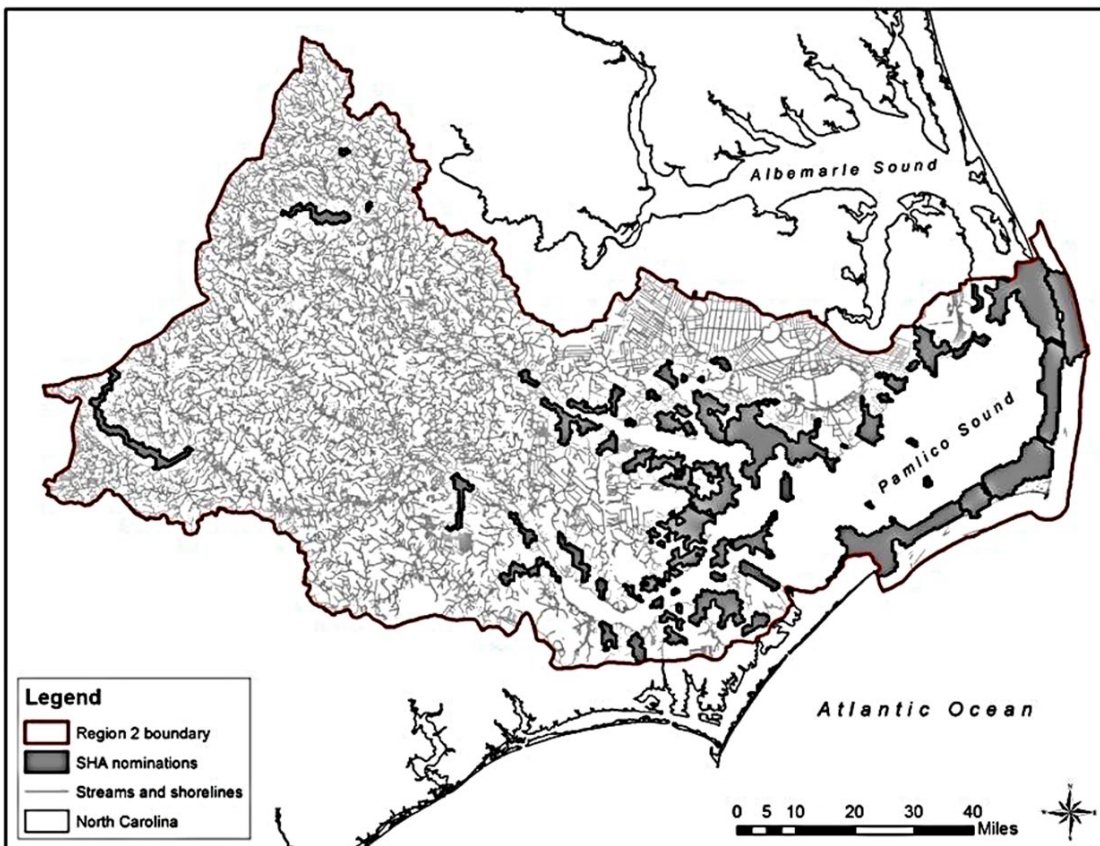


Figure 2.6. NCMFC nominated Strategic Habitat Areas (SHAs) for the Pamlico Sound Watershed (SHA Region 2), note the SHA areas in the mouth of the Neuse and Pamlico Rivers that encompass deep-water oyster reefs. (from NCDMF 2011)

Oyster habitat in Pamlico Sound, including both cultch planting sites and natural shell bottom, has been mapped across a long time period. Potential oyster habitat has been identified in areas deeper than 16.4 feet (5 meters), which is the depth at which oyster reefs are known to suffer mortality during low-oxygen events (Figure 2.7).

Using existing navigation aids (such as lights, buoys, and beacons) as boundary reference points for ease of compliance and enforcement, a total of 91,158 acres of deep-water area have been identified where oyster reefs are vulnerable to low-oxygen events. This area is divided into 29,561 acres in the Pamlico River and 61,597 acres in the Neuse River. However, within these larger areas, only about 845 acres represent potential oyster habitat—600 acres in the Pamlico River and 245 acres in the Neuse River—making up just 0.9% of the total identified deep-water area (2% in Pamlico River, 0.4% in Neuse River).

To protect the identified deep-water oyster reefs while minimizing areas that do not contain potential oyster habitat, two options are proposed for Designated Oyster Restoration Areas (DORAs) in both the Pamlico River and Neuse River (DORA options 1.b and 1.c, Figures 2.8 and 2.9). The two proposed DORA options do not include any known cultch planting sites and cover oyster reefs deeper than 16.4 ft (5 m) that have successfully re-grown oysters since the 2018–19 low-oxygen mortality event. These reefs are monitored by NCDMF and have oysters documented during the 2024–25 oyster season with shell lengths of at least 3 inches.

The larger DORA options (Management Option 1.b) cover 681 acres of potential oyster habitat (500 acres in Pamlico River and 180 acres in Neuse River), which represents approximately 81% of the vulnerable deep-water oyster habitat. The smaller DORA options (Management Option 1.c) cover 271 acres of potential habitat (200 acres in Pamlico River and 71 acres in Neuse River), which represents only approximately 32% of the vulnerable habitat.

The strategy of Deep-water Oyster Recovery Areas prioritizes the habitat value of these oyster reefs over the potential fishery resource they could provide, allowing reefs to not lose any gained shell volume and vertical height to fishery effort. The structural relief provided by oyster reefs plays a crucial role in the estuarine ecosystem. As the deep-water reefs located in DORAs recover, they would increase in habitat complexity from gaining height and more interstitial spaces. This complexity allows the reefs to function better as habitat for oysters and the numerous other commercially important species which rely on them. Oysters are viewed as ecosystem engineers, and for a more complete review on the significant role oyster reefs play in enhancing estuarine biodiversity, supporting fish production, improving water quality, and influencing hydrodynamic processes, see Chapter 3 of the 2016 CHPP (NCDEQ 2016).

Harvest may be allowed in the future if reefs recover to a point which a regulated harvest can be sustained. Subsequent Oyster FMPs can evaluate the success of the DORA approach by monitoring reef metrics such as height, rugosity, total area, and oyster demographics. Determination of successful recovery and developing sustainable harvest strategies would occur in a future FMP. Future sustainable harvest is defined as a level of harvest that would not result in a net loss of reef height through time and maintain reef height gained through DORA implementation.

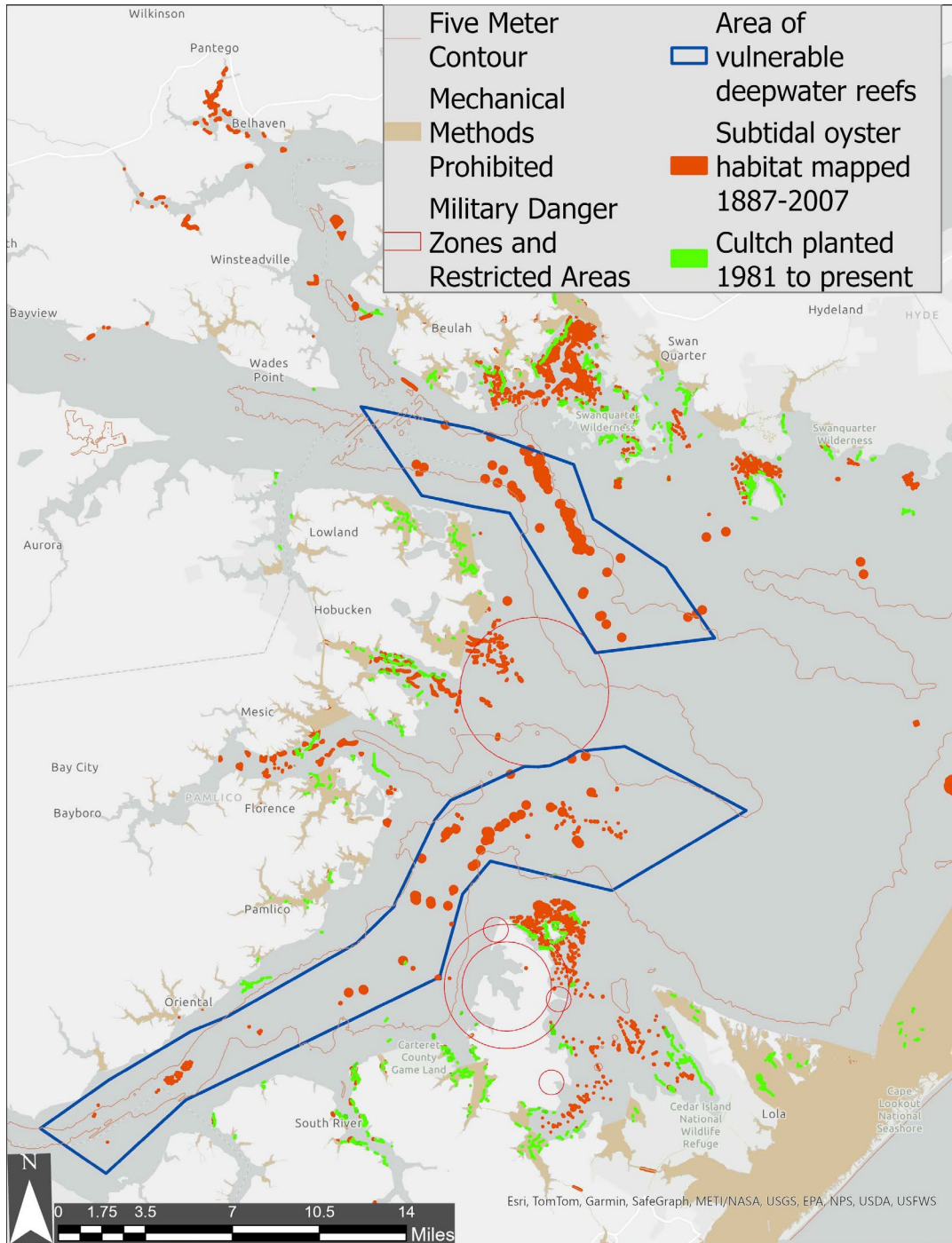


Figure 2.7. All known potential subtidal oyster habitat, including natural shell (red), and cultch planted sites (green), in western Pamlico Sound. All available historic and current data sources were used to illustrate potential locations for oyster reefs. Existing navigational markers were used to create boundaries around nearly all the identified vulnerable deep-water oyster habitat (blue polygons).

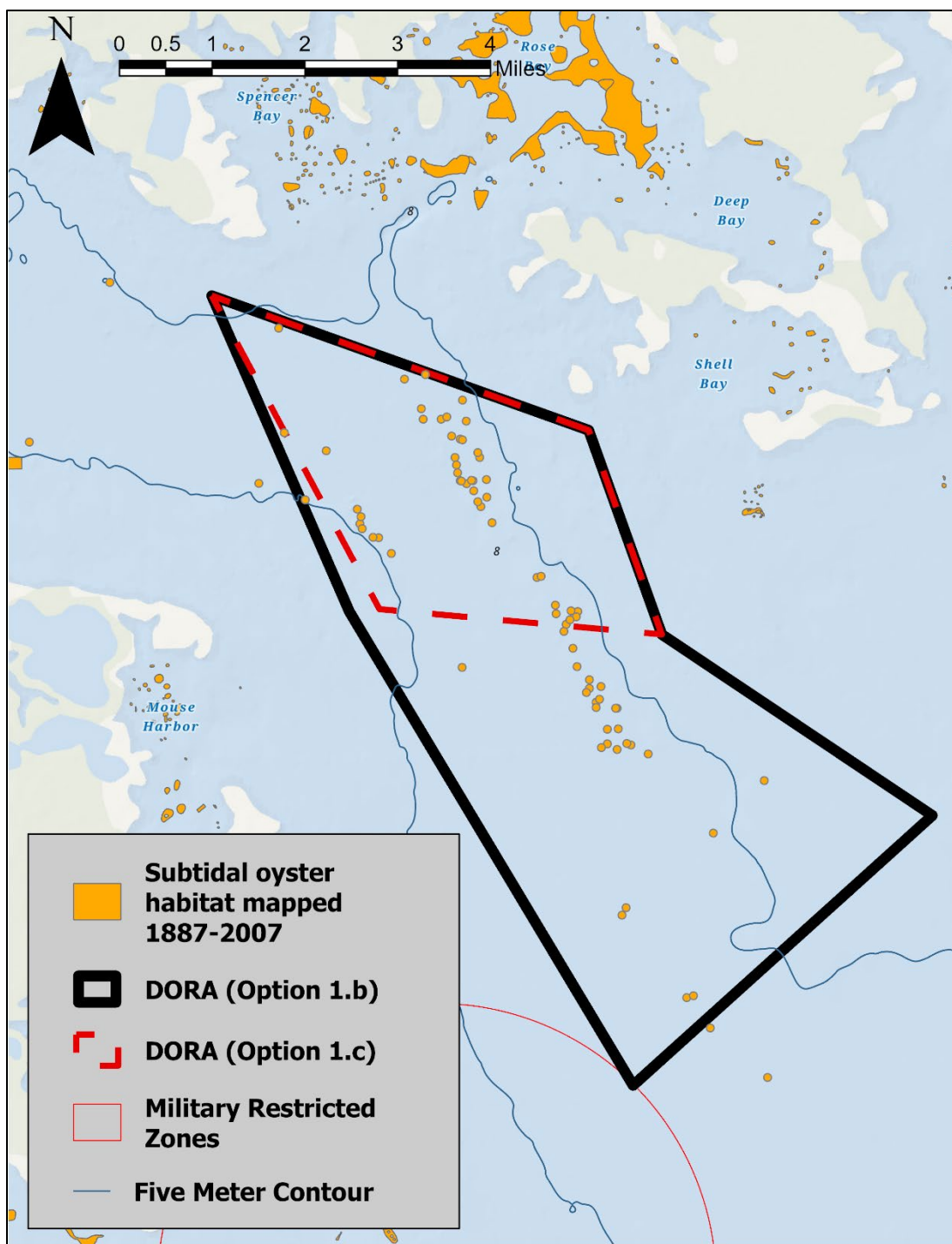


Figure 2.8. Two potential options for DORAs containing documented potential oyster habitat in the mouth of the Pamlico River. Proposed boundaries are delineated with already existing buoys and markers. The 5-meter contour line is shown to illustrate areas of oyster habitat located at this depth or below and vulnerable to low oxygen events. DORA Option 1.b represents a larger DORA than Option 1.c.

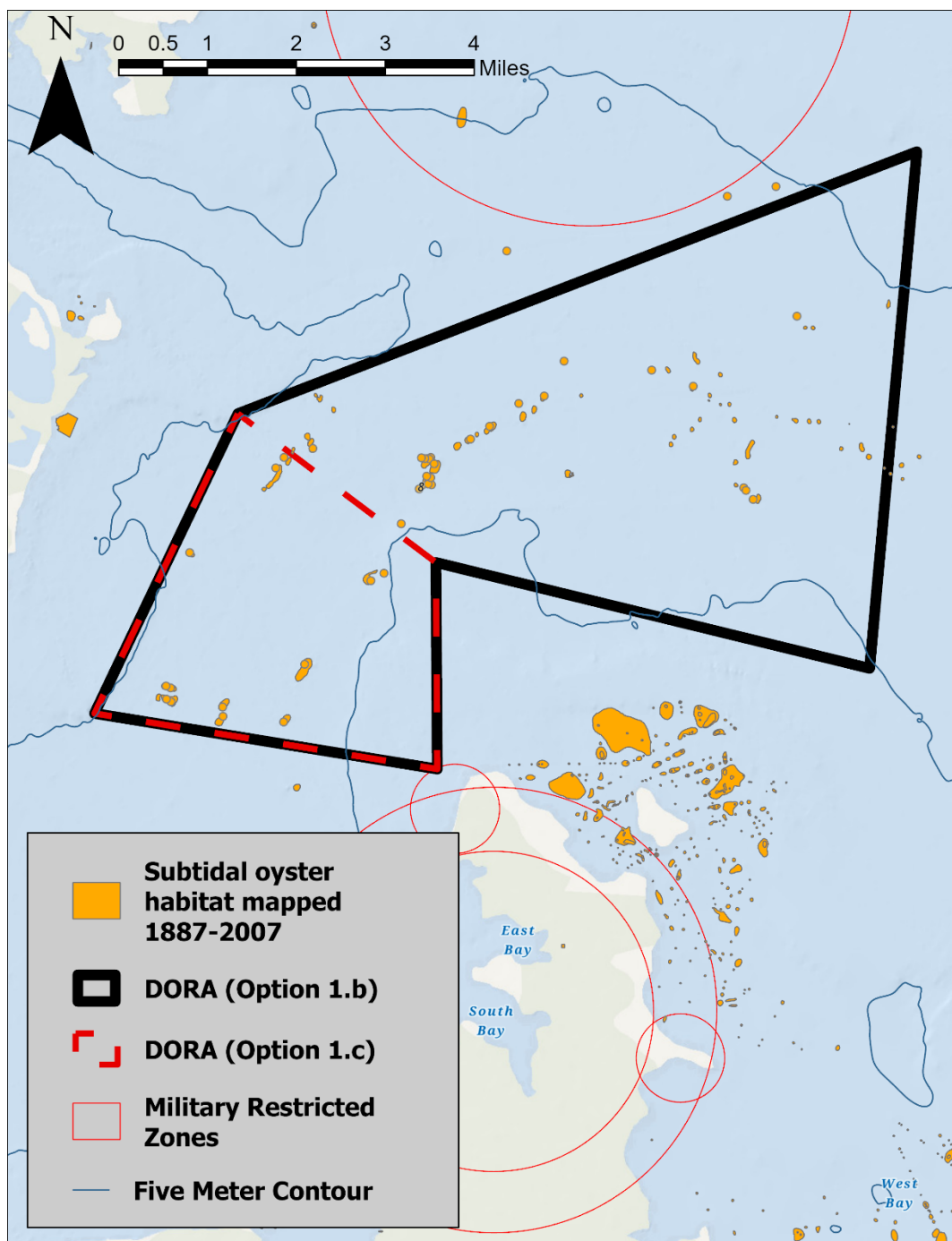


Figure 2.9. Two potential options for DORAs containing documented potential oyster habitat in the mouth of the Neuse River. Proposed boundaries are delineated with already existing buoys and markers. The 5-meter contour line is shown to illustrate areas of oyster habitat located at this depth or below and vulnerable to low oxygen events. DORA Option 1.b represents a larger DORA than Option 1.c.

The Cultch Planting Program operates under the U.S. Army Corps of Engineers Nationwide 27 permit. Currently, this permit is renewed every five years and grants the state 200 acres combined of acceptable inland water for oyster restoration. This permit restricts reef material to low relief sites, and from being planted in areas with existing natural shellfish populations to prevent destruction of important established habitat. For more information on the Cultch Planting Program see Appendix 4: Habitat & Enhancement Oyster Programs Information Paper. Past and present permit restrictions do not allow for the enhancement of deep-water reefs in Pamlico Sound with cultch. However, if future permitting could be secured to enhance or restore these deep-water reefs, low-relief cultch plantings would likely not be sufficient to quickly restore the reef height needed, and large high relief materials would need to be employed. The use of large materials such as boulders may prevent any future mechanical harvest of these sites once restored.

Cultch Supported Harvest (Tier 2)

Significant cultch planting effort has gone into creating harvestable reefs and replenishing cultch material lost in areas open to mechanical harvest in Pamlico Sound. Cultch planting has been central to Pamlico Sound oyster management, with some planted reefs over 40 years old and still producing harvestable oysters. Over time, extensive cultch planting initiatives have blurred the distinction between 'natural' reefs and those created by the NCDMF. The proposed Cultch Supported Harvest strategy would cover the portions of the Neuse and Pamlico River Management Areas not designated as DORAs and the entire Northern Dare and Northern Hyde Management Areas (Figure 2.3), but exclude rotational cultch areas proposed under Tier 3. Cultch planting effort will continue in these areas as long as the cultch planting program remains funded and operational. Cultch Supported Harvest Areas will be subject to the previously established bushel limits (15 bushels per day open water, 10 bushels per day bays; Figures 2.10 & 2.11) and the bays will continue to be capped to a total six-week possible season. This strategy would replace the current reactive approach of the mechanical harvest monitoring program established in 2010. The primary changes from previous management to the proposed strategy are that season length will be predetermined and based on NCDMF pre-season sampling of the oyster resource in these areas, and the 10-bushel per day bays and 15-bushel per day deep areas will be considered differently for each management area. This change eliminates the unpredictability in mechanical harvest season length experienced by harvesters and considers differences in oyster mortality experienced at varying depths of Pamlico Sound.

Past trigger sampling data can be used to analyze the relationship between the condition of the oyster resource during pre-season sampling and the number of weeks of mechanical harvesting that occurred before the sampling reached the management trigger, which is defined as two consecutive sampling events with less than 26% legal-sized oysters. Harvest rates are driven by effort in the fishery, and steep declines have been observed since implementation of the trigger sampling program in 2010. Effort after the 2016–2017 season has stabilized at a relatively low level, and data from that point

forward can be considered representative of the current mechanical fishery. Any significant changes in effort and/or participation in the future would require adaptive management to address.

Using trigger sampling data from the oyster mechanical harvest seasons between November 2017 and March 2023, the pre-season condition (percent legal oyster) of each management area was compared to the number of weeks it took for the management trigger to trip and close mechanical harvest in that area (Figure 2.12). This relationship was used to assign potential season lengths for starting conditions by area (10-bushel bays, 15-bushel deep). The two samples with the lowest percent legal oyster per management area were dropped before calculating the overall percentage legal, then compared to how long it took for two consecutive sampling events to be at 26% legal or less (current trigger to close a management area). Dropping the sites in poorest condition, which may not have been used by harvesters, prevents those sites from impacting the overall area pre-season condition. However, the typical difference when these sites were dropped was an increase of less than five percent for legal oysters. Proposed maximum season lengths in the 10-bushel per day bays reflect that these areas are capped to a six-week possible season, and 18 total possible weeks for the 15-bushel per day areas to reflect the end of the possible mechanical harvest season on March 31.

The proposed season lengths (Table 2.3) underestimated the actual time it took to trip the current management trigger two times by an average of two days across the entire period examined (Figure 2.13). The proposed season lengths have a minimum threshold for opening of 10% legal; if an area is less than 10% legal, mechanical harvest will not open. Using a minimum threshold of 10% would have resulted in openings not occurring in two areas under current management between 2017 and 2023.

Table 2.3. Proposed weeks of oyster mechanical harvest for 10-bushel (bay) and 15-bushel limit (open water) management areas based on the starting condition percentage of live legal oysters calculated from pre-season samples.

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

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

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

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

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

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

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

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

Rotational Cultch Sites (Tier 3)

The Cultch Planting Program has implemented a reef building strategy in Pamlico Sound to create large 10-acre cultch planting sites in areas open to mechanical harvest, with the goal of having at least 16 sites planted by 2026. Rotational cultch sites will be distributed across the sound with at least four planned for each management area. As of 2024, 13 large sites have been constructed with two management areas having at least four sites built already (Figure 2.14). To improve access to consistent oyster resources, a new fishery management approach is proposed for these large cultch sites. Currently, cultch sites have been made available to harvest as soon as they are planted, but typically it takes three ‘years’ (i.e., three 12-month cycles) for a new cultch site to produce legal oysters. The proposed management strategy for a Rotational Cultch Site is to not allow harvest for three years after initial construction, and then open harvest on the fourth year. After one season of harvest, the site would then be closed for the following three years. Immediately after the harvest season, the site would be evaluated by the NCDMF to determine if additional cultch material is needed. Sites would open and close via

proclamation on a four-year rotational schedule. Additional sites are planned for each management area to enable contingency based substitutions of rotational sites for potentially more successful sites. The goal would be to have at least one large rotational cultch site open per management area each season. Rotational Cultch Sites would not be subject to the season lengths set for Cultch Supported Harvest Areas. The large open sites in a management area would open to mechanical harvest on the Monday of the week prior to Thanksgiving week, which is typically the third Monday of November, and close on March 31. Rotational Cultch Sites would be limited to 10 or 15 bushels per day per vessel based on the harvest limit in the waterbody that each site is located within. This strategy focuses on the fishery value of these reefs and gives harvesters relatively open access to these cultch plantings.

Without a stock assessment or metrics of abundance for oysters in Pamlico Sound, management focuses on protecting oyster habitat and cultch planting to restore hard substrate ensures ongoing populations of harvestable oysters. The proposed three tier approach seeks to balance the habitat and fishery values of oysters in Pamlico Sound. Deep-water Oyster Recovery Areas (Tier 1) protect reefs where continued shell loss prevents remnant natural reefs from recovering. The habitat value of these areas is prioritized over their potential function as a harvestable fishery resource. Cultch Supported Harvest Areas (Tier 2) aim to allow harvest but prevent damage to oyster habitat through excessive removal of cultch material. Effort is limited by setting season lengths by management area according to conditions of the oyster resource. Additionally, cultch planting in these areas helps mitigate substrate loss via oyster harvest. Rotational Cultch Sites (Tier 3) are constructed with the goal of supporting the mechanical harvest oyster fishery. The fishery value of these sites is prioritized. Sites will be evaluated at the end of the harvest season and replenished with cultch before being allowed to re-grow harvestable sized oysters. The NCDMF will modify sampling and data collection protocols to better incorporate an abundance of indices into future management to be addressed in a subsequent fishery management plan.

Adaptive management

The fixed mechanical season lengths for Cultch Supported Harvest developed in this issue paper used fishery monitoring data for the five oyster mechanical harvest seasons between November 2018 and March 2023. On average, 93 participants landed oysters with mechanical gear between 2018 and 2023. Any large changes in effort would potentially result in fixed season lengths becoming either inadequate to provide protection to the oyster resource with increased participation in the fishery, or too restrictive with decreased fishery participation. If the three-year running average of participants in the mechanical oyster fishery changes by more than 25% (i.e., less than 70 or more than 116 participants), adaptive management would be triggered to re-evaluate the fixed season lengths outlined in Table 2.3. Effort and landings data as well as division mechanical harvest season sampling data will be used to assess the effectiveness of adopted fixed season lengths in relation to the condition of the oyster resource. If adaptive management is triggered, season lengths may be lengthened, shortened, or maintained as previously adopted. For example, if participation dropped to a 3-year average of 65 participants and in-season sampling of management areas consistently results in 2 additional weeks of

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mechanical harvest being added to the initial proclaimed season length, Table 2.3 can be modified to extend the season length to reflect this change.

Adaptive Management Framework

A three-year running average of the number of participants with landings in the wild mechanical oyster fishery of less than 70 or greater than 116 (calculated during annual FMP Update), triggers the examination of oyster sampling data and potential adjustment to fixed season lengths (Table 2.3) for Cultch Supported Harvest management strategy.

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

Step	Example 1	Example 2
1. Pre-season Industry Reports	Receive reports from fishers about locations of sites in the 10-bushel areas of Pamlico Management Area	Receive reports from fishers about location of sites in the 15-bushel area of Dare Management Area
2. Pre-season Sampling	NCDMF sampling including areas reported by fishers. Pre-season condition 25% legal.	NCDMF sampling including areas reported by fishers. Pre-season condition 40% legal.
3. Set Season Length (See Table 2.3)	25% legal = 5 weeks. Mechanical harvest season set via proclamation for 5 weeks in 10 bushel/day areas of Pamlico Management Area	40% legal = 10 weeks. Mechanical harvest season set via proclamation for 10 weeks in 15 bushel/day area of Dare Management Area
4. In-season Industry Reports	Reports from fishers about specific locations in the 10 bushel/day areas.	No additional reports from fishers
5. In-season Sampling	NCDMF in-season sampling occurs 2 weeks into the proclaimed 5-week season targeting areas reported by fishers. In-season condition = 20%	NCDMF in-season sampling occurs 5 weeks into the proclaimed 10-week season using initial fisher reports and prior experience. In-season condition = 24%
6. Evaluate Season Length (See Table 2.3)	20% legal = 4 weeks 4 weeks - 3 weeks (amount of season left) = 2 additional weeks In-season sampling shows 2 additional weeks may be added to the initial 5 week proclaimed season for this area for a total of 7 weeks	24% legal = 4 Weeks 4 weeks – 5 weeks (amount of season left) = -1 weeks. The number of additional weeks from the in-season evaluation is less than 0.
7. Modify Season (If needed)	New proclamation issued to extend the initial set harvest season by 1 week.	The initial proclaimed harvest season remains. No change.

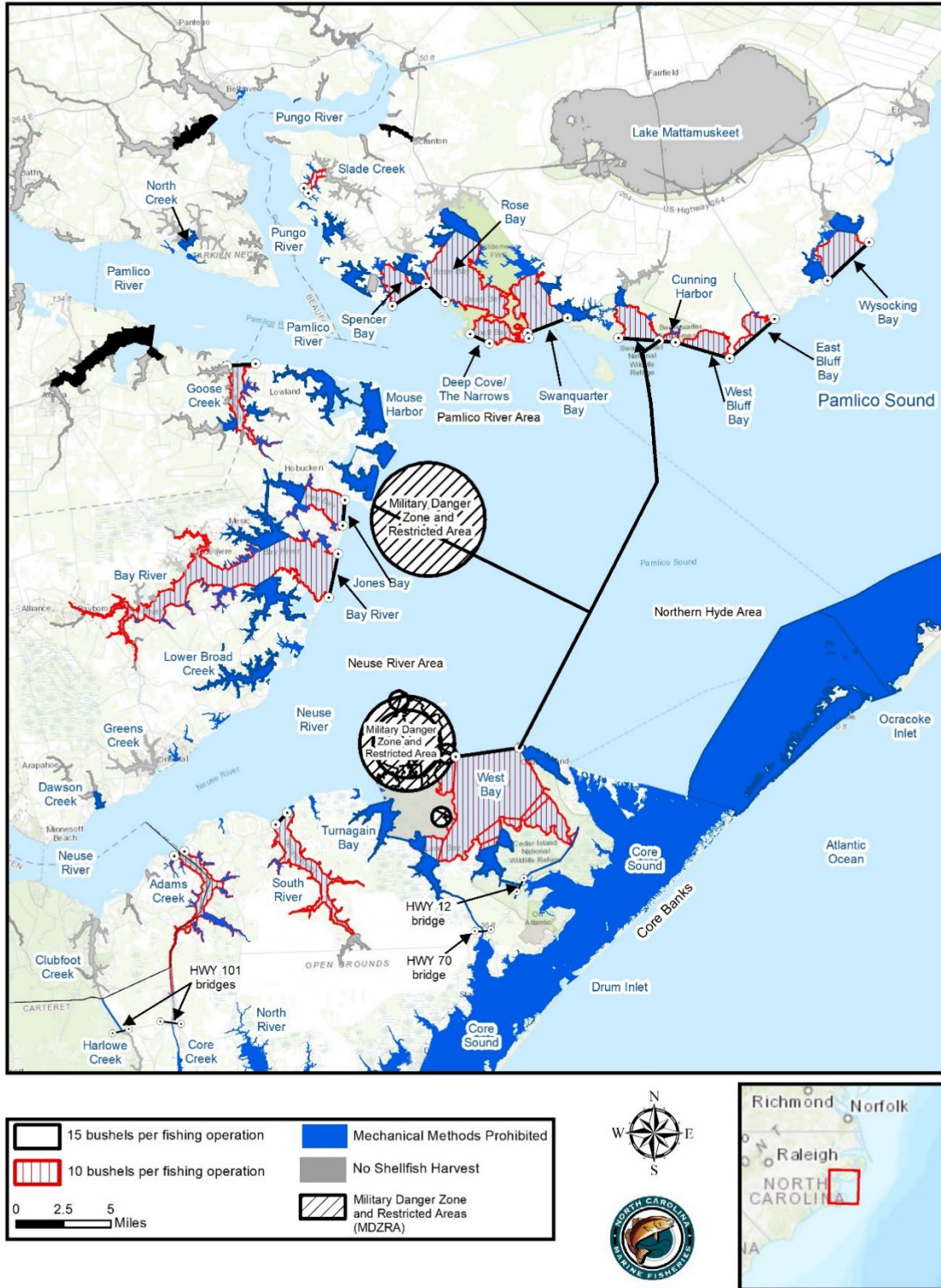


Figure 2.10. Bushel limits for bays and deep-water areas of western Pamlico Sound.

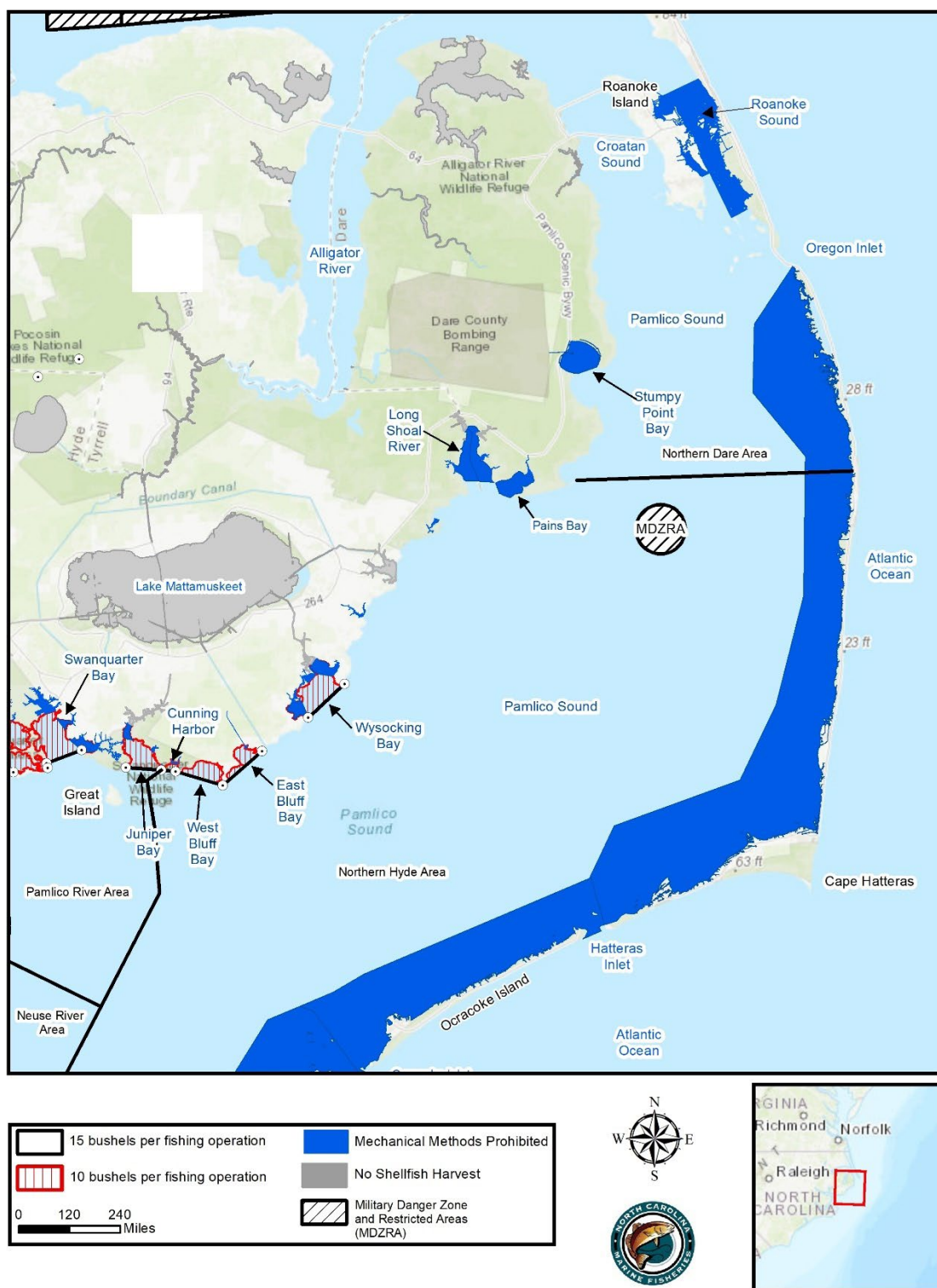


Figure 2.11. Bushel limits for bays and deep-water areas of eastern Pamlico Sound.

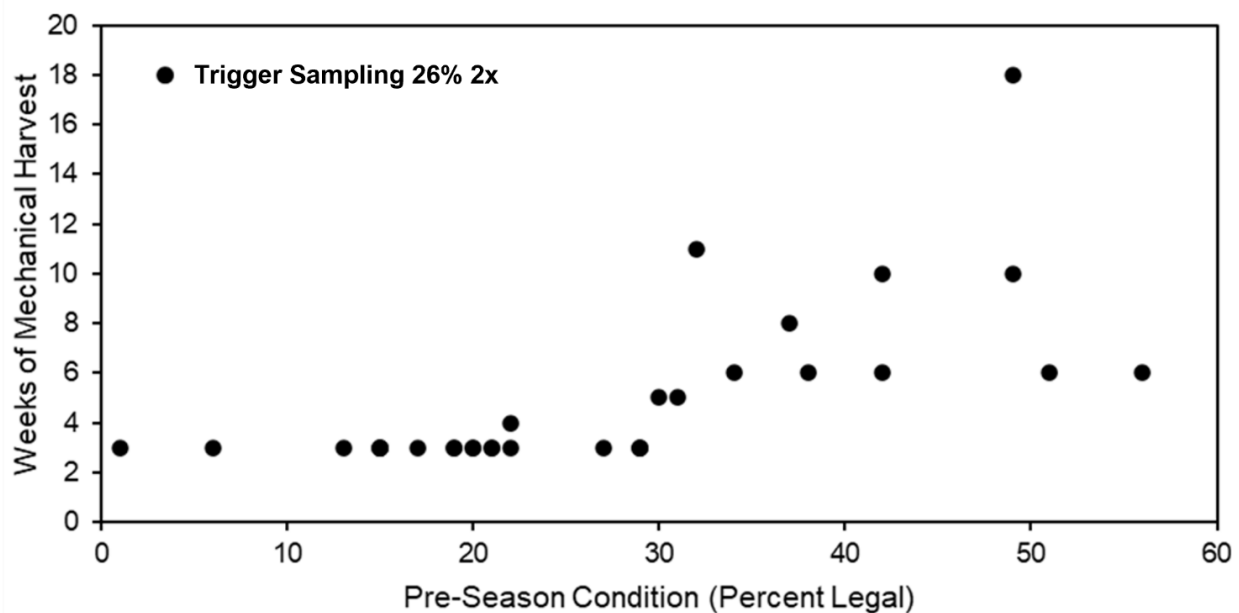


Figure 2.12. Pre-season condition (percent legal) of oysters in management areas sampled during mechanical harvest monitoring compared to the number of weeks it took for the management trigger to trip in that area from 2017 to 2023. The management trigger is 26% legal or less for two consecutive sampling events (26% 2x). The two lowest percent legal samples per area were dropped before calculating the pre-season condition of that area.

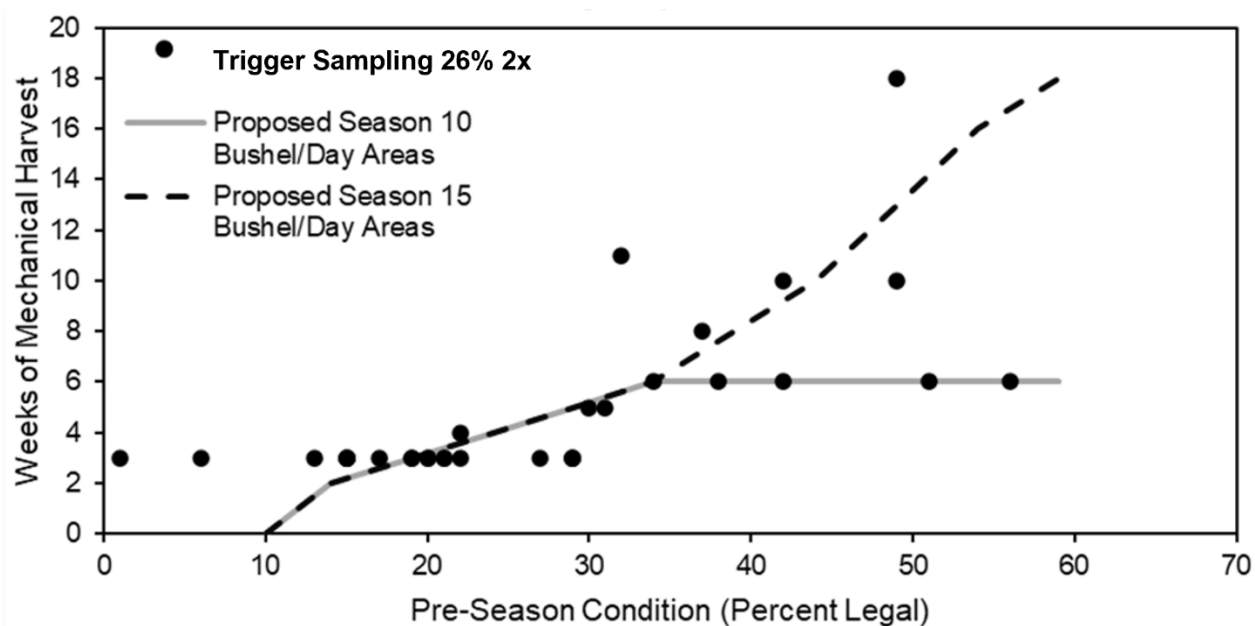


Figure 2.13. Pre-season condition (percent legal) of oysters in management areas sampled during mechanical harvest monitoring compared to the number of weeks it took for the management trigger to trip in that area from 2017 to 2023. The management trigger is 26% legal or less for two consecutive sampling events (26% 2x). The two lowest percent legal samples per area were dropped before calculating the pre-season condition of that area. The light gray line shows the proposed season length for the 10 bushel/day areas, and the dashed black line shows the proposed season length for the 15 bushel/day areas.

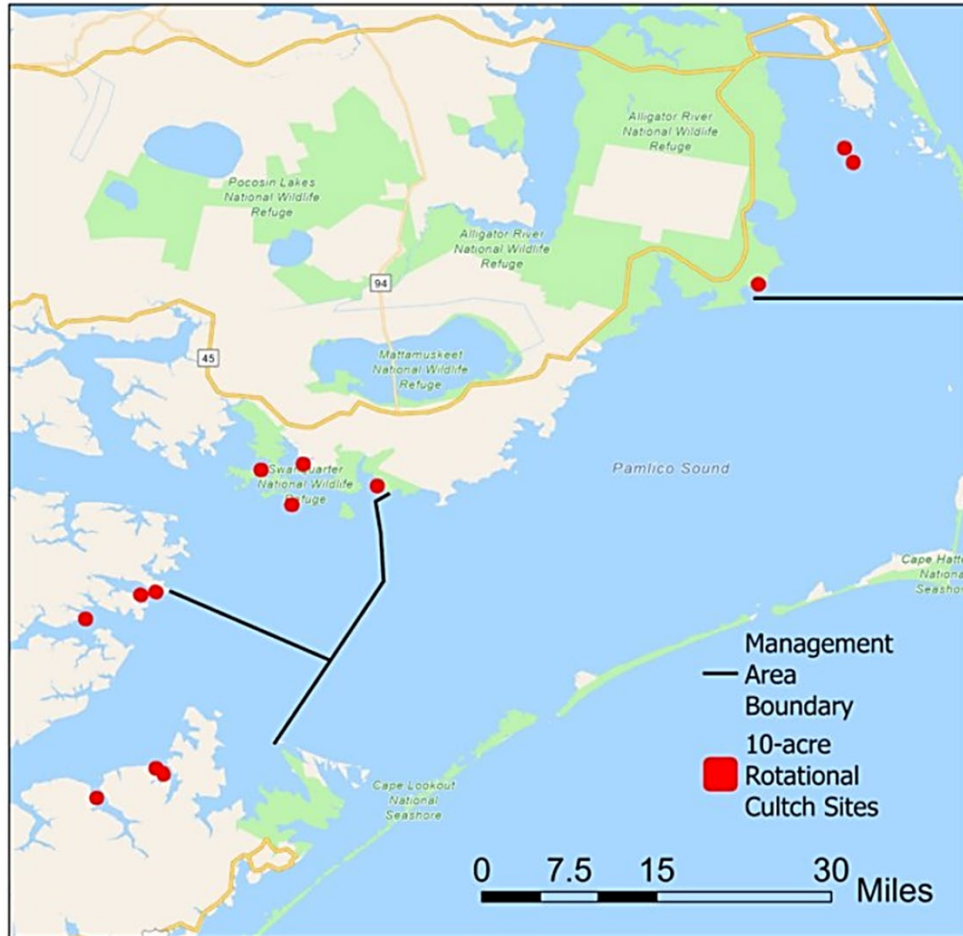


Figure 2.14. Locations of Rotational Cultch Sites that were constructed through 2024.

MANAGEMENT OPTIONS

Option 1: Deep-water Oyster Recovery Areas (DORAs)

- a. Status Quo (do not support)
 - Does not protect any deep-water (>5 m) oyster reefs in Pamlico Sound from mechanical harvest methods which reduce reef height.
 - Does not allow deep-water (>5 m) oyster reefs in Pamlico Sound to gain height and resiliency from negative water quality impacts.
- b. Adopt Deep-water Oyster Recovery Areas (DORAs larger option)
 - Protects 81% (681 acres: 500 acres in Pamlico River and 180 acres in Neuse River) of identified deep-water (>5 m) oyster reefs in Pamlico Sound from mechanical harvest methods that reduce reef height
 - Allow protected deep-water (>5 m) oyster reefs in Pamlico Sound to gain height and resiliency from negative water quality impacts.

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- Does not allow harvest in all areas of western Pamlico Sound which may periodically have harvestable oyster resource.
- c. Adopt Deep-water Oyster Recovery Areas (DORAs smaller option)
 - Protects 32% (271 acres: 200 acres in Pamlico River and 71 acres in Neuse River) of identified deep-water (>5 m) oyster reefs in Pamlico Sound from mechanical harvest methods which reduce reef height.
 - Allow deep-water (>5 m) oyster reefs in Pamlico Sound to gain height and resiliency from negative water quality impacts.
 - Does not allow harvest in all areas of western Pamlico Sound which may periodically have harvestable oyster resource.
 - Allows for harvest in areas of western Pamlico Sound which may periodically have harvestable oyster resource

Option 2: Cultch Supported Harvest

- a. Status Quo (maintain current trigger sampling approach)
 - Uncertainty and variability in season length annually.
 - Does not provide a standardized opportunity for industry to provide input into management sampling locations.
 - Maintains current habitat protection measures in the mechanical oyster fishery.
- b. Adopt Proposed Cultch Supported Harvest Strategy
 - Provides more certainty in annual season length by area.
 - Incorporates industry input into management sampling locations for pre and in-season sampling.
 - Provides habitat protection measures in the mechanical oyster fishery.

Option 3: Rotational Cultch Sites

- a. Status Quo (maintain current cultch site management)
 - All cultch planting sites are open to harvest of legal-size oysters.
 - No differentiation in management of wild and cultch planting sites.
 - Does not formalize NCDMF cultch planting efforts into an adopted fishery management strategy.
- b. Adopt Rotational Cultch Site Strategy
 - Some cultch sites would be closed to harvest on a rotational schedule.
 - The fishery value of these cultch planting sites is prioritized.
 - Formalizes NCDMF cultch planting efforts into an adopted fishery management strategy.

Option 4: Adaptive Management

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- a. Do not support Adaptive Management
 - Does not allow for changes in set season length based on changes in fishery participation.
- b. Adopt Adaptive Management (only applies if the proposed Cultch Supported Harvest Strategy is adopted)
 - Allows for modification of set season length based on changes to fishery participation.

RECOMMENDATIONS

The DMF recommends the following options:

Option 1. Deep-water Oyster Recovery Areas (DORAs)

- b. Adopt Deep-water Oyster Recovery Areas (DORAs larger option)

Option 2. Cultch Supported Harvest

- b. Adopt the proposed Cultch Supported Harvest strategy as described in the Issue Paper.

Option 3. Rotational Cultch Sites

- b. Adopt the proposed Rotational Cultch Site strategy as described in the Issue Paper.

Option 4. Adaptive Management

- b. Adopt the proposed adaptive management framework.

Advisory Committee Recommendations and Public Comment: see [Appendix 7](#)

NCMFC Selected Management Options

Option 1: Deep-water Oyster Recovery Areas (DORAs)

- b. Adopt the proposed Pamlico and Neuse River Deep-water Oyster Recovery Areas (DORAs), which are bound by existing navigational aids as presented to the NC MFC regional Advisory Committees, to protect deep subtidal oyster reefs from continued physical disturbance by mechanical gear. These areas will be closed to mechanical oyster dredging and monitoring efforts will be used to evaluate the effectiveness of closure within the next FMP amendment. The DORAs cover 681 acres of potential oyster habitat (500 acres in Pamlico River and 180 acres in

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Neuse River), which represents approximately 81% of the vulnerable deep-water oyster habitat.

Option 2: Cultch Supported Harvest

- b. Adopt the Cultch Supported Harvest strategy outlined in Appendix 2, which would set the season length based on pre-season sampling aided by industry input on sampling locations with the 10 bushel per day and 15 bushel per day areas considered separately.

Option 3: Rotational Cultch Site Strategy

- b. Adopt the inclusion of Rotational Harvest Cultch Sites strategy outlined in Appendix 2. This strategy would create a rotating series of readily available cultch areas available to harvest for the full extent of the mechanical season length each year with the intent of reducing harvest pressure on natural reefs.

Option 4: Adaptive Management

- b. Adopt the proposed adaptive management framework to allow for modification of set season length based on changes to participation in the fishery.

Appendix 3: Intertidal Oyster Harvest Management Information Paper

ISSUE

Addressing management needs for intertidal oysters in North Carolina.

ORIGINATION

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

BACKGROUND

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

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

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

The southern region of North Carolina contributes consistently to the overall public landings of oysters within the state (Figure 3.1). From 1994 to 2022, the southern region produced 51% of the state's total wild oyster landings, accounting for between 20% and 91% of the annual harvest. Although this region covers only 5.7% of the state's total coastal waterbody area, it has contributed more than half of the total oyster landings since 1994.

The North Carolina Eastern Oyster FMP Amendment 4 examined increasing landings and participation from commercial Shellfish License holders with decreasing catch per unit effort (average bushels landed per trip), and the potential of effectively open entry on a finite fishery resource via the commercial Shellfish License as management issues (NCDMF 2017). For more information see the following issue papers in Amendment 4 of the Eastern Oyster FMP: Assessing and Mitigating Harvest Effort Impacts on Oyster

Resources in the Southern Region and Consider Elimination of the Shellfish License and Require All Shellfish Harvesters to Have a SCFL or RSCFL. To address these concerns, the Marine Fisheries Commission (MFC) adopted specific management strategies. One of these strategies was the reduction of the daily oyster harvest limit for commercial Shellfish License holders from five bushels to two. This strategy was implemented in October of the 2017–2018 season with an allowance for up to four bushels per vessel per day if two or more Shellfish License holders were on board the vessel. In Amendment 4 of the Eastern Oyster FMP, the NCMFC also recommended excluding oysters harvested from public bottoms as eligible for harvest with the commercial Shellfish License. The elimination of oysters from the commercial Shellfish License requires legislative action and has yet to occur. They also proposed the development of a fishery independent sampling program for intertidal oysters in the southern region.

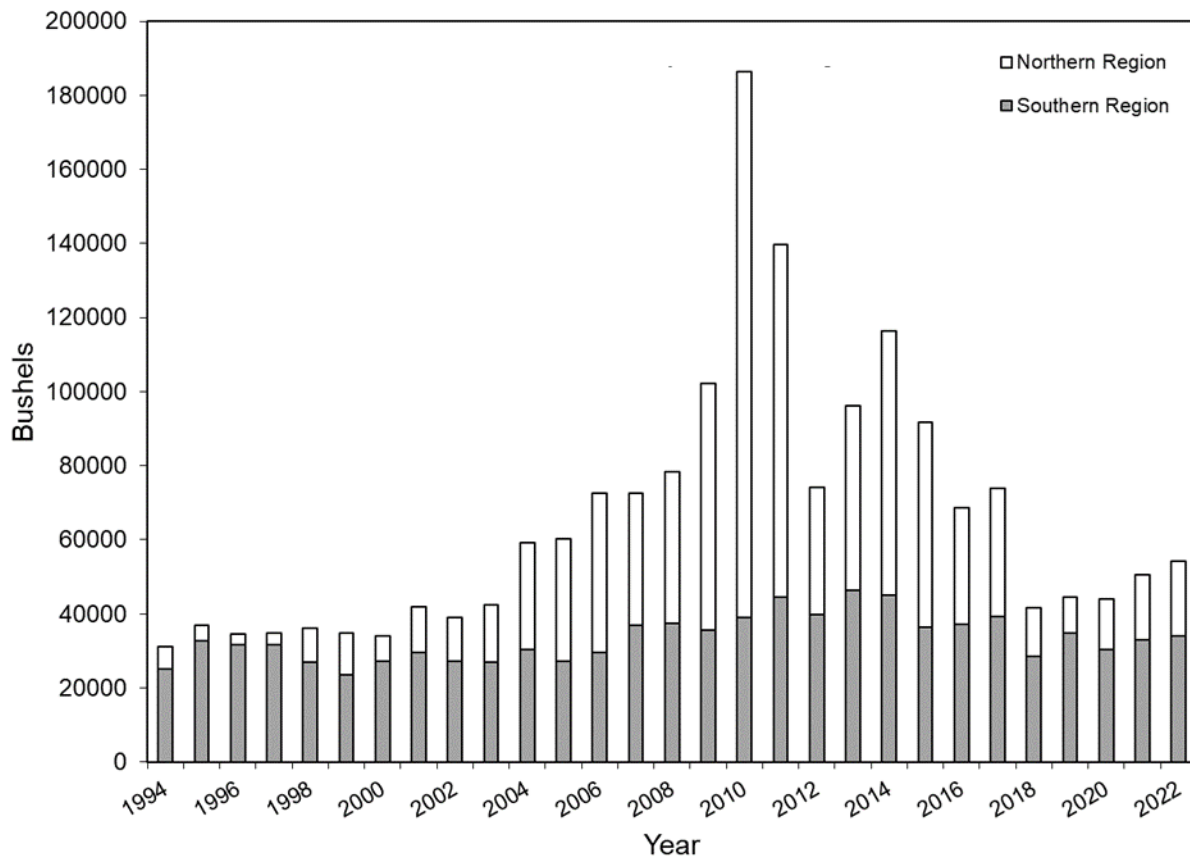


Figure 3.1. Commercial landings of oysters from public bottom in North Carolina from 1994 to 2022, showing annual landings in bushels from the southern region (waterbodies south of Bogue Sound; gray bars) and the northern region (white bars).

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

commercial Shellfish License holders over that period. The number of trips made by Shellfish License holders declined sharply in 2018. This coincides with NCDMF enacting the bushel reduction limit for Shellfish License holders as recommended by the MFC.

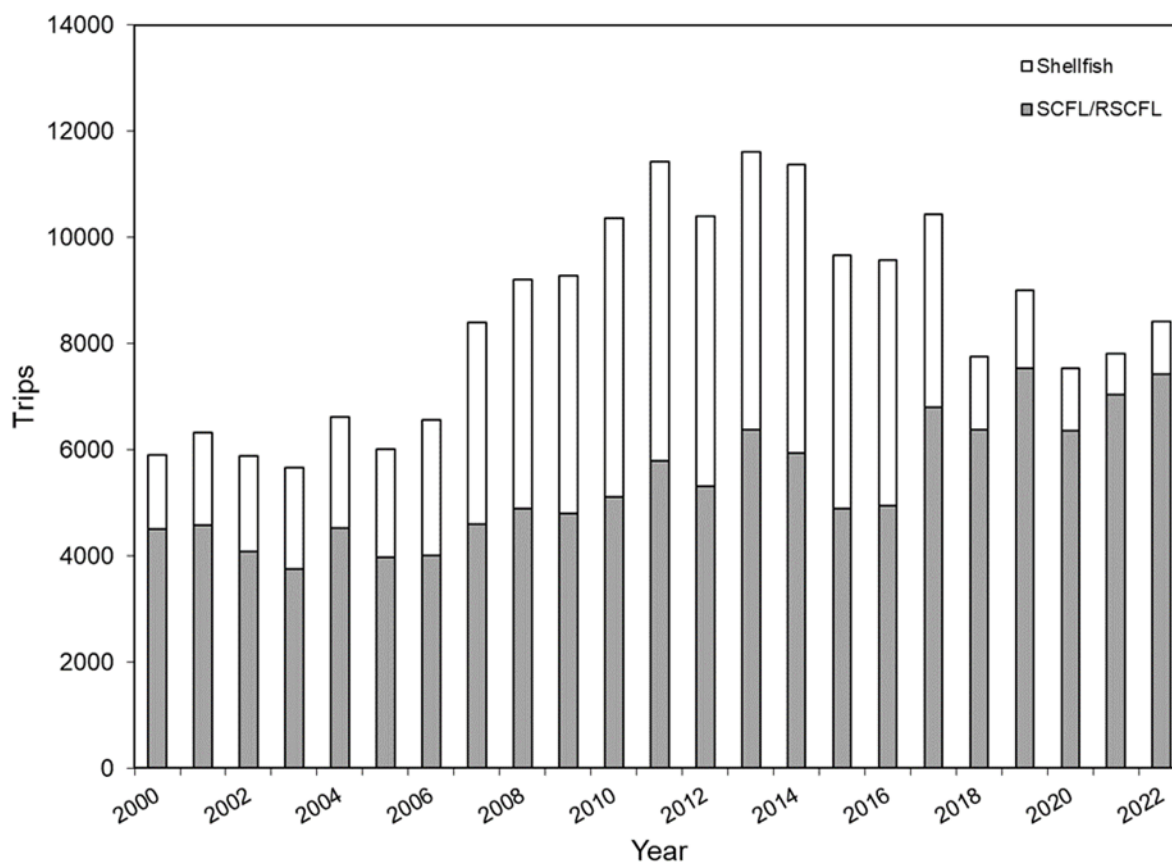


Figure 3.2. Commercial oyster fishing effort in trips for the southern region (waterbodies south of Bogue Sound) from 2000 to 2022, showing trips made by Shellfish License holders (white bars) and SCFL/RSCFL holders (gray bars).

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

fisheries independent data to provide information about oyster abundance or population structure, it is impossible to verify if trends in fisheries dependent data are reflective of the oyster population.

From 2000 to 2006, the average number of bushels landed per trip by SCFL/RSCFL holders in the southern region remained relatively close to the trip limit of five bushels, averaging 4.6 bushels per trip (Figure 3.3). However, starting in 2007, the average annual bushel amount landed per trip began to decline, reaching 3.7 bushels per trip by 2010. Between 2008 and 2017, the average annual bushel amount fluctuated but remained below four bushels per trip. Beginning in 2018 after the bushel limit for Shellfish License holders was reduced by management action implemented via Amendment 4, there was an increase in the average annual bushels per trip, reaching an average of 4.6 bushels per trip by 2023.

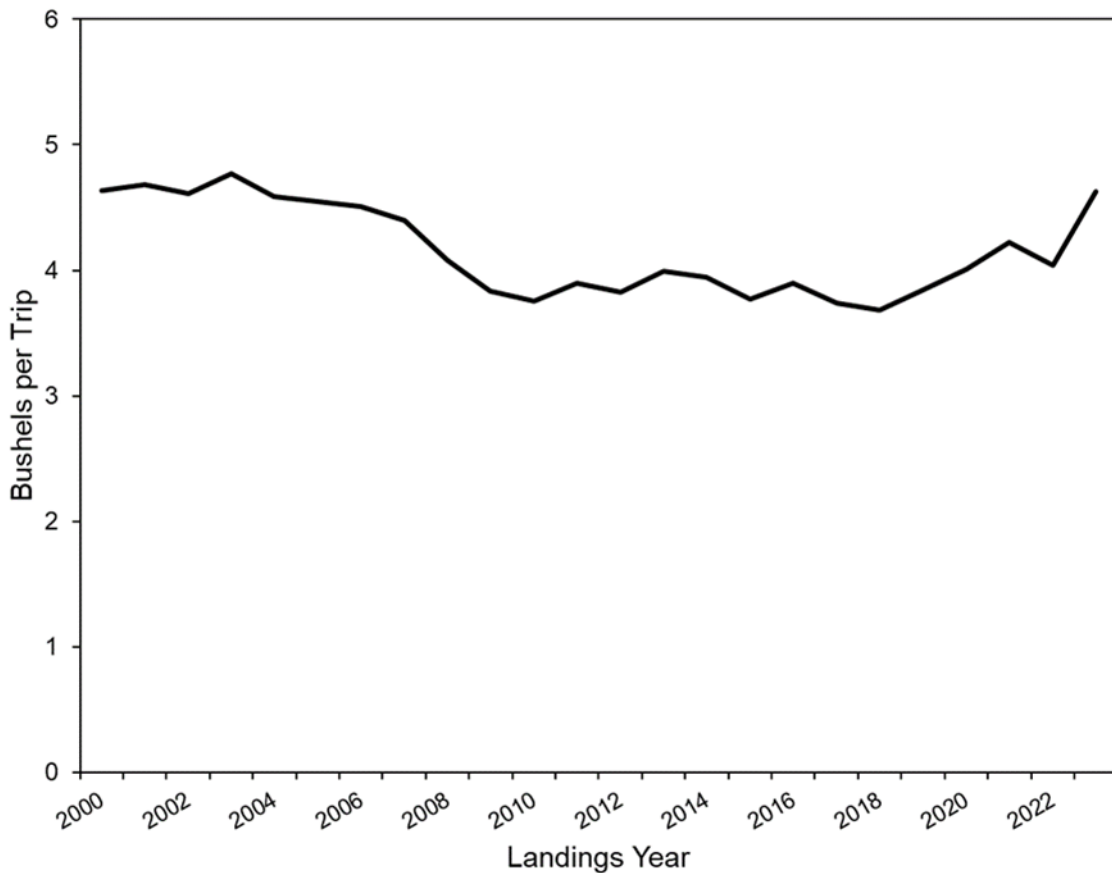


Figure 3.3. The catch-per-unit-effort (CPUE) for oyster commercial harvest in the southern region (waterbodies south of Bogue Sound) from 2000 to 2023. The black line represents the average annual bushel amount landed per trip by SCFL/RSCFL holders.

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

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

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

Intertidal oyster reefs in the southern region are also readily accessible to recreational harvesters. However, the extent of recreational shellfish harvesting compared to commercial harvesting is currently unknown. There is no established mechanism for

accurately quantifying the number of recreational shellfish harvesters in North Carolina, which limits the NCDMF's ability to estimate total recreational shellfish harvest in the southern region. For further details, please refer to Appendix 1: Recreational Shellfish Harvest Issue Paper.

In 2024, the NCDMF implemented a pilot fishery independent sampling program to monitor the intertidal oyster resource. Fifteen sentinel sites have been proposed across the southern region of the state to represent the intertidal oyster population. Sites include areas both open and closed to shellfish harvest. These sentinel sites will be surveyed using UAS (uncrewed aerial systems; drones), allowing for high-resolution repeated mapping, as well as traditional sampling for biological and water quality data. Sampling is planned to occur before and after the open harvest season, allowing development of fishery independent indices and assessment of fishing impacts on the oyster resource.

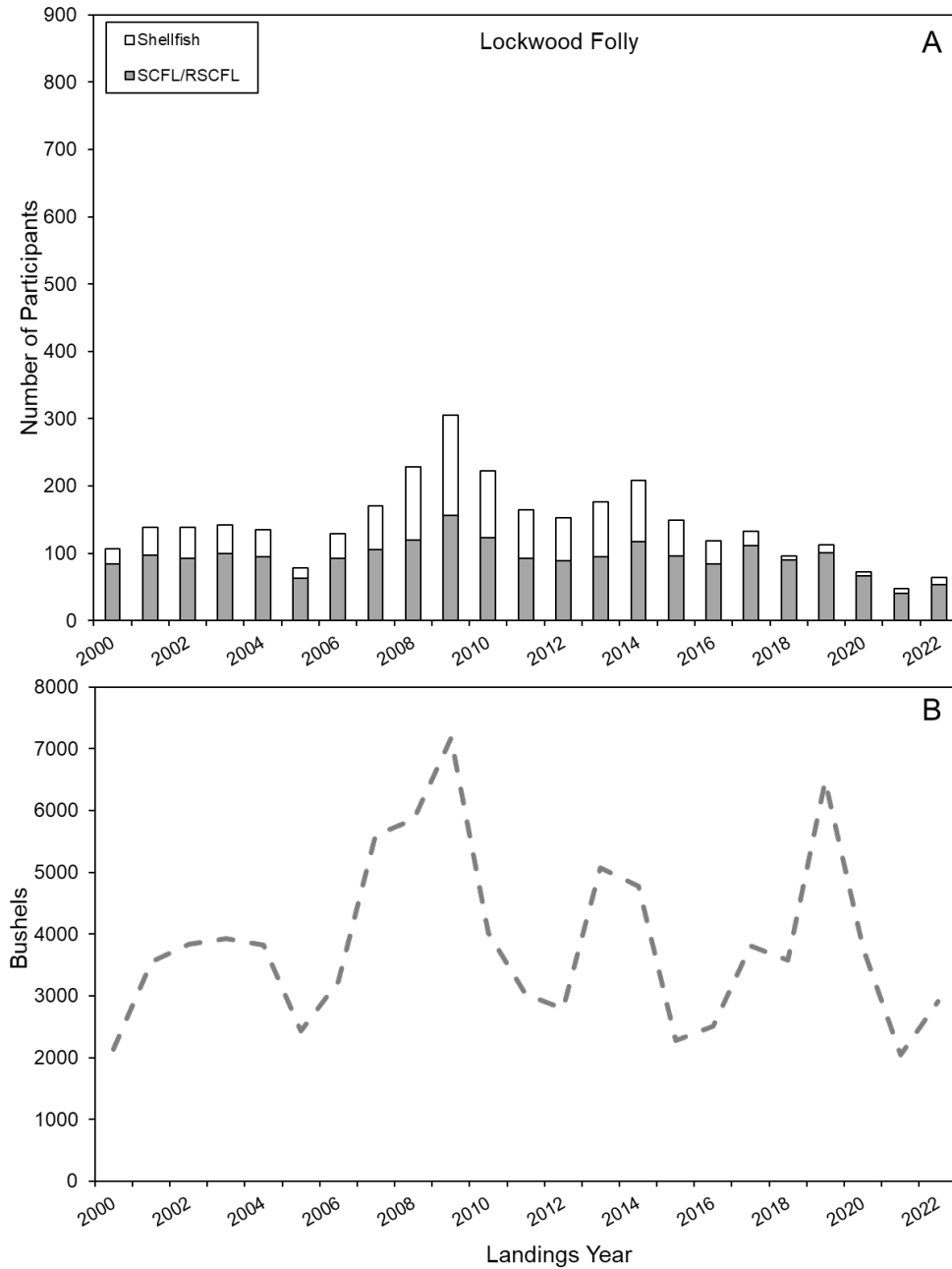


Figure 3.4. (A) Annual number of participants with oyster landings for Lockwood Folly River, from 2000 to 2022, by license type for Shellfish Licenses (white bars) and SCFL/RSCFL (gray bars). (B) Annual commercial landings of oysters in bushels for the Lockwood Folly River from 2000 to 2022.

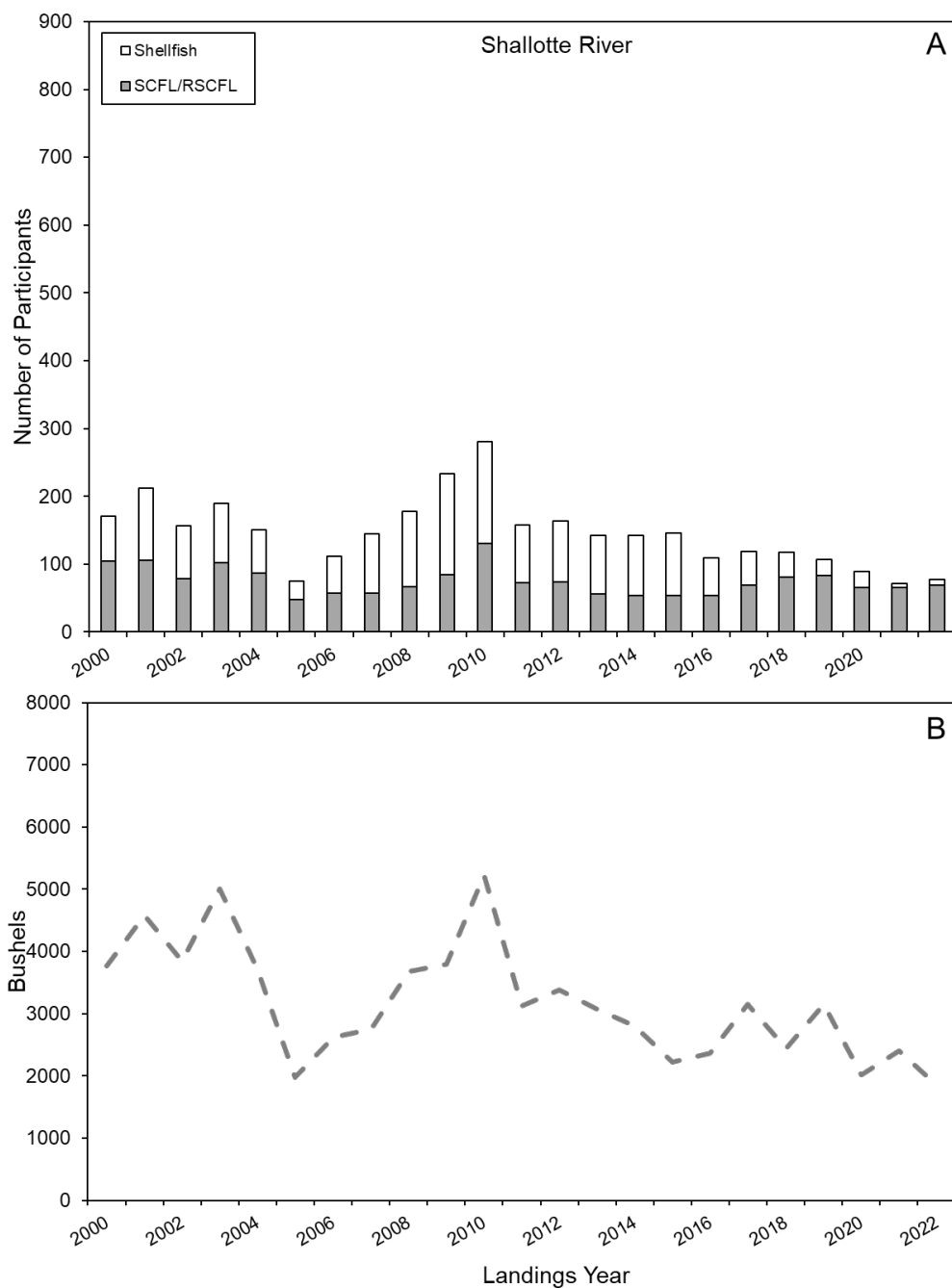


Figure 3.5. (A) Annual number of participants with oyster landings for Shallotte River, the entire bar height shows total number of participants, with the proportion of participants with Shellfish Licenses shown as white, and the proportion with SCFL/RSCFL shown as grey. (B) Total commercial landings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

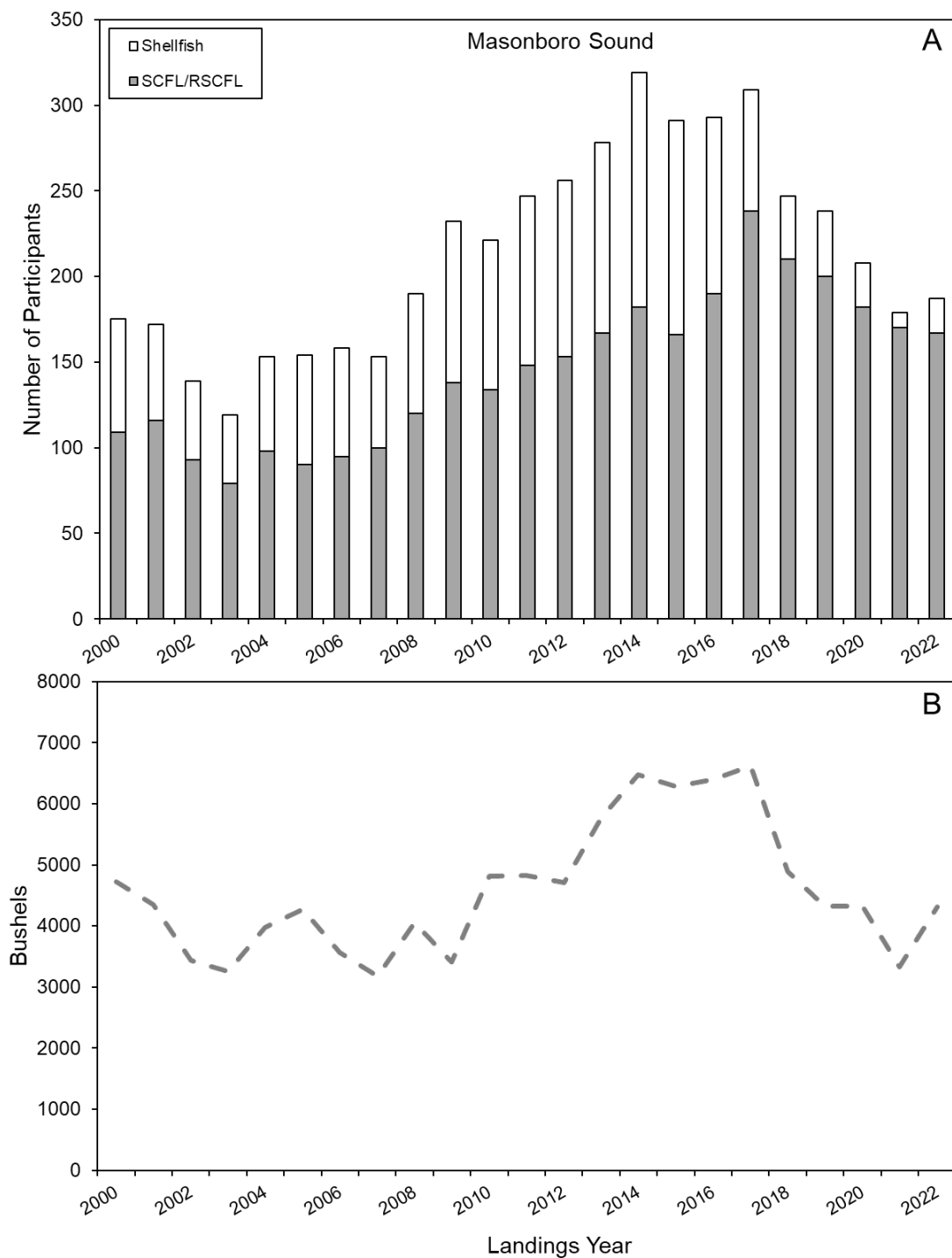


Figure 3.6. (A) Annual number of participants with oyster landings for Masonboro Sound, the entire bar shows total number of participants, with the proportion of participants with Shellfish Licenses shown as white, and the proportion with SCFL/RSCFL shown as grey. (B) Total commercial landings of oyster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

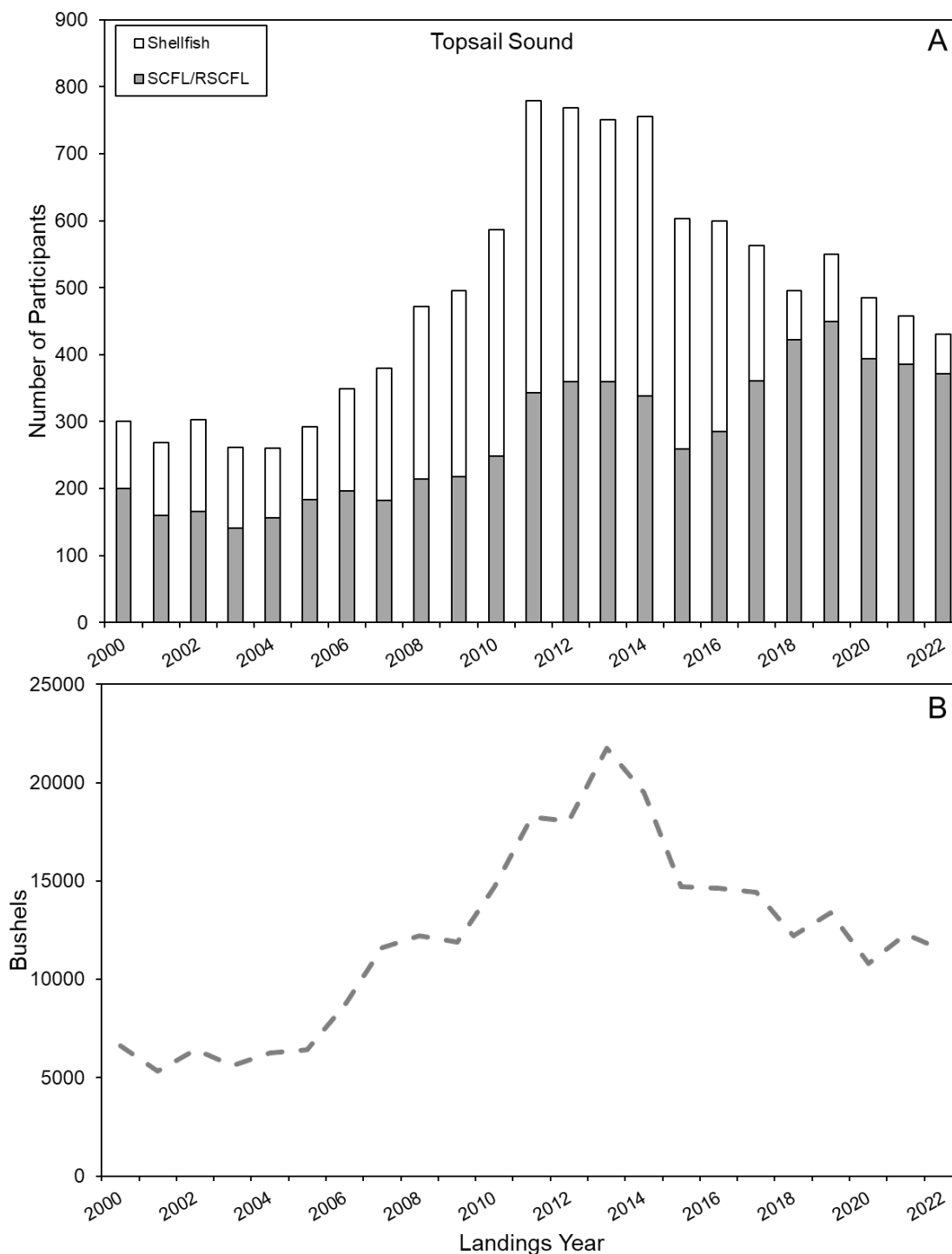


Figure 3.7. (A) Annual number of participants with oyster landings for Topsail Sound, the entire bar height shows total number of participants, with the proportion of participants with Shellfish Licenses shown as white, and the proportion with SCFL/RSCFL shown as grey. (B) Total commercial landings of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

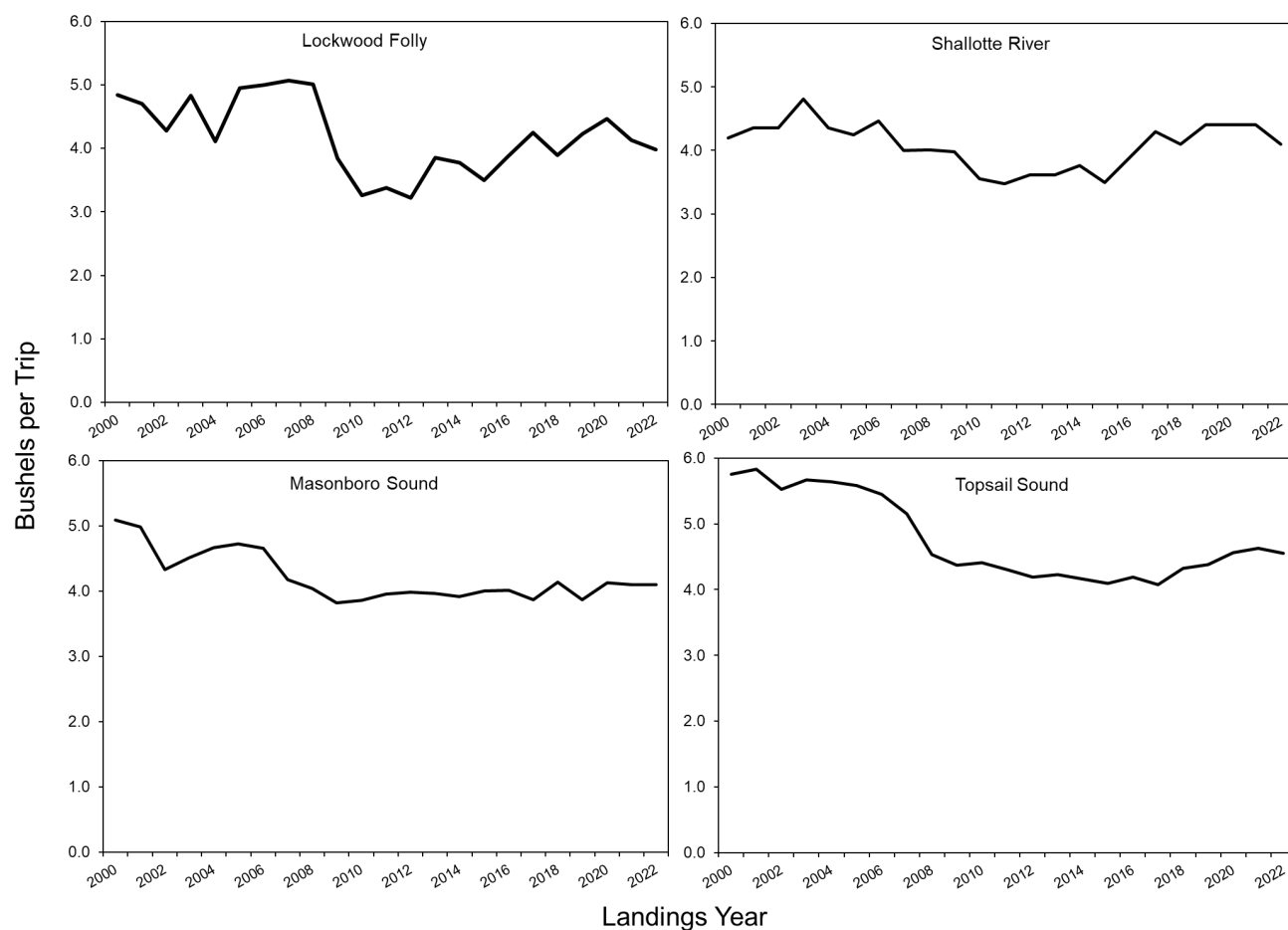


Figure 3.8. The catch-per-unit-effort (CPUE) for oyster commercial harvest in Lockwood Folly River, Shallotte River, Masonboro Sound, and Topsail Sound from 2000 to 2022. The black line represents the average annual bushel amount landed per trip for SCFL/RSCFL holders, separated by waterbody into individual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

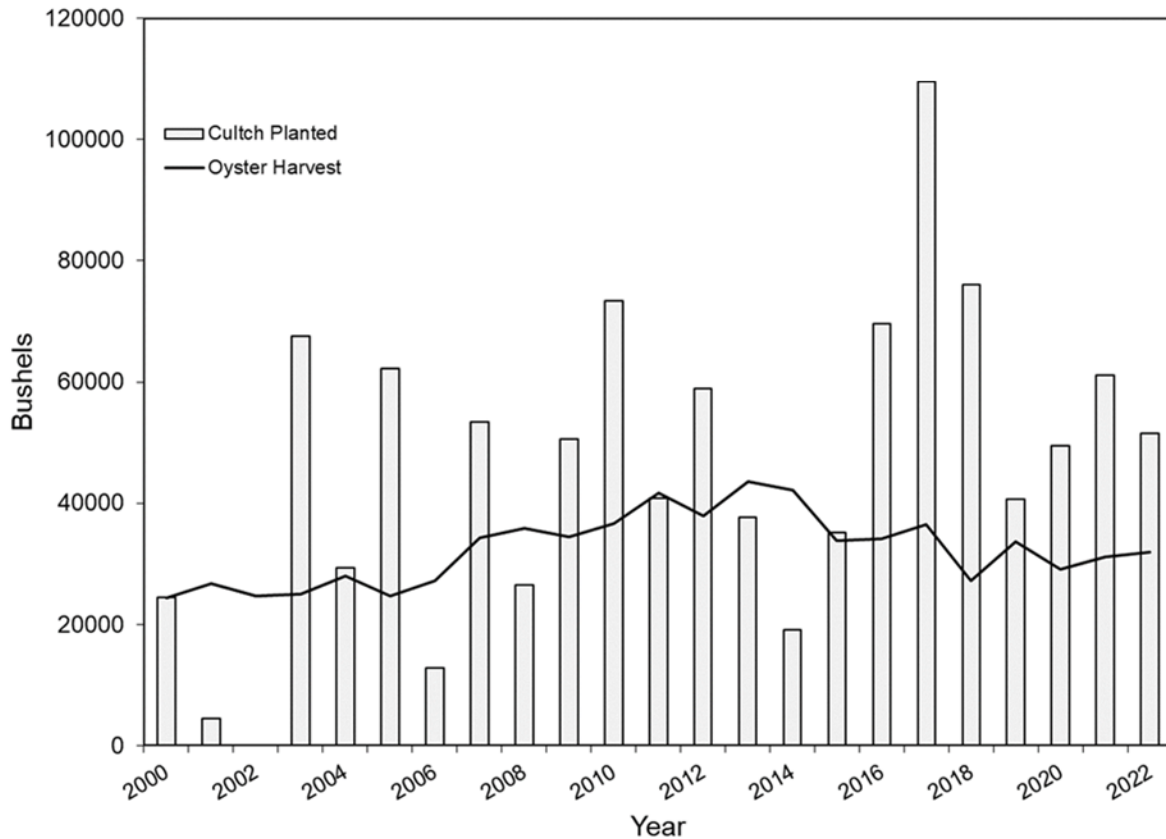


Figure 3.9. Annual bushels of cultch planted (gray bars) and commercially harvested oysters (as black line) for the southern region (waterbodies south of Bogue Sound).

AUTHORITY

N.C. General Statute

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

N.C. Rule

- North Carolina Marine Fisheries Commission Rules (15A NCAC)
- 03K .0201 Open Season and Possession Limit
- 03K .0202 Size Limit and Culling Tolerance

DISCUSSION

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

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

In the southern region, 1.42 times more bushels of cultch material have been planted compared to bushels of oysters commercially harvested between 2000 and 2022. While the cultch planting program in this region is not designed to function as direct replacement for oysters harvested in this region, the goal is to at least mitigate the amount of shell removed by commercial harvest and provide adequate substrate for oyster spat to settle. On a regional scale, the cultch planting program has been able to keep up with or exceed

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the amount of shell removed from the system via harvest overall. However, due to logistical constraints the cultch material is not distributed across all waterbodies, creating localized cultch surpluses and deficits when compared to harvest amounts. Recent cultch planting locations in the southern region have been limited to areas near one of two current cultch stockpile locations, Mile Hammock Bay (Onslow County), or Morris Landing (Onslow County). With deployment of the R/V Oyster Creek for the 2024 cultch planting season, cultch planting efforts in the southern region can be extended to sites in Pender, New Hanover, and Brunswick counties. Cultch planting efforts statewide are reliant on continued funding.

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

Appendix 4: Habitat & Enhancement Oyster Programs Information Paper

ISSUE

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

ORIGINATION

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

BACKGROUND

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

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

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

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

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

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

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

Terminology

While the state of North Carolina has been creating artificial reefs since the 1970s, not all reefs serve the same purpose. Of the 72 artificial reefs, only 17 are oyster sanctuaries. It is important to distinguish that while all artificial reef habitat is considered “reef,” not all reefs are considered “sanctuary.” The term “oyster sanctuary” refers to reefs protected from oyster harvest and some bottom disturbing gears through North Carolina Marine Fisheries Commission (NCMFC) rule 15A NCAC 03K .0209. It is also important to consider that created habitat within sanctuary boundaries always exists as a collection of

separate reef habitat patches. Therefore, sanctuaries are sometimes referred to as reef sites. In most cases concerning reef sites managed by the Oyster Sanctuary Program, the entire reef site authorized by state and federal permits is protected from oyster harvest. Therefore, the terms “reef,” “sanctuary,” and “reef site” are often used interchangeably. Conversely, the term “cultch site” refers to any site where a thin layer of material (recycled shell or marl limestone #4) has been laid out with the intention of creating oyster habitat open to harvest.

Site Selection Methodology

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

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

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

CULTCH PLANTING PROGRAM

For over a century, the NCDMF has worked to create cultch reefs to alleviate fishing pressure on North Carolina’s natural oyster reefs. Research has demonstrated the ability of cultch planted reefs to support significant oyster densities over time, with cultch sites hosting 9.6 times more oysters than natural subtidal reefs found throughout Pamlico Sound (Peters et al. 2017). Perhaps even more indicative of their effectiveness as a fisheries management strategy, North Carolina’s cultch reefs were found to have 4.5 times more legal sized oysters than on natural oyster reefs (Peters et al. 2017). Since its

inception, over 21 million bushels of cultch material have been planted in the form of small-scale, low-relief, harvestable oyster reefs (Figure 4.1). The program has been a longstanding collaboration between state government and local oyster harvesters to ensure cultch reefs are built in the best available locations for oyster recruitment.

Program History: The First 100 years of Cultch Planting

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

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

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

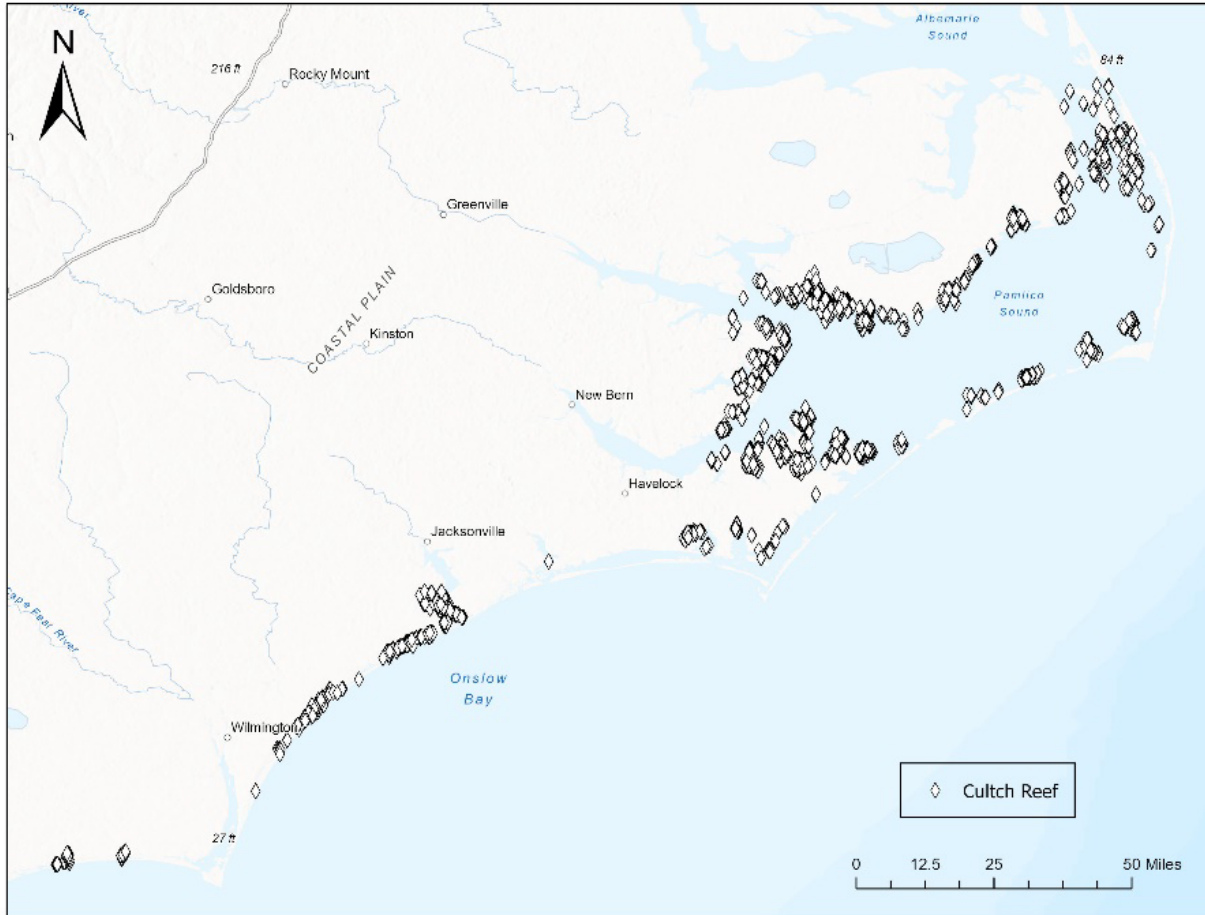


Figure 4.1. Map of cultch reefs planted between 1981–2022 from Dare County to the South Carolina border.

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

In 1998, the legislature revised the Cultch Program, namely by appropriating an annual budget of approximately \$300,000 for purchasing and transporting cultch material. This equated to planting 30–40 acres of harvestable oyster reefs each year. In fiscal year 2015–2016, funds for cultch increased to approximately \$600,000; then increased again in fiscal year 2016–2017 to \$900,000. In recent years, annual appropriations for the

program have increased to over \$1 million in some years to cover the cost of substrate, staffing, and vessels. Increases in appropriations resulted in substantial increases in annual deployments and investments in much needed modernization and improved efficiencies of fleet equipment.

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

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

Modern Cultch Planting Program: 2020 – Present

The goals defined by internal Cultch Planting Program documentation are as follows: 1) to provide suitable substrate for the attachment of natural oyster larvae, and 2) to increase oyster production. The Cultch Planting Program relieves harvest pressure from degraded natural reefs by developing permanent and routinely managed areas. In 2020, NCDMF hired the first biologist dedicated solely to the Cultch Planting Program with an objective to update and standardize site selection and sampling processes. The NCDMF currently plants between 300,000 and 400,000 bushels of cultch material annually, covering over approximately 40 acres of undeveloped inshore bottom (Table 4.1).

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

Recycled oyster shells are a well-known valuable resource for oyster restoration but remain in short supply in the state. Other states, including Virginia and Maryland, have legislative-backed shell recycling programs that offer tax credits and incentives to

businesses in exchange for oyster shells. Growing demand has increased the price of oyster shell and subsequently resulted in shell being exported out of North Carolina. Without sufficient incentives or funding, shell has become a rare resource for restoration efforts, further limiting cultch planting efforts to marl and concrete materials.

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

Peer-reviewed research has also independently quantified oyster recruitment on cultch sites. For instance, cultch reefs successfully hosted 4.5-times more legal oysters than natural reefs where no restoration effort had occurred (Peters et al. 2017). On average, cultch sites had 27 legal oysters (≥ 3 inches) per square meter (Peters et al. 2017). With 27 legal oysters/m² on cultch material, a conservative estimate suggests that one acre of harvestable cultch reef should yield approximately 368 bushels of legal oysters (300 oysters/bushel).

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

Cultch for Future Management

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

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

OYSTER SANCTUARY PROGRAM

Overview

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

The creation and preservation of oyster sanctuaries represent both a long-term, large-scale ecological restoration project as well as a long-term fisheries investment to the state of North Carolina. The network of sanctuaries provides ecosystem services that improve the quality of habitat throughout Pamlico Sound. Sanctuary sites offer nursery habitat for other species, increasing their abundance for commercial and recreational fishing; provide refuge and forage habitat for marine life; form travel corridors for transient finfish; and increase water filtration, reducing turbidity and excess nutrients in the estuary. The impacts of sanctuary sites expand far beyond their boundaries as brood stock populations supplement the growth of natural reefs and cultch sites. Furthermore, the necessity of oyster sanctuary construction falls within Recommendation 3.1 in the NC Coastal Habitat Protection Plan source document – “Greatly expand habitat restoration, including creation of subtidal oyster reef no-take sanctuaries” (NCDEQ 2016).

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

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

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

Legislation and Rules

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

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

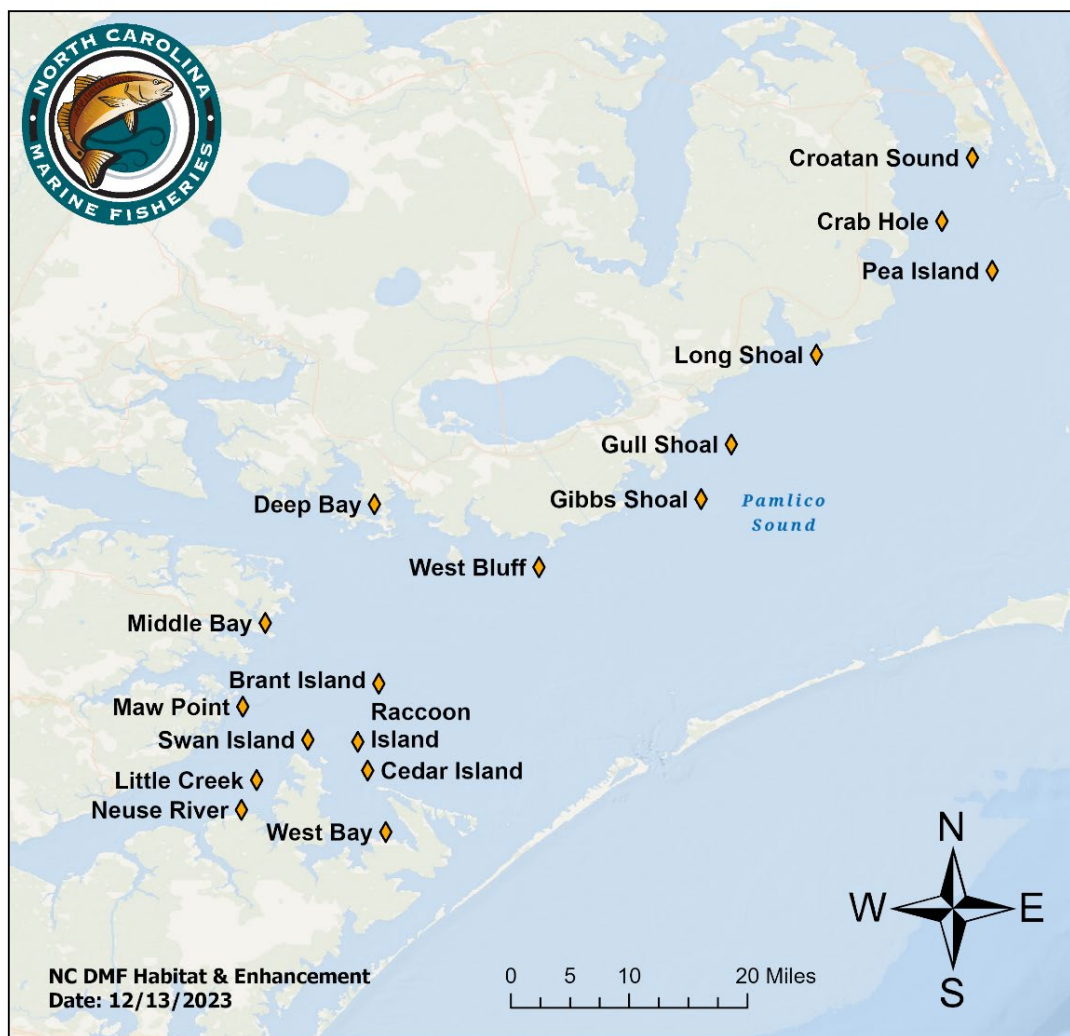


Figure 4.2. Jean Preston Oyster Sanctuary Network, Pamlico Sound, NC.

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

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

Funding History

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

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

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

Sanctuary Site Selection

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

Reef Design & Construction

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

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

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

Monitoring and Analyses

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

Measuring oyster density and size frequencies are some of the most effective ways to assess oyster reef performance (Baggett et al. 2015). NCDMF divers collect random samples for each material type within each sanctuary to measure density and population structure. Insights from oyster population metrics provide insight into material selection and improve site selection for future projects. Side scan sonar of sanctuaries every few

years provides further insight into the stability of deployed materials at each sanctuary. For instance, reefs built with recycled shell can persist if heavily colonized by oysters, and oyster growth and recruitment rates exceed mortality and shell degradation. However, constructed shell reefs rapidly degrade if not heavily colonized by oysters and are prone to being displaced in areas of heavy currents (Powell et al. 2006). Heavier and larger materials offer several advantages including long-term persistence and cost-effectiveness.

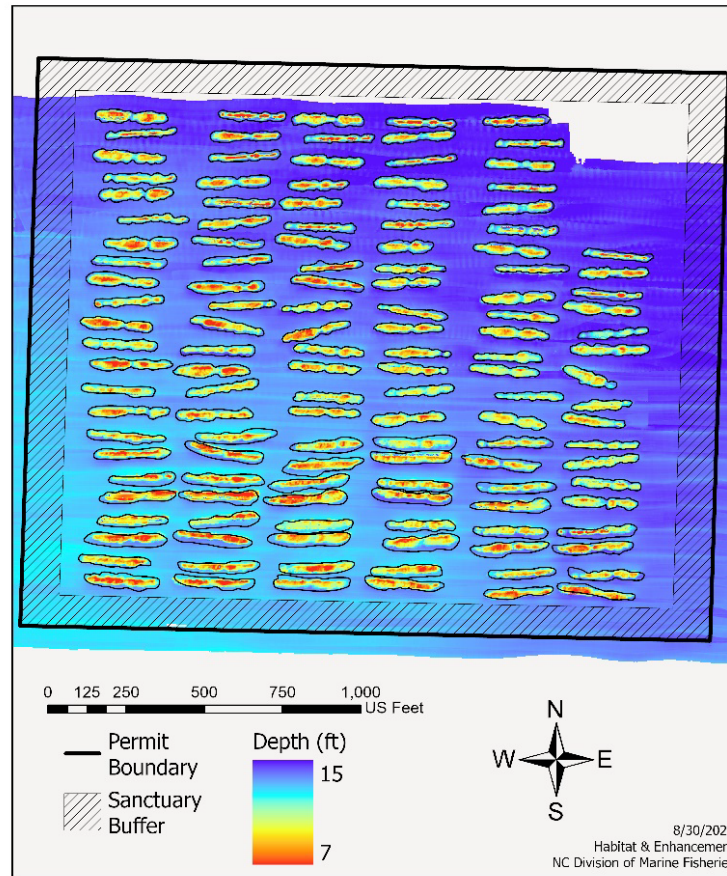


Figure 4.3. The side scan view of Cedar Island Oyster Sanctuary located in Pamlico Sound, North Carolina. The construction of the sanctuary began in 2021, using marl limestone rip rap and crushed concrete in a grid design with parallel ridges.

Data from sanctuary monitoring in 2023 suggest North Carolina's oyster sanctuaries had an average total density of 1,333 oysters/m² and an average legal density of 127 oysters/m². These estimates, along with those from independent peer-reviewed studies, verify and quantify the effectiveness of the Oyster Sanctuary Program. For instance, total

oyster density at sanctuary sites was 72 times greater than natural reefs open to harvest, and 7.5 times higher than restored harvested (cultch) areas (Peters et al. 2017). This trend extended to legal oyster density ($>75\text{mm}$), as sanctuary sites demonstrated 27 times greater density than natural harvested reefs and six times greater density than restored harvested reefs (Peters et al. 2017). The potential larval output per m^2 of sanctuary sites was significantly higher than at natural reefs (700 times greater) and cultch areas (four times), illustrating the high potential for larval spillover as intended in the design of the Oyster Sanctuary Network (Peters et al. 2017).

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Appendix 5: Eastern Oyster Management & Stock Status in Other States

Eastern Oyster management & stock status in other states. Fishery type is categorized as either recreational (Rec.) or commercial (Com.); Mechanical gear type abbreviated as 'Mech.'; bushels abbreviated as 'bu.'.

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

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

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State	Fishery	License Issued by	Gear	Daily Trip Limit	Season	Size Limit	Stock Assessment	Management
VA	Rec.	None	Hand	1 bu./vessel	1 Oct – 31 Mar (M–F until 3:00 pm)	3"	Yes	Virginia Oyster Stock Assessment and Replenishment. Partnership with VIMS and VMRC. Assessment Program and Restoration activities for Chesapeake Bay. Managed and surveyed by individual public oyster reefs. Virginia Public Oyster Grounds, 243,000 acres (380 sq miles) Fishing mortality limited by area using season length and fishing times.
	Com.	State	Hand	8 bu./person, 16 bu./vessel	Season length varies by areas, time allowed to fish varies by season			
			Hand Tong	14 bu./person, 28 bu./vessel				
			Mech.	8 bu./person, 16 bu./vessel				
NC	Rec.	None	Hand	1 bu.	1 Oct – 31 Mar	3"	No	Oyster restoration and enhancement programs in closed sanctuaries and public shellfish grounds. Mechanical harvest monitoring to close harvest when trigger falls below 26% legal by area.
	Com.	State	Hand	3–15 bu. (varies by license, area)	1 Oct – 31 Mar (Brunswick Co., Mar 15) (Mon–Sat)			
			Mech.	10 or 15 bu. (varies by area)	3rd Monday in Nov until closure by management trigger (M–F)			
SC	Rec.	State	Hand	2 bu., no more than 4 bu. per seven-day pd.	1 Oct – 27 May	None	No	Restoration and enhancement on public shellfish grounds.
	Com.	State	Hand, Mech.	None				

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State	Fishery	License Issued by	Gear	Daily Trip Limit	Season	Size Limit	Stock Assessment	Management
GA	Rec.	State	Hand	2 bu./person, 6 bu./vessel	1 Oct – 27 May	3"	No	Restoration and enhancement.
	Com.		Hand	None		2"		
FL	Rec.	State	Hand	120 lbs. per person/vessel	1 Sep – 31 May or 1 Oct – Jun 30, depending on County	3"	No	Restoration and enhancement.
	Com.		Hand Tong	1200 lbs. per person/vessel				
AL	Rec.	None	Hand	100 oysters	1 Oct – 30 April (M–F until 2 pm)	3"	No	Reefs are assessed annually by divers to determine if management changes are needed. Enhancement program funded by the sale of oyster tags.
	Com.	State	Hand, Mech.	6 sacks				
MS	Rec.	State	Hand	3 sacks per week	1 Oct – 31 Mar	3"	No	Restoration and enhancement.
	Com.	State	Hand, Mech.	15 sacks, quotas by area				
LA	Rec.	State	Hand	2 sacks	Wed after Labor Day to 30 Apr	3"	Yes	over 1,700 dredge samples and 1,000 diver quadrat samples used to inform fishery independent portion of stock assessment. 2,656 sq. miles of oyster ground. Shell Recycling and restoration and enhancement programs.
	Com.	State	Hand, Mech.	5–30 sacks per vessel (varies by region)				
TX	Rec.	State	Hand	220 lbs.	1 Nov – 30 April	3"	No	Restoration and enhancement. Area and season closures determined by monitoring and a traffic light approach.
	Com.	State	Hand, Mech.	330 lbs.	1 Nov – 30 April (M–F until 3:30 pm)			

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

ISSUE

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

ORIGINATION

The North Carolina Division of Marine Fisheries (NCDMF).

BACKGROUND

The Oyster and Clam Fishery Management Plans (FMPs) Advisory Committee (AC) met for a three-day workshop on July 15, 16, and 17, 2024, at Craven Community College in New Bern. As these two fisheries share considerable overlap in their ecology and management, the FMPs are being revised simultaneously though written separately. The purpose of the workshop was for the AC to assist NCDMF staff in evaluating management issues and options included in the draft documents of Amendment 5 to the Eastern Oyster FMP and Amendment 3 to the Hard Clam FMP. The NCDMF sought to solicit feedback and input on the impacts of management options on the oyster and clam resources and user groups. It is important to note the aim of the AC workshop was to receive input from committee members based on their experiences, expertise, and sector relationships, not to build a consensus among AC members or to recommend specific management strategies.

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

DISCUSSION

Base Plan

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

to the status of stock assessment completion in other states, including methodologies and findings.

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

An analysis of trip ticket data was added to the base plan illustrating relative landings contribution of the top 25% of participants in the oyster mechanical fishery. These data, along with the number of participants from 2010 to 2023, were added to the Mechanical Harvest section. It is important to note that Trip Ticket data are assigned to major water bodies (e.g., Pamlico Sound, Neuse River), but not at a finer detail to allow for spatial analysis on fishing effort by top contributors.

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

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

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

Habitat and Enhancement Programs

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

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

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

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

Mechanical Oyster Harvest

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

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

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

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

Intertidal Oyster Harvest

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

to limited shell availability, other materials besides marl should be considered for future cultch planting efforts.

Recreational Shellfish Harvest

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

Appendix 7: Summary Of Management Recommendations and Comment

Table 7.1. Summary of management recommendations from NCDMF, the Northern, Southern, Shellfish & Crustacean, and Habitat & Water Quality Advisory Committees (AC).

	NCDMF	Northern AC	Southern AC	Shellfish & Crustacean AC	Habitat & Water Quality AC
Appendix 1: Recreational Shellfish Harvest					
<i>Recreational License or Permit for Shellfish</i>	Support the MFC to task the DMF with exploring options outside of the FMP process for developing a solution to quantify recreational shellfish participation and landings, and to create a mechanism for providing recreational participants with SSRWQ health and safety information.	Support the MFC to task the DMF with exploring options outside of the FMP process for developing a solution to quantify recreational shellfish participation and landings, and to create a mechanism for providing recreational participants with SSRWQ health and safety information.	Support the MFC to task the DMF with exploring options outside of the FMP process for developing a solution to quantify recreational shellfish participation and landings, and to create a mechanism for providing recreational participants with SSRWQ health and safety information.	Support the MFC to task the DMF with exploring options outside of the FMP process for developing a solution to quantify recreational shellfish participation and landings, and to create a mechanism for providing recreational participants with SSRWQ health and safety information.	Support the MFC to task the DMF with exploring options outside of the FMP process for developing a solution to quantify recreational shellfish participation and landings, and to create a mechanism for providing recreational participants with SSRWQ health and safety information.
Appendix 2: Mechanical Oyster Harvest					
<i>Deep Water Recovery Areas (DORAs)</i>	Adopt the proposed Pamlico and Neuse River DORAs which are bound by existing navigational aids as presented to the regional ACs.	Recommended maintaining status quo and did not support adopting DORAs as a management strategy because of the unknown advantages and known disadvantages to the commercial industry.	Supported a significantly narrower approach to DORAs with the purpose of evaluating the effectiveness of the closures before considering closing the majority of the area.	Recommended maintaining status quo and did not support adopting DORAs as a management strategy.	Adopt the proposed Pamlico and Neuse River DORAs which are bound by existing navigational aids as presented to the regional ACs.

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<i>Cultch Supported Harvest</i>	Adopt the Cultch Supported Harvest strategy outlined in the issue paper.	Adopt the Cultch Supported Harvest strategy outlined in the issue paper. with the intent to streamline and adapt the trigger sampling procedure.	Adopt the Cultch Supported Harvest strategy outlined in the issue paper.	Adopt the Cultch Supported Harvest strategy outlined in the issue paper.	Adopt the Cultch Supported Harvest strategy outlined in the issue paper.
<i>Adaptive Management to Cultch Supported Harvest</i>	Adopt the proposed adaptive management framework.	Adopt the proposed adaptive management framework.	Adopt the proposed adaptive management framework.	Adopt the proposed adaptive management framework.	Adopt the proposed adaptive management framework.
<i>Rotational Harvest Cultch Sites</i>	Adopt the inclusion of Rotational Harvest Cultch sites as a management strategy as described in the issue paper.	Adopt the inclusion of Rotational Harvest Cultch sites as a management strategy as described in the issue paper.	Adopt the inclusion of Rotational Harvest Cultch sites as a management strategy as described in the issue paper.	Adopt the inclusion of Rotational Harvest Cultch sites as a management strategy as described in the issue paper.	Adopt the inclusion of Rotational Harvest Cultch sites as a management strategy as described in the issue paper.

Online Eastern Oyster Amendment 5 Public Questionnaire

The online Eastern Oyster Amendment 5 Public Questionnaire opened on December 11, 2024, and closed January 15, 2025. In total, the questionnaire had 8 participants, 6 of which left comments pertaining specifically to the draft of Amendment 5 to the Eastern Oyster Fishery Management Plan.

Comments to the open response questionnaire were mixed when it came to implementing deep water recovery areas (DORAs) in Pamlico Sound. Three responders voiced their opposition to closure areas. Both cited that die-offs occur in these areas as a result of hurricanes and water quality issues, and that oyster production is cyclical in these areas. One additional commentor also advocated against closure of large areas but suggested being amenable to a smaller closure area. One of these responders requested additional cultch planting and suggested improved involvement of local oystermen for future site selection.

One responder for both plans suggested stocking clams and oysters to help rebuild natural populations while allowing for continued traditional harvest methods. The same responder also expressed opposition to further public water leases and advocated for stricter labeling of farmed shellfish.

Another responder expressed the need for regulations that promote sustainable practices, specifically aquaculture and protecting wild shellfish populations from bottom disturbing gear.

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NC Marine Fisheries Commission

Hard Clam Fishery Management Plan

May 2025 Quarterly Business Meeting

Documents

Hard Clam Decision Document

Draft Hard Clam FMP Amendment 3

DECISION DOCUMENT

Hard Clam Fishery Management Plan Amendment 3



This document was developed by the Division of Marine Fisheries to help the Marine Fisheries Commission track previous activity and prepare for upcoming actions for the Hard Clam FMP Amendment 3.

May 2025

Summary

At their March 2025 Business Meeting, the Marine Fisheries Commission (MFC) selected their preferred management options for Amendment 3 to the Hard Clam Fishery Management Plan (FMP). The draft FMP was revised to include these selected options and then provided to the Secretary of the North Carolina Department of Environmental Quality. The Secretary submitted the draft FMP to the Joint Legislative Oversight Committee on Agriculture and Natural and Economic Resources (AgNER) for their 30-day review period (N.C. General Statute § 113-182.1(e)). The draft FMP will be provided to the MFC for their vote on final adoption of Amendment 5 at their May 2025 Business Meeting.

This revised Decision Document includes the MFC preferred management options selected at the March 2025 Business Meeting and the suite of management options and rationale behind them that were provided to the MFC for their consideration at that meeting.

Background

The Hard Clam FMP is undergoing its five-year review. Since there is no stock assessment for status determination, the goal is to manage the resource to maintain the species population to provide long-term harvest and continue to offer protection and ecological benefits to North Carolina estuaries. Only wild clam harvest issues and management strategies are considered in Amendment 3.

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

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

However, mechanical clam harvest fishery from public bottoms has sharply declined since the 1990s, reaching historic lows in both participation and landings.

The Hard Clam FMP Amendment 2 included a management strategy to allow harvesters access to clams before maintenance dredging. This allowance continues through 15A NCAC 03K .0301 (b); and through communication with the US Army Corps of Engineers on their schedule to ensure timely notification of dredging activities. This activity has not occurred since 2007.

Historically significant, the mechanical clam fishery has seen substantial reductions due to habitat impacts, pollution, market changes, and environmental events. With significant habitat concerns regarding SAV and oyster beds, diminishing economic value, and high management costs, management options for the fishery's future are provided.

Amendment Timing

(gray indicates completed step)

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

You are
here

Goal and Objectives

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

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

Management Measures

Management Carried Forward in Amendment 3

There are management measures from the original FMP to carry forward into Amendment 3 unless otherwise changed in Amendment 3. Management measures from the Hard Clam FMP Amendment 2 that will be carried forward into Amendment 3 are listed below:

- Maintain shading requirements for clams on a vessel, during transport to a dealer, or storage on a dock during June through September. These requirements would be implemented as a public health protection measure under 15A NCAC 03K .0110.
- Maintain management of the Ward Creek Shellfish Management Area as described in the Hard Clam FMP Amendment 1.
- Maintain current daily mechanical Hard Clam harvest limits by waterbody.
- Institute a resting period within the mechanical clam harvest area in the northern part of Core Sound.
- Take latitude/longitude coordinates of the poles marking the open mechanical clam harvest area boundary in the New River, still with the flexibility to move a line to avoid critical habitats.
- Maintain management of the mechanical clam harvest in existing areas from Core Sound south to Topsail Sound, including modifications to the mechanical clam harvest lines to exclude areas where oyster habitat and submerged aquatic vegetation (SAV) habitat exist based on all available information.

MFC Selected Management Measures

Outlined below are the preferred management options by issue selected in March 2025 by the MFC for Amendment 3 to the Hard Clam FMP.

Recreational Harvest

- Support the DMF to further explore potential options and develop a solution to estimate recreational shellfish participation and landings, with the intent to move towards a stock assessment and stock level management for both hard clams and oysters; and to establish a mechanism to provide all recreational shellfish harvesters with Shellfish Sanitation and Recreational Water Quality health and safety information outside of the FMP process.

Mechanical Clam Harvest

- Phase out mechanical clam harvest in three years (May 2028) to be consistent with G.S. 113-221 (d).
- Discontinue allowance for mechanical clam harvest in conjunction with maintenance dredging upon adoption of this plan

Suite of Management Options Presented

(Options outlined in blue represent MFC's preferred option selected in March 2025 and DMF's recommendation)

Recreational Harvest

Implementing a licensing or permitting requirement for recreational shellfish harvesters would give the DMF the opportunity to adequately collect recreational landings data needed for future stock assessments of Hard Clams and Eastern Oysters, and to inform participants of where to find information on harvest closure boundaries, where to sign up to receive polluted area proclamations or to access temporary closure maps, and where to find information on safe handling practices, particularly as it relates to *Vibrio* bacteria.

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

Option 1: Recreational Harvest

(Refer to pp. 68-75 in the Draft Hard Clam FMP Amendment 3, Appendix 2 for additional details)

a. Status Quo

- b. Support the DMF to further explore potential options and develop a solution to estimate recreational shellfish participation and landings, with the intent to move towards a stock assessment and stock level management for both hard clams and oysters; and to establish a mechanism to provide all recreational shellfish harvesters with SSRWQ health and safety information outside of the FMP process.

Mechanical Clam Harvest

Due to the requirements of G.S. 113-221 (d), it is unlikely that the mechanical clam harvest fishery could be ended immediately upon adoption of this amendment. An immediate closure of this fishery could “result in severe curtailment of the usefulness or value of equipment in which fishermen have any substantial investment” as outlined in statute. This would require “a future effective date so as to minimize undue potential economic loss to fishermen”. As such, the DMF did not include the immediate end to the mechanical clam harvest fishery as a possible management option. Other possible management options include, but are not limited to, status quo, further limiting mechanical clam harvest areas, and phasing out the fishery. These management options would only affect mechanical clam harvest from public bottom and would not affect their use on private bottom.

Status quo would allow the fishery to continue to operate as it currently does. The fishermen currently operating in the fishery could continue, and new harvesters could join. The cost to the state for demarcation and enforcement would remain the same, making up a significant cost compared to the total value of the fishery. Concerns about effects of bottom disturbing gears on structured habitats would not be addressed.

Mechanical clam harvest areas could be further limited to create boundaries that are more easily enforceable that also create buffers around critical habitat to protect them from sedimentation associated with bottom disturbing gears, as was done in the North River (See Figure 22 in the draft FMP). To improve enforceability the boundaries would be based on permanent structures or known geographic features, be rectangular or rhomboid in shape without zig-zagging lines and have complete line of sight visibility. As with status quo, fishermen currently operating in the fishery could continue, and new harvesters could join. The cost to the state for demarcation would be reduced, but the resources required for enforcement would likely remain the same, making up a significant cost compared to the total value of the fishery. This would help address habitat concerns, but sedimentation would still occur from mechanical harvesting operations.

The mechanical clam harvest fishery could be phased out over a set timeframe, as was done with the shellfish relay program. This option would allow fishermen currently operating in the fishery to continue during the phase out period but would discourage new participants. The phase out period would allow current mechanical harvesters time to get rid of gear and transition to other clam harvesting methods or fisheries. This option would address habitat concerns, as well as cost concerns with demarcation and enforcement. This option is consistent with G.S. 113-221 (d), as it gives “a future effective date so as to minimize undue potential economic loss to fishermen”.

After hearing concerns from the FMP Advisory Committee about participants wanting the ability to re-enter the fishery, the DMF developed an option for a phase out timeframe of three years from adoption of this amendment unless minimum participation and landings increases occur in the fishery in any year prior to 2027. This increase in participation and landings would show the fishery is no longer diminishing. Historical fisheries data were examined to develop potential thresholds for the minimum participation and landings that would signal renewed participation in the fishery. A reasonable threshold for participants in the mechanical clam harvest fishery on public bottom is ten participants. Ten participants have not been active in a single year in the fishery since 2017 and is over three times the number of active participants in 2022 (three participants), but still less than a tenth of the peak participation in 1996 (132 participants). A reasonable threshold for landings in the mechanical clam harvest fishery on public bottom is one-million clams. The fishery has not landed over one million clams since 2014 (1.5 million clams) and the threshold is over six times the number landed in 2022 (less than 200,000 clams), but still less than an eighth of the peak landings in 1995 (8.2 million clams). In this option, if both thresholds are met in any single year prior to January 2027, the issue would be brought back to the MFC for consideration at their next business meeting. The MFC would decide whether to move forward with phase out of the fishery. This timing ensures that if the phase out continues as planned, fishermen would still have three years to sell their gear and exit the fishery before the phase out is complete and the fishery closes in 2028, which would be consistent with G.S. 113-221 (d).

There is a potential that setting participation and landing thresholds that trigger reconsideration by the MFC for phasing out the fishery may have an unintended consequence. Fishermen may re-enter this fishery in the near term in an effort to maintain it as an option in the long term. Based on the habitat degradation effects of mechanical clam harvest, along with the aforementioned DMF resources needed for demarcation and enforcement of management areas, the DMF recommends the phasing out of this gear within three years without triggers for reconsideration of the phase out.

Discontinuing the allowance for mechanical clam harvest in conjunction with maintenance dredging could also be considered. This would end a program that has not been utilized since 2007. This option could be pursued on its own, or in conjunction with a closure or phase out of the whole fishery. This would require a change to rule 15A NCAC 03K .0301 (b).

ending the allowance for mechanical clam harvest in conjunction with maintenance dredging activities.

Option 1: Mechanical Clam Harvest

(Refer to pp. 55-67 in the Draft Hard Clam FMP Amendment 3, Appendix 1 for additional details)

- a. Status Quo
- b. Further limit mechanical clam harvest areas to improve enforceability and protect habitat
- c. Phase out mechanical clam harvest in three years (May 2028) to be consistent with G.S. 113-221 (d) unless two metrics are met that signify increased participation and landings in the fishery
- d. Phase out mechanical clam harvest in three years (May 2028) to be consistent with G.S. 113-221 (d)

Option 2: Mechanical Clam Harvest in Conjunction with Maintenance Dredging

(Refer to pp. 55-67 in the Draft Hard Clam FMP Amendment 3, Appendix 1 for additional details)

- a. Status Quo
- b. Discontinue allowance for mechanical clam harvest in conjunction with maintenance dredging upon adoption of this plan

Next Steps

The MFC selected their preferred management options at their March 2025 Business Meeting. The draft FMP was revised to include these selected options and then provided to the Secretary of the North Carolina Department of Environmental Quality. The Secretary submitted the draft FMP to the Joint Legislative Oversight Committee on Agriculture and Natural and Economic Resources (AgNER) for their 30-day review period (N.C. General Statute § 113-182.1(e)). At the May 2025 business meeting, the MFC will be presented any comments from the review and will vote on the final adoption of measures for the Hard Clam FMP Amendment 3. After adoption, the DMF will immediately begin implementation of the adopted management measures.

DRAFT, 2025

North Carolina Hard Clam Fishery Management Plan Amendment 3

North Carolina Division of Marine Fisheries



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EXECUTIVE SUMMARY

The Hard Clam is a commercially and recreationally important molluscan shellfish species harvested in North Carolina's estuarine waters. The commercial Hard Clam fishery has been in decline since its peak in the 1980's. The mechanical harvest portion of the commercial fishery has seen the most pronounced decline, landing less than 2% of the fishery's peak harvest (1995) each year from 2017 to 2022. Harvest from the recreational fishery cannot be quantified because the number of recreational shellfish harvesters in North Carolina is currently unknown.

The status of the Hard Clam stock in North Carolina is unknown due to data limitations preventing the NCDMF from conducting a Hard Clam stock assessment and calculating sustainable harvest metrics. Data available for the stock are commercial landings, data collected from fish houses, and an annual recreational survey. Landing trends will reflect population abundance to an extent, but other factors like market demand, regulations, changes in effort, and gear technology also affect trends (NCDMF 2017).

The goal of the N.C. Hard Clam FMP is to manage the Hard Clam resource to provide long-term harvest and continue to offer protection and ecological benefits to North Carolina's estuaries. The following objectives will be used to achieve this goal: to use the best available biological, environmental, habitat, fishery, social, and economic data to effectively monitor and manage the Hard Clam fishery and its environmental role; to manage Hard Clam harvesting gear use to minimize damage to the habitat; to coordinate with DEQ and stakeholders to implement actions that protect habitat and environmental quality consistent with the Coastal Habitat Protection Plan (CHPP) recommendations; and to promote stewardship of the resource through public outreach to increase public awareness regarding the ecological value of Hard Clams and encourage stakeholder involvement in fishery management and habitat enhancement activities.

To meet the goal and objectives of Amendment 3, two issues within the North Carolina Hard Clam fishery are addressed: 1) phase out of the mechanical harvest fishery; and 2) quantifying recreational shellfish harvest.

The observed declines in harvest and participation in the mechanical clam harvest fishery, along with habitat concerns associated with bottom disturbing gears, as well as significant cost to the state for management of this fishery prompted a re-examination of whether this fishery should still be allowed to operate. Additionally, the allowance of mechanical clam harvest in conjunction with maintenance dredging was also explored. To address this issue, the N.C. Marine Fisheries Commission (NCMFC) selected the following management at its March 2025 business meeting:

1. Mechanical Clam Harvest

- Phase out mechanical clam harvest in three years (May 2028) to be consistent with G.S. 113 221 (d)

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2. Mechanical Clam Harvest in Conjunction with Maintenance Dredging
 - Discontinue allowance for mechanical clam harvest in conjunction with maintenance dredging upon adoption of this plan

The number of recreational shellfish harvesters in North Carolina is currently unknown, which prevents reliable estimates of total recreational harvest of shellfish. Because there is no license or permit required for recreational shellfish harvest, there is currently no mechanism for reaching and educating recreational harvesters regarding human health and safety information on shellfish harvest like there is for commercial harvesters when they acquire their license. This issue is shared for the Eastern Oyster FMP Amendment 5. To address this issue for both FMPs, the NCMFC selected the following management at its March 2025 business meeting:

1. Recreational Harvest
 - Support the DMF to further explore potential options and develop a solution to estimate recreational shellfish participation and landings, with the intent to move towards a stock assessment and stock level management for both hard clams and oysters; and to establish a mechanism to provide all recreational shellfish harvesters with Shellfish Sanitation and Recreational Water Quality health and safety information outside of the FMP process.

Additionally, the following management measures from Amendment 2 are carried forward into Amendment 3:

- Daily harvest limit for recreational purposes is 100 clams per person per day not to exceed 200 per clams per vessel per day.
- Maintain shading requirements for clams on a vessel, during transport to a dealer, or storage on a dock during June through September. These requirements would be implemented as a public health protection measure under 15A NCAC 03K .0110.
- Maintain management of the Ward Creek Shellfish Management Area as described in the Hard Clam FMP Amendment 1.
- Maintain current daily mechanical Hard Clam harvest limits by waterbody (Table 1).
- Institute a resting period within the mechanical clam harvest area in the northern part of Core Sound.
- Take latitude/longitude coordinates of the poles marking the open mechanical clam harvest area boundary in the New River, still with the flexibility to move a line to avoid critical habitats.

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- Maintain management of the mechanical clam harvest in existing areas from Core Sound south to Topsail Sound, including modifications to the mechanical clam harvest lines to exclude areas where oyster habitat and submerged aquatic vegetation (SAV) habitat exist based on all available information.

INTRODUCTION

This is Amendment 3 to the Hard Clam Fishery Management Plan (FMP). FMPs are the ultimate product that brings all information and management considerations into one document. The N.C. Division of Marine Fisheries (NCDMF) prepares FMPs for adoption by the N.C. Marine Fisheries Commission (NCMFC) for all commercially and recreationally significant species or fisheries that comprise state marine or estuarine resources. The goal of these plans is to ensure long-term viability of these fisheries. By law, each FMP must be reviewed at least once every five years (G.S. 113-182.1). The NCDMF reviews each FMP annually and a comprehensive review is undertaken approximately every five years. The last comprehensive review of the plan (Amendment 2) was approved by the NCMFC in 2017. All management authority for the North Carolina Hard Clam fishery is vested in the State of North Carolina. The NCMFC adopts rules and policies and implements management measures for the Hard Clam fishery in Coastal and Joint Fishing Waters in accordance with G.S. 113-182.1. Until Amendment 3 is approved for management, Hard Clams are managed under Amendment 2 (NCDMF 2017).

The status of the Hard Clam stock in North Carolina is unknown due to data limitations preventing the NCDMF from conducting a Hard Clam stock assessment and calculating sustainable harvest metrics. Data available for the stock are commercial landings, data collected from fish houses, and an annual recreational survey. Data is obtained from the North Carolina Trip Ticket Program, where catch rates are estimated for both hand and mechanical harvest. Landing trends will reflect population abundance to an extent, but other factors like market demand, regulations, changes in effort and gear technology also affect trends (NCDMF 2017).

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

Fishery Management Plan History

Original FMP Adoption:	2001
Amendments:	Amendment 1 (2008) Amendment 2 (2017)
Revisions:	None
Supplements:	None
Information Updates:	None
Schedule Changes:	None
Next Comprehensive Review:	Five years after adoption of Amendment 3
Past versions or revisions of the Hard Clam FMP (NCDMF 2001, 2008, 2017) are available on the NCDMF website: Fishery Management Plans NC DEQ	

Management Unit

Includes the Hard Clam, *Mercenaria mercenaria*, and its fisheries in all Coastal and Joint Fishing Waters of coastal North Carolina. G.S. 113-221.

Goal and Objectives

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

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

DESCRIPTION OF THE STOCK

Biological profile

DISTRIBUTION

The Hard Clam, *Mercenaria mercenaria*, is a large bivalve distributed along the east coast of North America from the Gulf of St. Lawrence, Canada to the central coast of eastern Florida (Harte 2001, Abbott 1986, Mackenzie et al. 2002). This species has been transplanted in the northwest Pacific (Crane et al. 1975, Carlton 1992, Chew 2001), Puerto Rico, Europe (Heppell 1961, Chew 2001), China (Chavanich et al. 2010), and Japan (Hiwatari et al. 2006). Another species, *M. campechiensis*, also known as the Southern Quahog, inhabits ocean waters off North Carolina and occurs mainly from North Carolina to Florida (Hadley and Coen 2006). The Hard Clam is not native to the Gulf of Mexico (Abbott 1986); however, a subspecies, *M. mercenaria texana*, and *M. campechiensis* inhabit the Gulf Coast and have been mistaken for *M. mercenaria* (Dillon and Manzi 1989a,b).

Common names for *M. mercenaria* include Hard Clam, Quahog, Quahaug, Northern Quahog, Littleneck Clam, and Cherrystone Clam. Hard Clams occur throughout the south Atlantic region in estuaries from the intertidal zone to depths exceeding 18 m (Abbott

1974; Eversole et al. 1987). In North Carolina, Hard Clams are most abundant in higher salinity waters inside the barrier islands from Ocracoke southward to the South Carolina border (NCDMF shellfish bottom mapping data, unpublished). Hard Clams are found near Oregon and Hatteras inlets and the western side of Pamlico Sound but are much less abundant compared to clams that inhabit waters inside and south of Ocracoke Island.

HABITAT PREFERENCES AND TOLERANCES

Hard Clams occupy mostly shallow, estuarine environments and can inhabit a variety of sediment types, including sand or muddy sediments, bare, coarse substrates, as well as seagrass and near oyster beds (Wells 1957, Roegner and Mann 1991, Harte 2001). Localized adult population densities can vary considerably, ranging from small patches to extensive beds, and density is dependent on many environmental factors, including organic content and composition of sediment and localized flow (Fegley 2001). Experimental and field studies have shown that areas with heterogeneous substrate mixtures of sand or mud with shell or gravel often support more clams than homogeneous substrates as the larger substrate can act as a spatial predator refuge (Anderson et al. 1978, Arnold et al. 1984). Increased densities and survivorship have also been observed for Hard Clams that inhabit seagrass beds (Peterson et al. 1984; Peterson 1986b).

Hard Clams have a wide temperature and salinity tolerance which likely contributes to their extensive species range and successful transplantations worldwide. Adult Hard Clams can tolerate temperatures between -6 and 35°C (21.2 and 95°F; Stanley and Dewitt 1983); below freezing temperatures, subtidal clams have a higher survival rate than those exposed in the intertidal areas (Eversole et al. 1987). Growth rates of Hard Clams are most favorable at water temperatures around 20°C (68°F) and growth ceases at 9°C (48.2°F) and 31°C (87.8°F; Ansell 1968; Eversole et al. 1986). Hard Clams have been found in waters with salinity ranging from 4 to over 35 parts per thousand (ppt) but cannot survive extended periods in salinities less than about 12 ppt. Growth is optimal at salinities from 24 to 28 ppt for adults (Chestnut 1951a) and 26 to 27 ppt for larval growth and survival to settlement (Davis 1958, Davis and Calabrese 1964). Hard Clams cease siphoning water below 15 and above 40 ppt (Hamwi 1968), or below about 4°C (39.2°F; Loosanoff 1937) and above 34°C (93.2°F; Roegner and Mann 1991), and will close their valves tightly during periods of stress and respire anaerobically to reduce mortality (Eversole et al. 1987).

Adequate water circulation is essential for successful growth and recruitment of Hard Clams. Water currents move food, maintain water quality, remove waste, and transport eggs and larvae in the water column (Eversole et al. 1986). Hard Clams obtain food by filtering suspended particulate matter and absorbing dissolved organics directly from the water. Larvae and adult Hard Clams can select their food and regulate the quality and quantity of food they consume. Hard Clams adapt well to a changing food supply, but are sensitive to the presence or absence of particular algal species that can affect growth (Eversole et al. 1986; Eversole et al. 1987). More detailed habitat and water quality information is available in the Environmental Factors section.

REPRODUCTIVE BIOLOGY

The gametogenic and spawning cycle of the Hard Clam varies with latitude (Eversole et al. 1984; Eversole et al. 1987). Spawning occurs in North Carolina from spring through fall, when water temperatures reach 20°C (68°F; Loosanoff and Davis 1950; Porter 1964). Spawning clams release eggs and sperm through the exhalent siphon into the water where fertilization occurs and rapid development begins. The first larval stage is the trochophore stage that lasts about a day, followed by several veliger/pediveliger stages that last approximately 20 days. Juvenile clams (spat) settle along edges of sandbars and channels where varying water currents occur (Carriker 1959). Hard Clams will also settle in substrates with shell and subtidal vegetation. These substrates appear to have better conditions for spat survival than unstructured substrates because they offer protection from predators (Kerswill 1941; Wells 1957; MacKenzie 1977; Peterson 1982).

Precursors to both male and female sex cells are found in the gonads of juveniles (Eversole 2001). During the juvenile stage, gonadal cells differentiate and clams develop predominately as males. As adults, many clams transform into females. The sex ratio of adult clams is approximately 1:1 across its geographical range (Eversole 2001).

Sexual maturity in Hard Clams tends to be a function of size not age, therefore maturity is dependent on growth. Sexual maturity is usually reached during the second to third year at a shell length of 1.3 inches (33 mm), but faster growing clams may mature at an earlier age (Eversole et al. 1987). The legally harvestable size of one-inch thick (25.4 mm) is typically reached by age two to five with three as a reasonable average expectation in North Carolina (C. Peterson, UNC Institute of Marine Science, personal communication).

Although estimates vary, fecundity depends on size and condition (Ansell and Loosmore 1963). Several studies have found that fecundity increased with shell length (Bricelj and Malouf 1980; Peterson 1983; Eversole et al. 1984; Peterson 1986a). Reproductive senescence is often common in long-lived species but there is no evidence that reproductive production declines with age in Hard Clams (Peterson 1983; Peterson 1986a). Hard Clams occur in aggregations over a wide area, and close proximity of adults is important for successful reproduction to occur in organisms that spawn in the water column (Peterson 2002). Because Hard Clams have limited mobility, spawning efficiency could be reduced in areas where harvest has caused a significant decrease in number and size of Hard Clams within these aggregations. Reduced spawning efficiency could affect future recruitment in Hard Clam populations (Fegley 2001; Peterson 2002).

SIZE STRUCTURE, AGE, AND GROWTH

Hard Clam populations exhibit a wide size range of individuals (Fegley 2001). Growth rates of Hard Clams are highly variable and depend on water temperature, habitat, food availability, and genetics (Ansell 1968; Pratt and Campbell 1956; Chanley 1958; Peterson et al. 1983; Peterson et al. 1985; Arnold et al. 1991). Shell growth is greatest during the first year after which growth decreases as age increases (Eversole et al. 1986; Eversole et al. 1987).

Age can be determined by direct examination of annual growth lines within the shell. Age frequency distributions differ widely among sites within and between regions (Fegley 2001). There is also variation in the age of similar-sized clams even within the same habitat (Peterson et al. 1984; Rice et al. 1989; Fegley 2001). The maximum age seen in North Carolina is 46 years old (Peterson 1986a); however, the maximum life span of this species can exceed 100 years (Ridgway et al. 2011).

Shell growth patterns vary by latitude. North Carolina shell growth follows a southern growth pattern where light bands form during the winter months when animals are growing the fastest and dark band form during the late summer to fall months when growth is slowest, resulting in annual banding patterns (Peterson et al. 1983; Jones et al. 1990; Arnold et al. 1991, Goodwin et al. 2021). The opposite shell pattern growth is observed in northern latitudes (i.e., Connecticut to Massachusetts and England) where a dark band forms during the colder winter months, and a light band forms during the warmer months. At the middle part of the geographical range (i.e., New Jersey) shell pattern banding follows the “northern” banding pattern during the first several years of growth and then takes on a more “southern” banding pattern as they age (Fritz 2001). Unlike in other areas of their geographic range where growth ceases during certain times of the year, mature Hard Clams in North Carolina are capable of depositing shell material throughout the entire year, suggesting the species may serve as an important sclerochronological archive, documenting some of the most complete records of intra-annual environment conditions in their shells (Goodwin et al. 2021).

BIOLOGICAL STRESSORS

Few data are available on direct predation rates on larval Hard Clams (Kraeuter 2001), but high natural mortality in the larval stages suggest predation is probably high during this life stage. Newly set or juvenile Hard Clams (<1 mm shell length) are vulnerable to many predators. Primary predators of juvenile Hard Clams include Snapping Shrimp (*Alpheus heterochaelis*), Mud Crab (*Dyspanopeus sayi*), and Blue Crab (*Callinectes sapidus*; Beal 1983; Kraeuter 2001). Stone Crabs (*Menippe mercenaria*) are effective predators of both juvenile and adult Hard Clams, capable of opening large Hard Clams (30–60 mm shell length) that typically cannot be preyed on by Blue Crabs, and the abundance of Stone Crabs in North Carolina has been increasing since 2000 (Wong et al. 2010). Several types of snails (*Urosalpinx* sp., *Polinices* sp.), whelks (*Busycon* sp.), Cownose Rays (*Rhinoptera bonasus*), and various birds feed on adult Hard Clams (Kraeuter and Castagna 1980; Kraeuter 2001). As Hard Clams grow the number of potential predators is reduced (Kraeuter 2001). Hard Clam survival from predation is affected by sediment characteristics such as presence of shell fragments and seagrasses, and presence of other prey species (Peterson 1982; Peterson 1986b; Kraeuter 2001).

Infectious diseases can result in devastating losses of wild populations of some mollusks but Hard Clams appear to be relatively disease free and studies of captive populations show that non-predation losses are typically only 5% to 10% per year (Eldridge and Eversole 1982; Eversole et al. 1987; Bower et al. 1994). QPX (Quahog Parasite X = Unknown) is a parasite found in Hard Clams along the eastern coast of North American

from Atlantic Canada to Virginia (Smolowitz et al. 1998; Dahl et al. 2011). QPX disease has not been identified in Hard Clams south of Virginia (Dahl et al. 2011) and a 2011 study confirmed QPX disease is a cold-water infection and not likely to occur in North Carolina because of warmer waters that impedes development of this disease in Hard Clams (Dahl et al. 2011).

Many large-scale Hard Clam mortalities along the northeastern United States and Canada are related to air exposure during extreme cold events and negative impacts from stress associated with parasites (Smolowitz et al. 1998). Diseases in larval and juvenile Hard Clams held in culture conditions are often caused by bacteria, fungi, and viruses that are common in the cultured bivalves and are associated with opportunistic invaders of animals under stress in high-density culture situations (Ford 2001).

Anthropogenic activities can also affect Hard Clam populations. Physical disturbances including bulkhead and dock construction, boat scarring, and dredging, can disrupt the sediment and increase turbidity (Bricelj et al. 2017), which can negatively impact Hard Clam feeding and growth. Additionally, extensive dredging can change bottom topography and flow patterns (Bricelj et al. 2017), which can alter food availability and larval distribution. Propeller wash from boat traffic may also displace sediment that can expose clams and increase their vulnerability to predators, and clam larvae that go through the propeller and engine cooling system are at risk of damage. Furthermore, toxic compounds from pressure-treated wood used to construct new docks, piers, and bulkheads leach into the water and accumulate in the sediment (Weis and Weis 1996). New construction often occurs in the spring, coinciding with Hard Clam spawning, which can expose Hard Clam larvae to toxic leachates (Bricelj et al. 2017).

Stock Unit

The unit stock is considered all Hard Clams occurring within North Carolina coastal waters.

Assessment Methodology

Data are not available to perform a traditional assessment, so it was not possible to estimate population size or fishing mortality rates.

Stock Status

Data limitations prevent the NCDMF from conducting a Hard Clam stock assessment and calculating sustainable harvest metrics. Data available for the stock include commercial landings and fishing effort (i.e., trips) reported to the Trip Ticket Program, biological data collected from the commercial catch, and voluntary responses to an annual recreational survey. Amendment 2 of the FMP recommends the status continue to be defined as unknown due to the continued lack of data needed to conduct a reliable assessment of the stock.

DESCRIPTION OF THE FISHERY

Additional analyses and discussion of North Carolina's commercial and recreational Hard Clam fisheries can be found in earlier versions of the Hard Clam FMP (NCDMF 2001, 2008, and 2017); all FMP documents are available on the NCDMF Fishery Management Plans website. Commercial and recreational landings can be found in the [License and Statistics Annual Report](#) (NCDMF 2022) on the [NCDMF Fisheries Statistics](#) website.

Discussion of socio-economic information (NCDMF 2022) describes the fishery as of 2021 and is not intended to be used to predict potential impacts from management changes. This and other information pertaining to FMPs are included to help inform decision-making regarding the long-term viability of the state's commercially and recreationally significant species and fisheries. For a detailed explanation of the methodology used to estimate economic impacts, please refer to the NCDMF License and Statistics Section Annual Report (NCDMF 2022).

Commercial Fishery

Since the inception of the Trip Ticket Program (TTP) in 1994, Hard Clam data collection has continuously improved. Hard Clam landings come from both public harvest and private production, which are managed under different regulations, therefore trip numbers, landings, and effort cannot be compared between public harvest and private production. Since 2003, approximately 1% of the annual landings cannot be identified as either public harvest or private production. Much of the improvement has been from better recording and editing requirements, and from the new licensing system. In the following sections the different gear types in the fishery are separated into either public harvest or private production. Because there are some trips that could not be differentiated in the database, they were excluded from analyses.

The Hard Clam industry has provided a way to make a living and food for coastal communities along the entire Atlantic East Coast from the Canadian maritime region to Florida. Fluctuations in commercial landings are common along the Atlantic East Coast with a general trend of decline through time (Figure 1). A large part of the decline in Atlantic Coast landings occurred in the 1970's as a result of overfishing in New York and closure of shellfish beds due to bacterial pollution (MacKenzie et al. 2002). For more information on environmental pathogens, see Environmental Factors, Threats, and Alterations section.

GEAR TYPES

Hand Harvest

The hand harvest fishery for Hard Clams is year-round in North Carolina. Hand harvesting methods include signing (spotting siphon holes), treading, hand raking, hand tonging, and bull raking. Clams are taken by hand and rake in shallow water, up to 4 feet deep (≤ 1.2 m) while hand tongs and bull rakes are used in deeper water up to 20 feet deep (1.2 to 12.2 m; Cunningham et al. 1992). Bull rakes have been used to exploit clam populations in New River, White Oak River, Bogue Sound, Newport River, North River, and the

Intracoastal Waterway channel of Brunswick, New Hanover, Pender, and Onslow counties. Many subsistence fishermen use bull rakes in the southern area of the state.

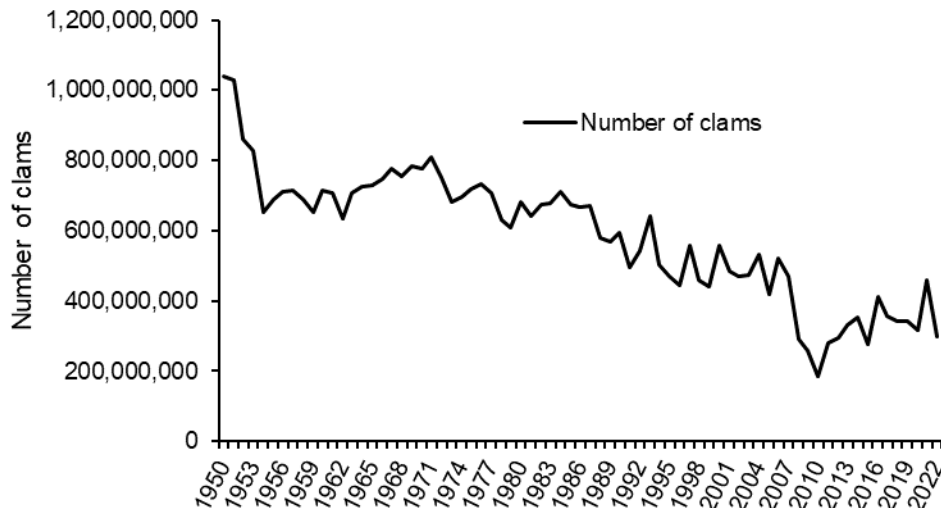


Figure 1. Commercial Hard Clam landings (number of clams, using a conversion factor of 0.32 oz per individual; ASFMC 1992) along the Atlantic East Coast (Maine south to Florida east coast), 1950–2022. Source: NMFS commercial fisheries landings database, except for NC landings from 1994 to 2022 using TTP.

Mechanical Harvest

The two types of mechanical harvest gear currently used in North Carolina are the hydraulic escalator dredge and the clam trawl or “clam kicking” vessel. The hydraulic escalator dredge has an escalator or conveyor located on the side of the vessel. A sled is connected to the front end of the escalator. When the front end of the escalator is lowered to the bottom, the sled glides over the bottom. A blade on the sled penetrates the bottom to a depth of about four inches (10 cm) and collects the clams as they are forced from the bottom by water pressure (Cunningham et al. 1992). In clam trawling or “kicking”, clams are dislodged from the bottom with propeller backwash and a heavily chained trawl with a cage attached at the cod end towed behind the boat gathers the clams. Kick boats are generally 20 to 30 ft long and can operate in depths from 3 to 10 feet (1.0 m to 3.05 m). The propeller is usually positioned 12 to 15 inches above the bottom and extra weight can be added to the stern to improve the angle and height above the bottom. For better efficiency in varying water depths, boats include a winged rudder, which has two iron plates welded on either side of the rudder to deflect water downward (Cunningham et al. 1992). One person operates smaller kick boats, while larger boats may have a crew of two or three (Guthrie and Lewis 1982).

HISTORICAL PUBLIC HARVEST FISHERY

North Carolina Hard Clam harvest has fluctuated historically, often in response to changes in demand, improved harvesting techniques, and increases in polluted shellfish area closures. Hand harvest accounted for all recorded landings prior to the mid-1940s, when early forms of mechanical harvest were developed. Hand harvest is currently allowed year-round with daily harvest limits. A daily harvest limit of 6,250 clams per fishing operation from public waters was established in 1986 by proclamation and has remained in effect since (NCMFC Rule 15A NCAC 03K .0301 (a)).

The first mechanical method for harvesting Hard Clams was known as dredging. This gear allowed fishermen to remain on board and enabled them to work in poor weather (Guthrie and Lewis 1982). Trawls were first used to harvest clams in 1968 and remain in use today in a technique known as “kicking” (Guthrie and Lewis 1982). Increased market demand and more efficient gear soon led to increased landings around the 1970s (Figure 2). Another major development in the fishery occurred in 1968 with the advent of hydraulic dredges. This gear used jets of water from a high-pressure pump to displace bottom sediments covering the clams and a conveyor carried the catch up to the vessel. Hard Clam landings remained stable through the 1960s and 1970s. Since the late 1980s, Hard Clam landings have declined. This decline may be the result of decreased abundance, increasing closures of shellfish waters from pollution, changing market demand, and storm events.

Allocation conflicts did not occur in the Hard Clam fishery until the late 1980’s as more management measures were put in place to reduce habitat impacts causing harvesters to compete more for the limited resource. Mechanical harvest methods can negatively impact submerged aquatic vegetation (SAV) and oyster rocks (Peterson et al. 1987). Regulations to protect habitats from mechanical harvest methods have been in place since 1977 and mechanical harvest has largely been confined to deeper waters of the sounds and rivers. A rotation scheme for White Oak River and New River, including a portion of the Intracoastal Waterway (IWW), has been implemented annually by proclamation since the early 1980s. The intent was to prevent overharvesting of the clam stocks, discourage violations by mechanical harvesters who cross the lines in search of more lucrative clam quantities, and prevent the taking of undersized clams, or “buttons”. The NCDMF also allows harvest of clams by mechanical means in some navigational channels before maintenance dredging activities performed by the U.S. Army Corps of Engineers (USACE). For a thorough history of the Hard Clam fishery including overall history, historic landings and trends, management changes for mechanical commercial gear, length of seasons, and openings and closures of bays, please refer to [Amendment 2 of the Clam FMP](#).

PRESENT PUBLIC HARVEST FISHERIES

The current minimum size limit for clams is 1-inch thickness (width). The current daily hand harvest limit is 6,250 clams and the fishery is open year-round. Current public mechanical harvest limits vary by waterbody. In some instances, mechanical harvest areas are rotated (alternately open and closed) with other areas (Table 1). Since 2008, upon adoption of Amendment 1 to the Hard Clam FMP, Core Sound has been divided into

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two areas and the northern area is open every other year while the southern area is opened annually. In 2015 adjustments were made to the Newport River area due to oyster encroachment. Then in 2017 there were modifications to the areas in Core Sound and North River, and use of mechanical methods was prohibited in Bogue Sound due to SAV encroachment.

Table 1. Current daily mechanical Hard Clam harvest limits by waterbody.

Waterbody	Daily harvest limit (Number of clams)	Additional information
Northern Core Sound	5,000	Rotates one year open and one year closed opposite the open/close rotation of the New River
Southern Core Sound	5,000	Open annually
North River	3,750	Open annually
Newport River	3,750	Open annually
White Oak River	6,250	Rotates one year open and one year closed opposite the open/close rotation of the New River
New River	6,250	Rotates one year open and one year closed opposite the open/close rotation of Northern Core Sound, the White Oak River, and the IWW in the Onslow/Pender counties area
New River Inlet	6,250	Open annually from Marker 72A to the New River Inlet
IWW Onslow/Pender counties area	6,250	Intracoastal Waterway (maintained marked channel only) from Marker #65, south of Sallier's Bay, to Marker #49 at Morris Landing. All public bottoms within and 100 feet on either side of the Intracoastal Waterway from Marker #49 at Morris Landing to the "BC" Marker at Banks Channel. Open every other year when the New River is closed.

ANNUAL LANDINGS, TRIPS, PARTICIPATION, AND MARKET GRADES

Separating Hard Clam landings data into public harvest and private production is inexact prior to 1994 because landings information was collected on a voluntary basis. Since 1994, about 88% (1994–2013 combined estimates) of the total commercial Hard Clam harvest came from public harvest areas in North Carolina. The annual number of Hard Clams from public bottom averaged 19.6 million from 1994 to 2022, but landings have

steadily declined through time. Annual landings averaged 11.7 million from 2012–2022 (Figure 2).

There are year-to-year fluctuations in the number of trips harvesting Hard Clams. The annual number of trips has declined during the time series (1994–2022), with the highest number of trips in 1994 (Figure 3). Adverse weather conditions (e.g., hurricanes, and heavy rain events) can impact the annual landings. Freshwater runoff after storm events often causes shellfish harvest area closures and therefore reduces Hard Clam harvest effort for short time periods.

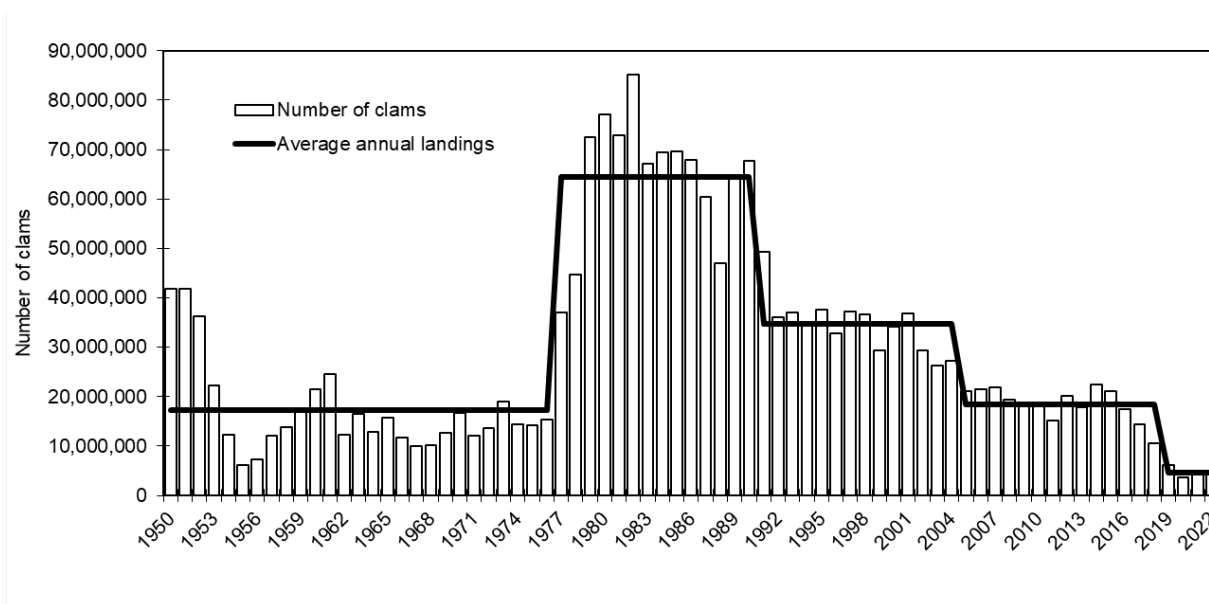


Figure 2. Hard Clam landings (number of clams) from public harvest and private production showing the average annual landing trends (solid line) for specific time periods, 1950–1976, 1977–1990, 1991–2004, 2005–2018, 2019–2022. TTP.

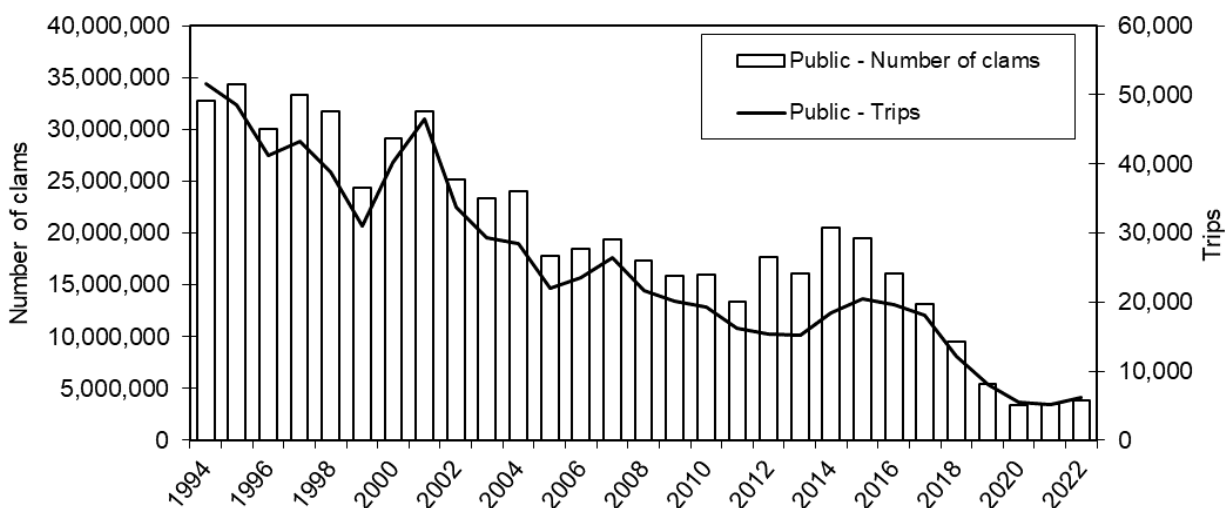


Figure 3. North Carolina annual commercial Hard Clam landings (number of clams) and trips from public harvest, 1994–2022. TTP.

New River and Core Sound are the top two waterbodies where Hard Clams are harvested from public harvest areas, accounting for 50% of the landings from 1994 to 2022 (Figure 4). Landings in the southern part of the state, including the areas of Stump Sound, Lockwood Folly, Topsail Sound, Masonboro Sound, Cape Fear River, Shallotte River and the Inland Waterway, accounted for an additional 25% of the public Hard Clam landings from 1994 to 2022.

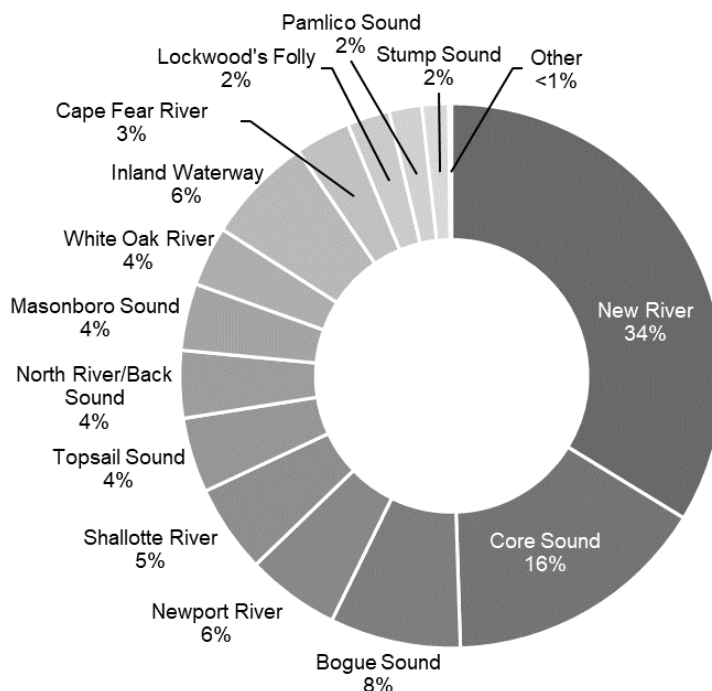


Figure 4. Commercial Hard Clam landings (percent of total landings) by waterbody from public harvest 1994 to 2022 combined. TTP.

Clam fishery participation has declined by about 82% over the last twenty years (Figure 5). There was an increase in participation in the hand harvest fishery from 2013–2015, then a decline from over 600 participants in 2015 to less than 280 participants in 2022 (Figure 5). Hand gears have had an order of magnitude more participants across the entire time series (Figure 5).

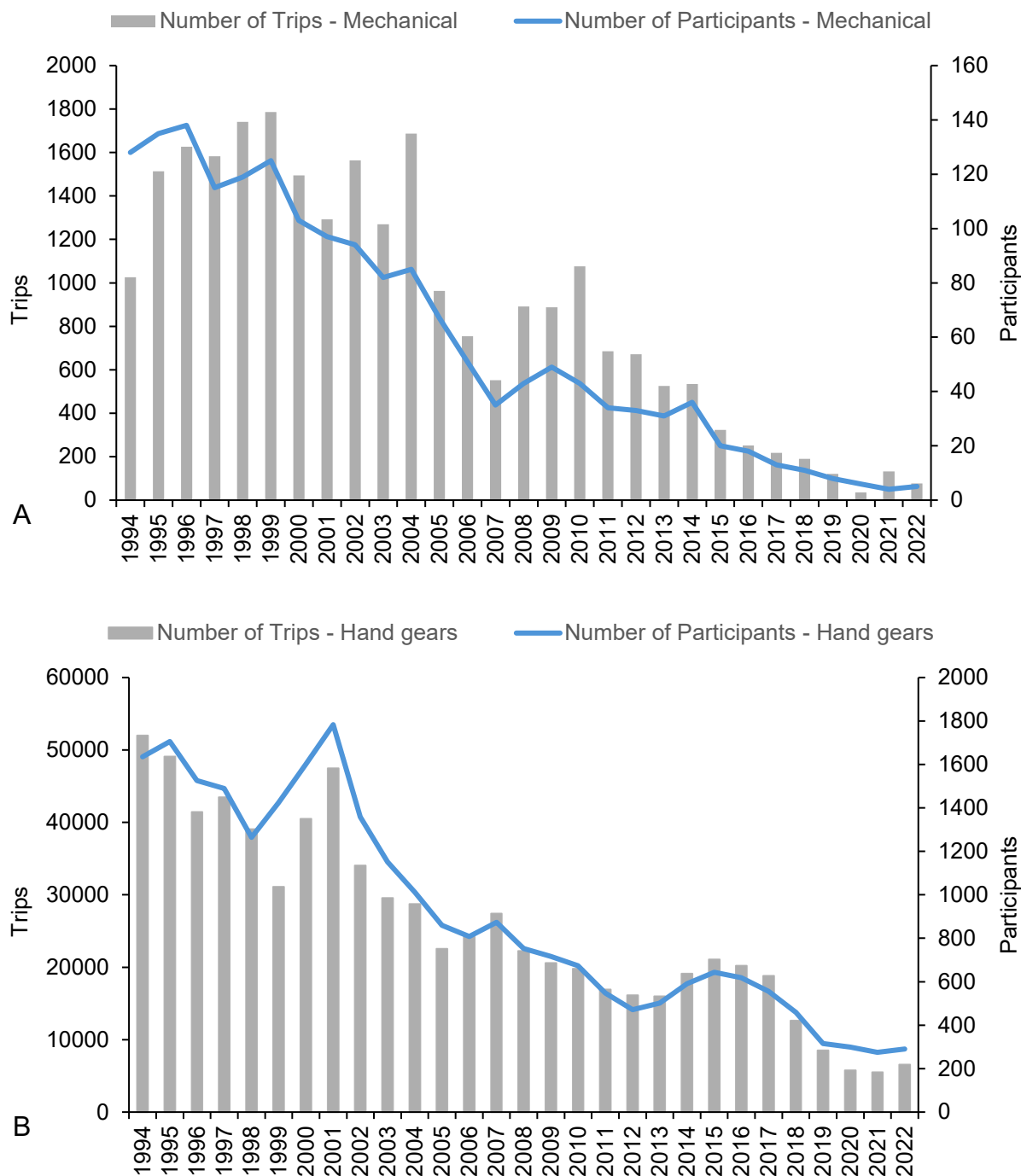
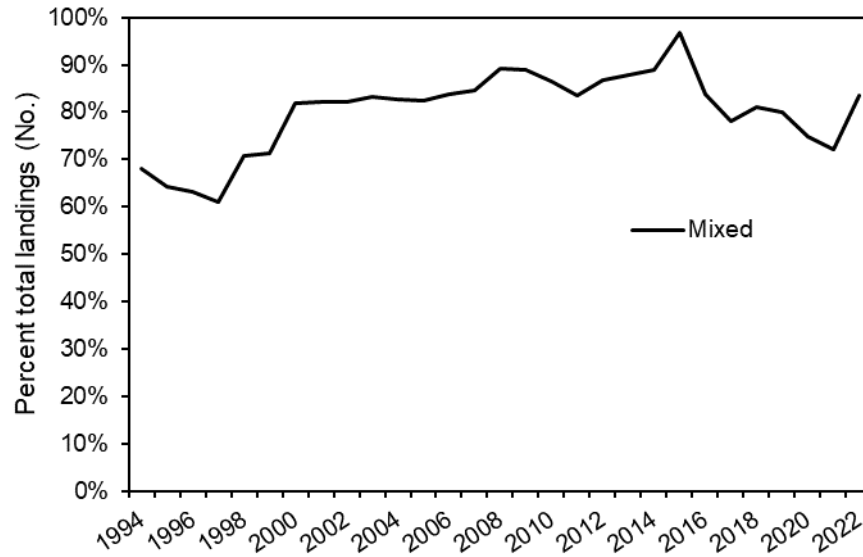


Figure 5. Participant and trip count by gear category for Hard Clam harvest, 1994–2022. (A) mechanical gear and (B) hand gears. Data provided by the NCDMF TTP.

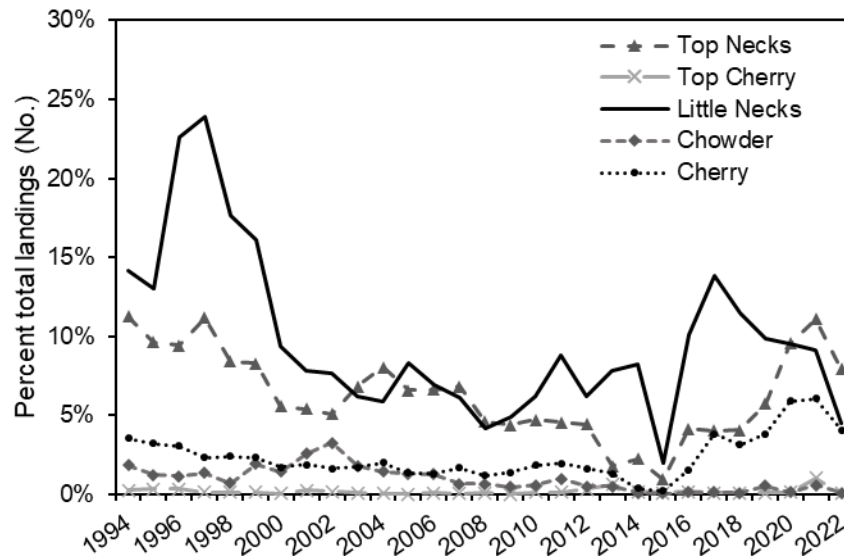
Hard Clam harvest is sorted by thickness (shell width) into various market grades when purchased by the seafood dealer. A mixed or unclassified market grade is the most common Hard Clam size category from public harvest and comprised 79% of the total landings from 1994 to 2022 (Figure 6a). Little neck, which consists of the smallest clams typically measuring between 1-inch (25 mm) to 1 ¼-inch (32 mm) in thickness, is the second most dominant market category of Hard Clam from public harvest (Figure 6b). Top neck is the next largest market category in size with individuals ranging from 1 ¼-inch (32 mm) to 1 ⅝-inch in thickness (41 mm). The proportion of Hard Clams graded as top necks from public harvest has remained about the same throughout the time series (6% on average; Figure 6b). Hard Clams in the cherry and top cherry market grades have a shell thickness that ranges between 1 ⅝-inch (41 mm) to 2 ¼-inches (57 mm). These two market categories have not shown much change in proportion to the total Hard Clam public harvest from 1994 to 2022, although the cherry market grade began to see a slight increase in 2017 (Figure 6b). Chowder Hard Clams are the largest market category by size and are any Hard Clams greater than 2 ¼-inch shell thickness (Figure 6b).

Hand Harvest

Hand harvest from public areas is a year-round fishery and has average landings of 16,274,336 clams per year (1994–2022). Most hand harvest occurs in the spring and summer when warm water is conducive to wading (Figure 7). Annual public harvest and the number of hand harvest trips per year for Hard Clams has declined overall from 1994 to 2022, except for a moderate increase from 2012 to 2014 (Figure 8). The annual catch per unit effort (CPUE; number of clams per trip) from public area hand harvest also reflects this increase from 2012 to 2014 but has subsequently dropped back down to around 600 clams per trip (Figure 9).



A.



B.

Figure 6. Annual landings (percent of total annual landings) of Hard Clams from public harvest by market grade, 1994–2022 combined. A. Mixed grade only; B. All other market grades. TTP.

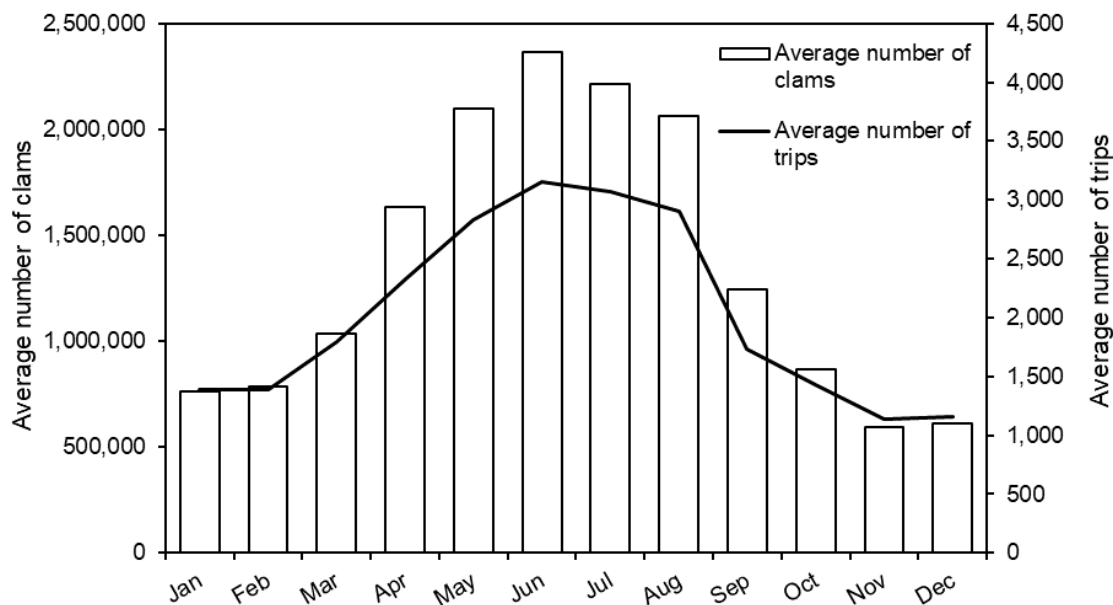


Figure 7. Average Hard Clam landings (number of clams) and average number of trips by month from public harvest using hand gears, 1994–2022. TTP.

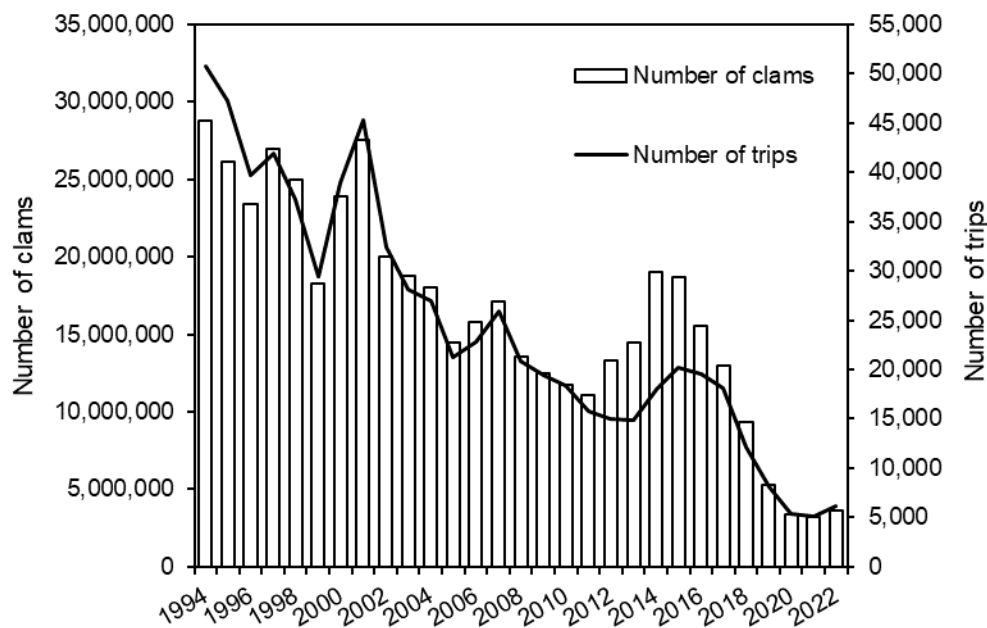


Figure 8. Annual Hard Clam landings (number of clams) and trips from public harvest using hand gears, 1994–2022. TTP.

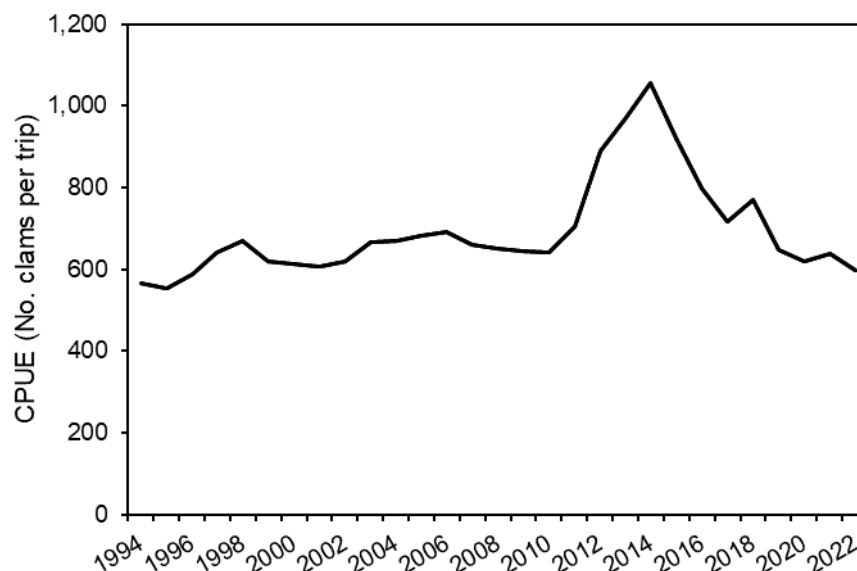


Figure 9. Annual catch per unit effort (CPUE; number of clams per trip) of hand harvest from public areas, 1994–2022. TTP.

Mechanical Harvest

Mechanical harvest season usually begins the second Monday in December and extends through the week of March 31. Harvest is allowed only from 7:30 a.m. to 4:00 p.m. on Monday through Friday until before the Christmas holiday and then Monday through Wednesday after December 25 for the remainder of the open harvest season.

Hard Clam landings from public harvest, using mechanical methods, has average landings of 3,319,605 clams each fishing year (1994/95 to 2021/2022). The mechanical clam harvest season usually has the highest landings at the beginning of the fishing season in December and declines as the season progresses (Figure 10). Landings outside of the usual mechanical clam harvest season are from temporary openings for the maintenance of channels and temporary openings in Core Creek when bacteriological levels are at acceptable levels to harvest clams. Hard Clam landings and trips fluctuate from fishing year to fishing year and appear to be greatly influenced by harvest from the New River mechanical harvest area (Figure 11). Mechanical clam landings have remained below 1,000,000 clams per season since 2016/2017.

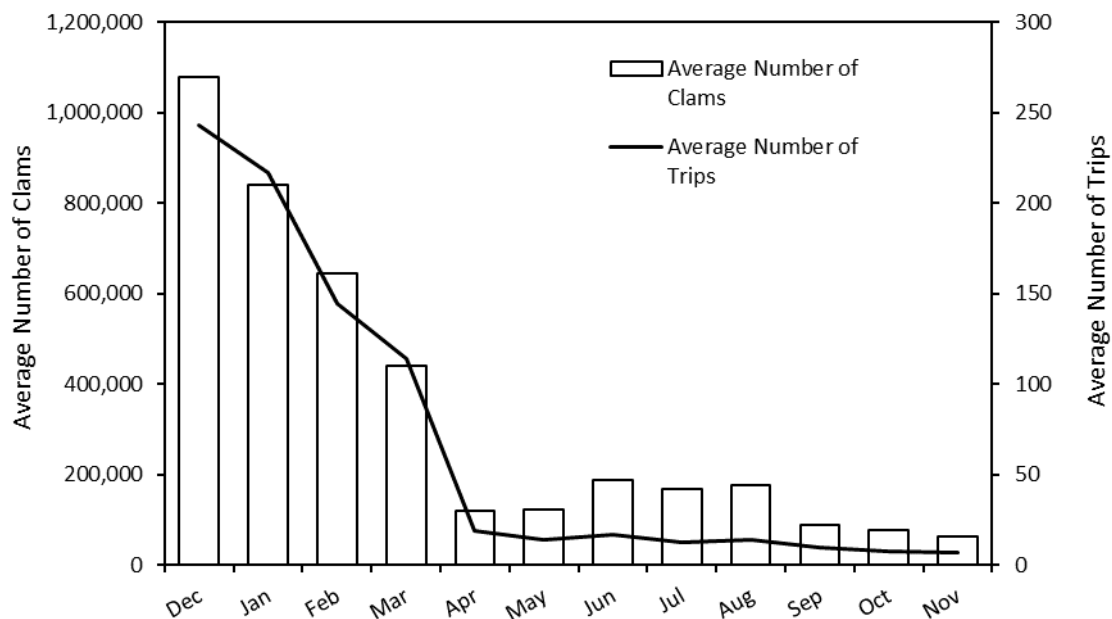


Figure 10. Average Hard Clam landings (number of clams) and average number of trips by month from public harvest using mechanical gears, 1994/95–2022/March 2023. TTP.

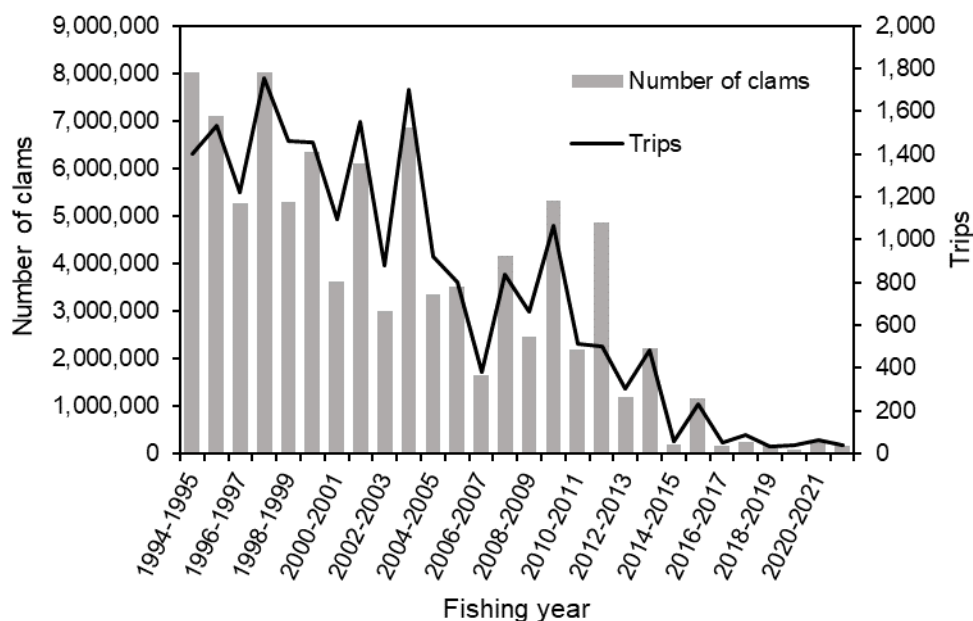


Figure 11. Hard Clam landings (number of clams) and trips from public harvest using mechanical gears by fishing year (Dec-Nov), 1994/95–2021/2022. TTP.

PRIVATE SHELLFISH CULTURE: SHELLFISH LEASES AND FRANCHISES

This plan does not focus on management of private shellfish culture through shellfish leases and franchises; however, detailed information on the history and management of private shellfish culture can be found in [Amendment 2 of the Hard Clam FMP](#). It should also be noted that there is only one seed distributor in North Carolina, which hinders the growth of private shellfish culture for clams in the state.

Recreational Fishery

Hard Clams are commonly harvested recreationally year-round in North Carolina by hand and rakes. The recreational bag limit is currently 100 clams per person per day with no more than 200 clams per vessel at a minimum size of 1-inch thick. The NCDMF has limited data on recreational clam fishing, including the number of participants and the extent of their economic activity. Efforts to accurately quantify the impact of recreational fishing on shellfish (mollusks and crustaceans) have been met with limited success in North Carolina. The NCDMF collects data on recreational fishing in conjunction with the Marine Recreational Information Program (MRIP). However, MRIP collects information on finfish only. In addition, because any North Carolina resident can purchase a low cost commercial shellfish license to take shellfish in commercial quantities for recreational purposes, harvest from a commercial shellfish license used for recreational purposes does not get recorded because it is not sold to a seafood dealer.

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

Recreational harvest of Hard Clams in North Carolina does not require a fishing license, thus, the total amount of recreational landings cannot be estimated and remains unknown. However, a mail survey has been used since 2010 to estimate harvest from Coastal Recreational Fishing License (CRFL) holders. This population of recreational harvesters makes up an unknown proportion of total recreational harvest, but still provides insight into catch rates, harvest trends, and scale of harvest by CRFL holders. In 2010, surveys were only mailed out in November and December, so harvest and effort estimates are very low (Table 2). Estimates of harvest and catch rate have declined since 2013 (Figure 12). In 2022, recreational harvest was roughly one half of that in 2020 and only 30% of the time series average.

Recreational clam harvest was reported from 60 waterbodies throughout coastal North Carolina. Overall survey results demonstrate a distinct seasonality for the recreational harvest of clams, with peak activity observed during summer months. This, coupled with

DRAFT SUBJECT TO CHANGE

the highest concentrations of clamming activity being observed in Pamlico, Bogue, and Masonboro sounds and during summer months, suggests coastal tourism may significantly impact recreational clam harvest. More background and history on recreational shellfish harvest can be found in Appendix 2 (the Recreational Harvest Issue Paper).

Table 2. Estimated number of trips, number of Hard Clams harvested, and catch rate (clams per trip) per year of Coastal Recreational Fishing License holders, 2010–2022. An asterisk (*) for 2010 indicates a partial year of sampling.

Year	Number of trips	Number of clams	Catch rate
2010*	528	8,731	18.4
2011	6,350	127,597	22.9
2012	6,726	146,151	27.3
2013	8,644	191,842	26.2
2014	6,325	162,656	28.8
2015	7,637	166,419	27.4
2016	8,456	84,199	12.3
2017	3,435	75,171	21.8
2018	2,362	26,769	11.3
2019	5,088	114,042	22.4
2020	6,557	62,164	9.5
2021	1,765	15,471	8.8
2022	6,628	28,241	4.3

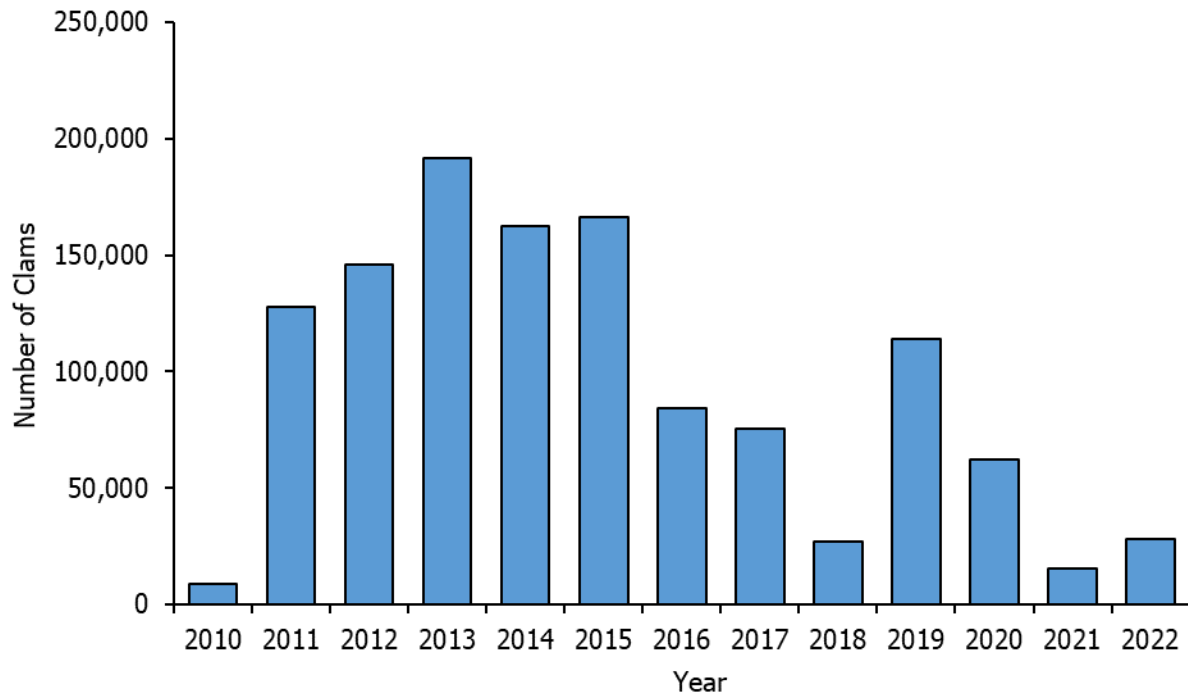


Figure 12. Annual recreational Hard Clam landings (number of clams) in North Carolina, 2010–2022. Data from 2010 represent a partial year of sampling.

Summary of Economic Impact

ECONOMIC ASPECTS OF THE FISHERY

Ex-Vessel Value and Price

The value of Hard Clams to the North Carolina seafood industry has fluctuated over time. Before the mid-1970s, their economic contribution was relatively small, representing no more than 1–2% of the total value of landed seafood in the state. In 2013, clams were the sixth most economically important commercial seafood species in North Carolina. Landings of clams accounted for 4.7% of the total value of commercial non-finish landings and 2.9% of the total value of all commercial seafood landings in the state.

The real value (the value that is adjusted for inflation) of North Carolina Hard Clam landings on public bottom has generally declined over the last twenty years peaking at just under \$9 million in 1995 and declining until 2011 where ex-vessel value increased yearly until it peaked in 2015 at about \$6 million before declining again in the last 7 years. When adjusted for the effects of inflation, 2021 saw the lowest landings value in the time series since 1994, then landings started increasing in 2014 and 2015, which then continued declining year over year to 2022 (Figure 13). The decline in total value is largely driven by a decrease in catch described in the previous section (Figure 11).

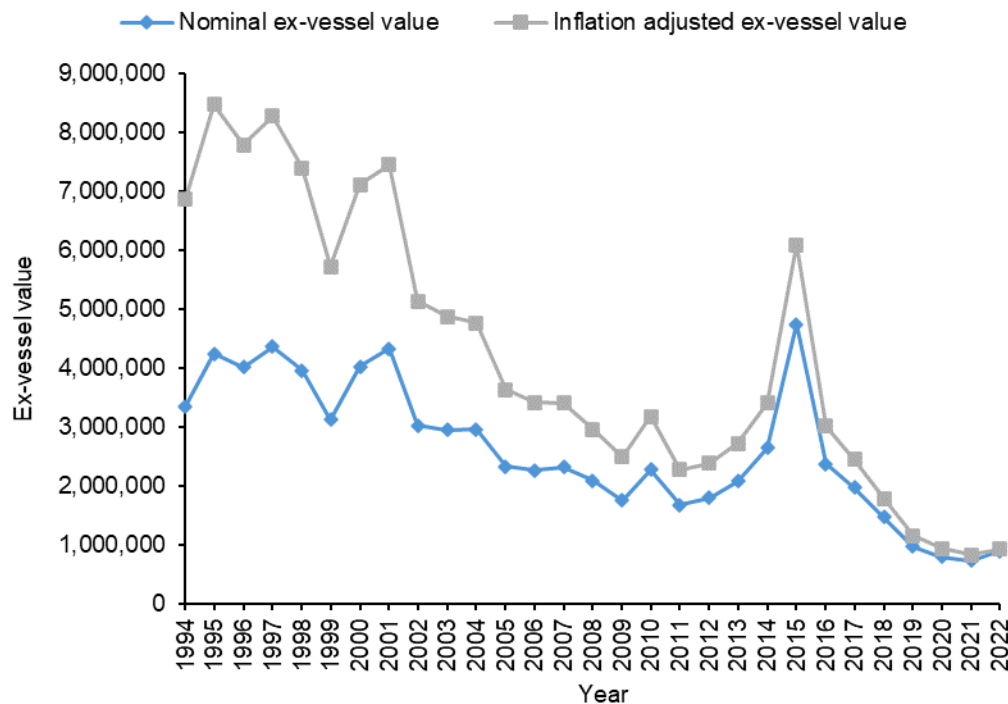


Figure 13. Annual ex-vessel value of Hard Clams in North Carolina, 1994–2022. Inflation adjusted values are in 2022 dollars. NCDMF TTP.

The average price per clam stayed constant from 1994–2014 before increasing dramatically in 2015, followed by a drop in 2016, and then a consistent increase from 2017–2022 (Figure 14). When adjusted for 2022 dollars, the average price per clam from 1994 to 2022 peaked in 2015 at \$0.31 and had the lowest average value in 2012 at \$0.14. In the last five years clam values have increased from \$0.19 in 2018 to \$0.21 in 2021 and \$0.27 in 2022.

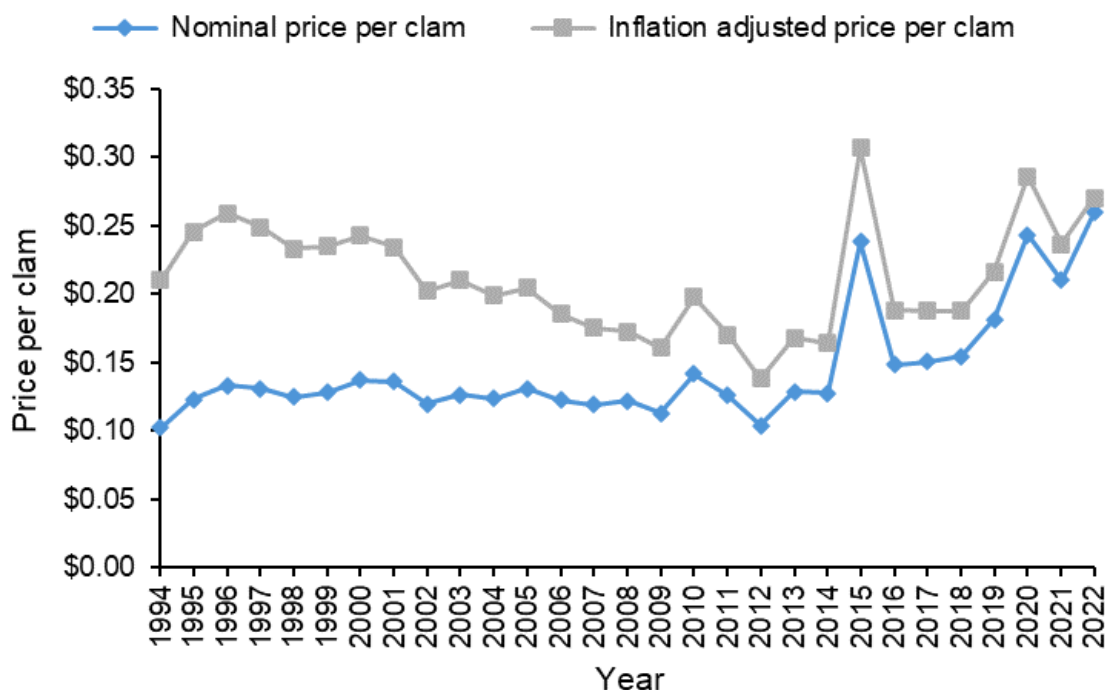


Figure 14. Annual average nominal and inflation adjusted price per clam harvested on public bottom in North Carolina 1994–2022. Data provided by the NCDMF TTP.

From 2004 to 2019 the value of all clam grades was stable and did not have much variation across grades. In 2020, there was a large spike in little neck prices and then a sharp decrease in 2021 before coming back up to \$0.52 in 2022. This market volatility could have been influenced by outside market drivers such as the COVID-19 pandemic.

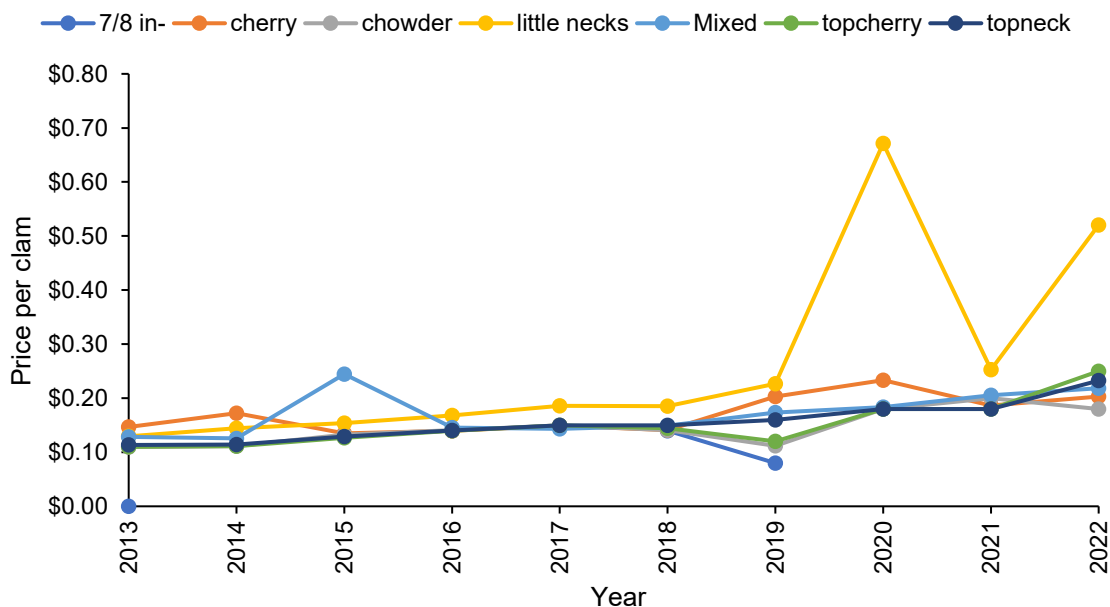


Figure 15. Annual average ex-vessel grade prices of Hard Clams in North Carolina, 2013–2022. Data provided by the NCDMF TTP.

Most water bodies account for a constant amount of the clam harvest value over time (Figure 16). Notably, the New River has seen a decrease in the market share of landed clams in the last two years. Clam landings from public bottom in New River fell from 65% of the market share in 2014 to 9% in 2022. Core Sound and Bogue Sound have made up more of the landed clams in the last 5 years making up a combined 43% of clams landed from public bottom in 2022.

Gear

From 2004 to 2022, hand harvest dominated the percent of total ex-vessel value of clam landings. The percentage of mechanical harvest value saw a decrease over that period from a peak of 24% in 2003 to a low of 13% in 2015. As a proportion of clam harvest on public bottom, mechanical harvest has oscillated around 20% of market share for most of the time series with high yearly fluctuations from 2011–2016. From 2018 to 2022 hand harvest made up at least 86% of the harvest (Figure 17). Since 2016 mechanical harvest has accounted for between 20% and 24% of landings (Figure 17).

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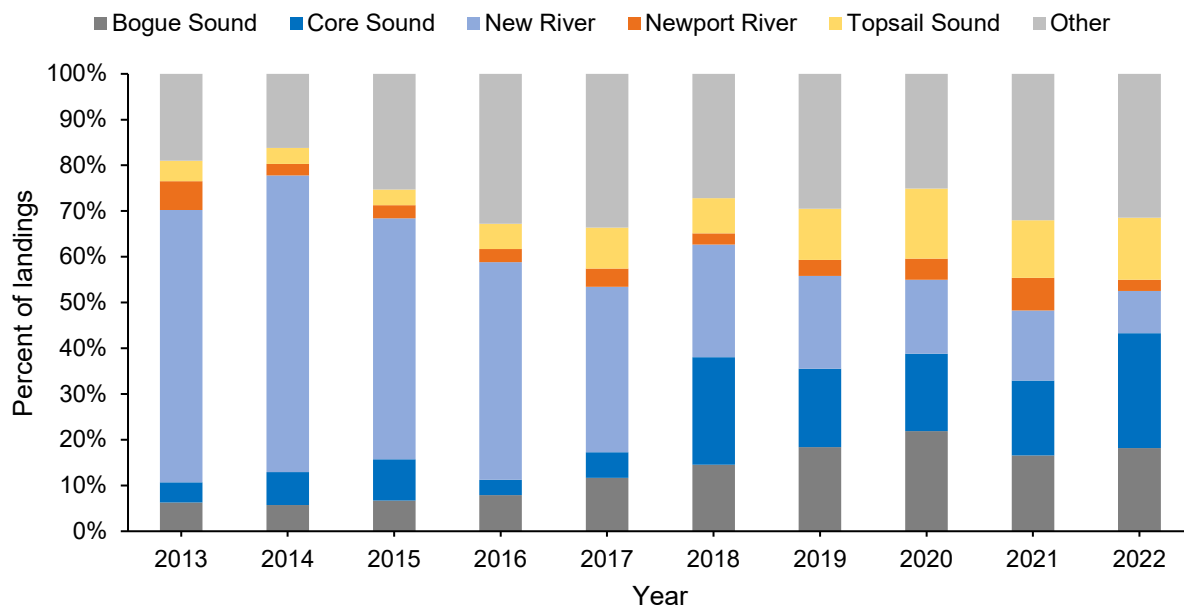


Figure 16. Percent of total annual commercial Hard Clam harvest value by waterbody, 2013–2022. Data provided by the NCDMF TTP.

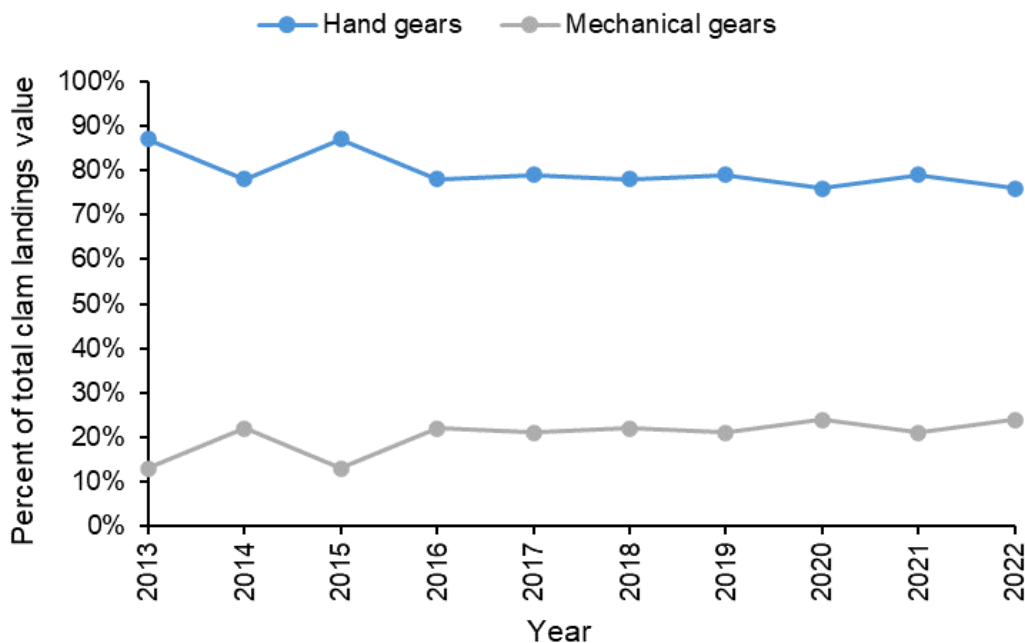


Figure 17. Annual percent of total landings value by gear type used to harvest Hard Clams, 2013–2022. Data provided by the NCDMF TTP.

Participation And Trips

The NCDMF tracks commercial landings of shellfish in the state through the Trip Ticket Program. Among the variables collected, number of participants, number of trips, gear types, location of landings and harvest, and number of dealers are categorized and summarized in this section.

In the last 20 years, 97% of clammers have recorded landings worth under \$25,000 with 43% of clammers landing clams worth \$500 or less a year. This indicates most participants use clamming as a supplement to their income.

Those participating in hand harvest were primarily in the 50–59 year old age group, with participation of individuals < 49 years old declining over time (Figure 18).

As is the case in all commercial fisheries in North Carolina, clam fishers may only sell their catch to licensed seafood dealers. The number of dealers reporting landings of clams has declined since a high of 94 in 2013. The number of dealers purchasing clams fell to 47 in 2019. Since 2019 the annual number of dealers participating in the purchase of clams has been stable with 26 in 2022.

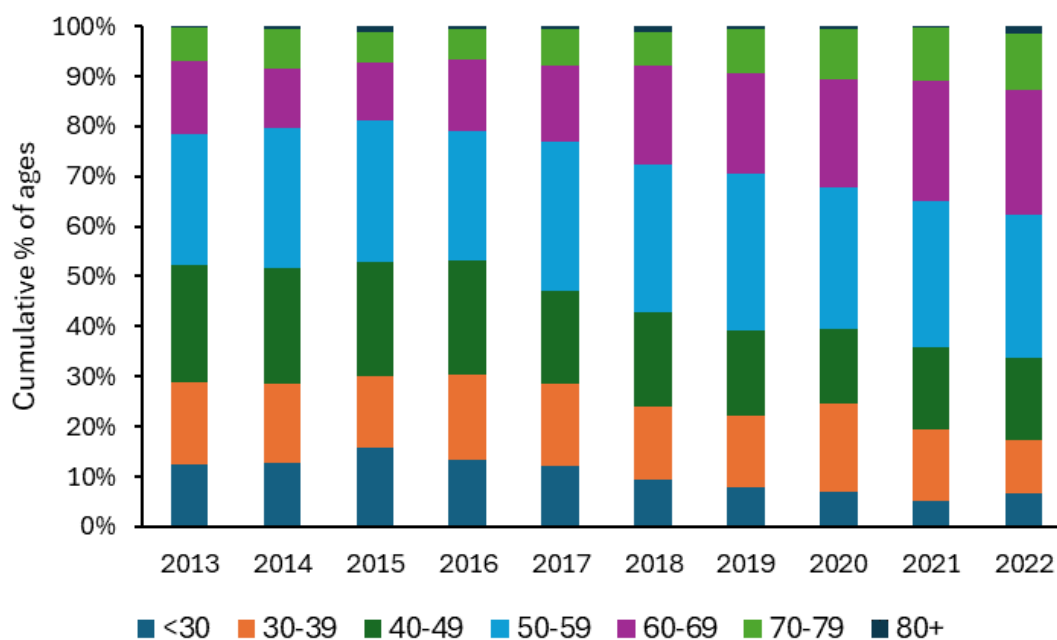


Figure 18. Age group demographics for Hard Clam hand harvest, 2013 – 2022 Data provided by the NCDMF TTP.

Economic Impact of the Commercial Fishery

The expenditures and income within the commercial fishing industry, as well as those by consumers of seafood produce ripple effects as the money is spent and re-spent in the state economy. Each dollar earned and spent generates additional economic impacts by stimulating further activity in other industries which fosters jobs, income, and business sales. These impacts are estimated using the NCDMF commercial fishing economic impact model which utilizes information from socioeconomic surveys of commercial fishermen and seafood dealers in North Carolina, economic multipliers found in *Fisheries Economics of the United States, 2020*, and IMPLAN economic impact modeling software. In 2022, the commercial clam fishery in North Carolina supported an estimated 326 full-time and part-time jobs, approximately \$1.37 million in income, and approximately \$3 million in sales impacts (Table 3). In the last ten years the industry has contracted in landings, participants, and economic impacts.

Recreational Fishery Economics

The NCDMF has limited data on recreational clamming, including the number of participants and the effect of their effort on the economy. For more information on the Recreational Fishery, see Appendix 2 (the Recreational Harvest Issue Paper).

Table 3. Economic impact of the commercial Hard Clam fishery in North Carolina, 2013–2022 reported in 2022 dollars. NCDMF Fisheries Economics Program.

Year	Participants ¹	Trips ¹	Clams landed (in thousands) ¹	Estimated Economic Impacts			
				Ex-vessel value (in thousands) ¹	Jobs ^{2,3}	Income impacts (in thousands) ³	Sales impacts (in thousands) ³
2022	276	6,194	3,828	\$890	326	\$1,370	\$2,988
2021	268	5,140	3,557	\$789	313	\$1,399	\$2,996
2020	292	5,438	3,430	\$903	338	\$1,389	\$2,997
2019	311	8,151	5,428	\$1,110	365	\$1,793	\$4,119
2018	452	12,211	9,492	\$1,710	537	\$2,667	\$5,843
2017	544	18,189	13,156	\$2,349	647	\$3,490	\$7,920
2016	599	19,612	16,047	\$2,891	722	\$4,247	\$9,252
2015	627	20,413	19,529	\$5,850	885	\$8,400	\$18,830
2014	581	18,372	20,538	\$3,267	728	\$4,883	\$11,222
2013	491	15,241	16,061	\$2,611	606	\$4,124	\$8,767

¹As reported by the NCDMF trip ticket program.

²Represents both full-time and part-time jobs.

³Economic impacts calculated using the NCDMF commercial fishing economic impact model and reported in 2022 dollars.

SOCIAL IMPORTANCE OF THE FISHERY

Commercial Fishermen

The NCDMF Fisheries Economics Program has been conducting a series of in-depth interview-style surveys with commercial fishermen along the coast since 1999. Data from these interviews are added to a growing database and used for fishery management plans, among other uses. The description of the clam fishery from these surveys can be found in Amendment 2.

ECOSYSTEM PROTECTION AND IMPACT

Coastal Habitat Protection Plan

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

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

Hard Clams occur extensively in estuarine systems. Habitats for juvenile and adult Hard Clams include both intertidal and subtidal soft bottom (defined by Street et al. (2005) as “unconsolidated, unvegetated sediment that occurs in freshwater, estuarine, and marine systems” to include both deeper subtidal bottom and shallow intertidal flats), shell bottom (which can be commonly referred to as oyster beds, rocks, reefs, bars, and shell hash),

and SAV. NCDMF's Estuarine Bottom Habitat Mapping (EBHM) Program mapped North Carolina's shellfish-growing bottom habitats between 1990 and 2021 and identified the top clam-producing bottom types across the state, as listed in Table 4.

By region, *Subtidal Hard Vegetated without Shell* (SAV on sandy bottom) was the most productive clam habitat in the Pamlico Sound region, but in regions south of Pamlico Sound, unvegetated intertidal and subtidal shelly bottom types both produced more clams than vegetated bottom (Table 4). Other unvegetated, non-shelly bottom types (identified in the CHPP as "soft bottom habitat") also provide habitat for clams, but the EBHM program generally found clams at lower densities in those habitats than in shell bottom and SAV habitat. The EBHM program data support findings in the scientific literature that SAV (Peterson et al. 1984; Irlandi 1994; Carroll et al. 2008) and shell bottom (Peterson et al. 1995) provide superior habitat to unstructured soft bottom habitat. In addition to hosting lower densities of clams, soft bottom habitat is by far the most extensive estuarine habitat in North Carolina, and faces fewer threats than structured habitats. Therefore, the protection of SAV and shell bottom habitats from both physical impacts and water quality degradation are important when considering protecting clam habitats.

Table 4. Average clam densities for the top five clam-producing bottom types as identified by the EBHM program.

EBHM bottom habitat category	Avg. clams per square meter	Habitat description
Intertidal Firm Non-vegetated Shell	2.03±0.03	Intertidal oyster reef/reef fringe on sandy or muddy sand bottom
Intertidal Hard Non-vegetated Shell	1.50±0.04	Intertidal oyster reef/reef fringe on sandy or shelly bottom
Subtidal Firm Non-vegetated Shell	0.86±0.03	Subtidal oyster reef/reef fringe on sandy or muddy sand bottom
Subtidal Hard Non-vegetated Shell	0.87±0.04	Subtidal oyster reef/reef fringe on sandy or shelly bottom
Subtidal Hard Vegetated w/o Shell	0.71±0.01	SAV beds on sandy bottom

Habitat and Enhancement Program

The NCDMF has not identified a need to target restoration efforts towards increasing Hard Clam populations; however, NCDMF supports enhancement programs which benefit native shellfish species through a variety of initiatives. In recognition of the eastern oyster as a keystone species in estuarine habitat, these initiatives focus on oyster restoration, while indirectly and simultaneously providing enhancement to Hard Clam habitat.

CULTCH PLANTING

The objective of the NCDMF cultch planting program is to provide shellfish habitat on public bottom grounds open to commercial harvest. While cultch planting is traditionally viewed as an oyster restoration measure, it may also serve as a restoration tool for other shellfish species, including Hard Clams. A comprehensive overview of the cultch planting program is available in the Eastern Oyster FMP Amendment 5, Appendix 4.

OYSTER SANCTUARIES

Oyster Sanctuaries in North Carolina are designed in such a way that enhanced habitat complexity may provide habitat for both oysters and other species typically found on or near oyster reefs. At many of these sites, soft bottom habitat between hard substrate patches may provide ideal habitat for clam colonization and also offer refuge from predation (Castagna 1970).

Hard Clams, as with oysters, in harvest-protected sanctuaries can serve as broodstock populations, providing subsidies to harvestable areas (Gobler et al. 2022). While a monitoring protocol is in place for oyster sanctuaries, there is currently no provision for addressing Hard Clam ecology associated with these protected areas.

A comprehensive overview of the Oyster Sanctuary Program is available in the Eastern Oyster FMP Amendment 5, Appendix 4.

SHELLFISH AQUACULTURE

Aquaculture of Hard Clams has ecosystem service value similar to wild stocks. Hard Clams maintain the capacity to filter large volumes of water. Depending on the ploidy of Hard Clams in culture, environmental conditions, and the duration of grow out, shellfish aquaculture may provide an additional source of larvae for habitat enhancement. However, currently there are limited seed producers in North Carolina, potentially hindering the growth of clam aquaculture.

CLAM RESTORATION EFFORTS IN OTHER STATES

Although a majority of shellfish restoration efforts have focused on oysters, a few recent projects have looked at effective strategies for enhancing depleted clam populations along the east coast. The cost-effectiveness of various methods has been investigated, including the use of spawner sanctuaries, planting seeded shell, and larval release in shallow lagoons of New York and Florida (Arnold et al. 2002; Doall et al. 2009; Gobler et al. 2022). Among these strategies, spawner sanctuaries appear to have had the most success. This strategy, as suggested by Peterson (2002), takes advantage of the long lifespan and sustained reproductive output of *M. mercenaria*.

A study conducted in Shinnecock Bay, along Long Island, New York observed the 9-year impact of transplanting 3.2 million adult Hard Clams and placing them in high-density no-take spawner sanctuaries (Gobler et al. 2022). Compared to neighboring lagoons during the same time period, Shinnecock Bay saw a 16-fold increase in landings of clams, in

addition to significant decreases in harmful algae density and chlorophyll A concentration and a significant net gain in seagrass habitat (Gobler et al. 2022). While other projects testing the spawner sanctuary strategy had mixed results, their takeaways highlighted the importance of suitable environmental conditions using healthy adult clams. For instance, shallow water (< 2 m), higher DO, higher temperatures, and higher salinity (> 20 psu) likely all play a significant role in both the ability of adult clams to recondition between spawning years, as well as survivability and recruitment of larvae (Castagna & Chanley 1973; Doall et al. 2009; Arnold et al. 2002; Gobler et al. 2022).

Therefore, careful consideration of environmental variables must occur during site selection for any possible clam restoration projects. While both oysters and clams have similar ecological roles as filter feeders in shallow water estuaries, each has specific physiological tolerances and environmental needs. Oysters can survive a wide range of environmental conditions, while clams have a narrower tolerance of environmental variables and are not constrained to the tidal column upper limits (Galimany et al., 2017). Furthermore, researchers have placed considerable emphasis on the necessity of long-term monitoring surveys (similar to protocols used for NC's Oyster Sanctuary Program) following any restoration efforts involving *M. mercenaria* (Simpson et al. 2022).

Environmental Factors, Threats, and Alterations

PHYSICAL THREATS

Mobile Bottom Disturbing Fishing Gear

Goal 3 of the 2016 CHPP is to “enhance and protect habitats from adverse physical impacts,” which includes reducing the impacts of mobile bottom disturbing fishing gear, the negative effects of which are described in detail in Section 8.1.1 of the 2016 CHPP. Soft bottom habitat, because of its low structure and dynamic nature, has historically been considered the most appropriate location to use bottom disturbing gear. NCMFC rules restrict bottom disturbing gears in designated soft bottom habitat. Fishing gears with the greatest potential to damage soft bottom include dredges and trawls. Of the threats to structured clam habitat, physical disturbance from mechanical harvest of clams and oysters is the most obvious. Impacts of mechanical harvest on unstructured, soft bottom sediments are less studied, and the 2021 CHPP (NCDEQ 2021) highlights the need for increased monitoring of the condition of North Carolina's estuarine soft bottom habitat with regards to chemical and microbial contaminants and benthic macroinvertebrate communities. Recommended Action (RA) 8.6 in the 2021 CHPP (expansion of DWR's benthic macroinvertebrate sampling to estuaries) could directly contribute to a better understanding of the impacts of bottom disturbing gear on soft bottom habitats, and RA 8.1 (convene an expert workgroup to document data gaps and monitoring needs) and RA 8.2 (develop an ecosystem condition report) will provide a roadmap to better understanding impacts to Hard Clam habitats. For more in depth information on mobile bottom disturbing fishing gear, see the [Mechanical Harvest Issue Paper](#).

Hand Harvest Methods

Intensive hand harvest methods can be destructive to oyster rocks. The harvest of clams or oysters by tonging or raking on intertidal oyster beds causes damage not only to living oysters but also to the cohesive shell structure of the reef (Lenihan and Peterson 1998). This destruction has been an issue where oysters and Hard Clams co-exist, primarily around the inlets in the northern part of the state and on intertidal oyster beds in the south (NCDMF 2001a). For more history on hand harvest methods, see [Amendment 2 of the Hard Clam FMP](#).

WATER QUALITY THREATS

Marine bivalves, including oysters, have been shown to accumulate chemical contaminants, such as hydrocarbons and heavy metals, in high concentrations. Reductions in growth and increased mortality have been observed in soft-shelled clams (*M. arenaria*) following oil spill pollution events (Appeldoorn 1981). Impaired larval development, increased respiration, reduction in shell thickness, inhibition of shell growth, and general emaciation of tissues have been attributed to adult bivalve exposure to heavy metal contamination (Roesijadi 1996).

High concentrations of organic contaminants also result in impairment of physiological mechanisms, histopathological disorders, and loss of reproductive potential in bivalves (Capuzzo 1996). As shellfish can easily accumulate chemical pollutants in their tissues, consumption of impaired shellfish can create a health risk. Subsequently, shellfish closures occur due to chemical contamination, commonly associated with industry, marinas, and runoff.

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

Non-point sources of microbial contamination include runoff from animal agriculture operations and urban development. Animal agriculture produces waste with fecal bacteria, runoff from pastures, concentrated animal feeding operations (CAFOs), and land where CAFO waste has been applied as manure, all of which can be transported to surface waters and subsequently lead to shellfish restrictions (Wolfson and Harrigan 2010; Burkholder et al. 2007; Hribar 2010). Impervious surfaces (e.g., roads, roofs, parking lots) facilitate runoff and microbe transportation, facilitating significant water quality degradation in neighboring watersheds (Holland et al. 2004). For instance, in New Hanover County, an analysis of the impact of urban development showed that just 10–20% impervious cover in an area impairs water quality (Malin et al. 2000). In North Carolina, most CAFOs primarily house swine and poultry with a majority located in the coastal plain portions of the Cape Fear and Neuse River basins; however, both occur in all basins across the coastal plain (NCDWR 2024; Off 2022).

Hypoxia

Point and non-point sources (developed and agricultural lands) are also sources of increased nutrient loads, which fuel phytoplankton growth and increase the strength and frequency of algal blooms. The eventual bacterial decomposition of these blooms results in a depletion of dissolved oxygen levels that can be dangerous to shellfish, particularly in warm, deep waters. Increased eutrophication leads to decreased oxygen levels (hypoxia and anoxia), which North Carolina's estuaries can already be prone to because of salinity stratification and high summertime water temperatures (Buzzelli et al. 2002). These low-oxygen events degrade the usability of subtidal oyster reef habitats for fish (Eby and Crowder 2002) and cause high rates of oyster mortality in the deeper (4–6 m) waters of the estuaries (Lenihan and Peterson 1998; Powers et al. 2009; Johnson et al. 2009). Increased state action to limit nutrient loading from urban and agricultural lands is critical for reducing hypoxia impacts to estuarine habitat and resources, including oysters and the reefs they create (NCDWR 2024).

CLIMATE CHANGE

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

For instance, Paerl et al. (2020) investigated the impact of tropical cyclones on nutrient delivery and algal bloom occurrences in the Neuse River Estuary and Pamlico Sound. They found high-discharge storm events, such as high-rainfall tropical cyclones, can double annual nutrient loadings to the estuary, leading to increased nutrients and dissolved organic carbon. Phytoplankton response to moderate storm events is immediate, while during high-rainfall events like Floyd (1999), Matthew (2016), Florence (2018), and Dorian (2019) phytoplankton growth is diverted downstream to Pamlico Sound, where it can persist for weeks. Additionally, increased organic matter and phytoplankton biomass from heavy rainfall events contribute to oxygen depletion, exacerbating hypoxic and anoxic conditions in the Neuse River and Pamlico Sound.

Additionally, warming water temperatures caused by climate change may benefit growth rates for pathogens that can negatively impact resources. For instance, increased water temperatures have been linked to increasing abundance of the bacterium, *Vibrio*, over the past 60 years (Vezzulli et al. 2016). This is a significant public health issue and can disrupt shellfish markets, as *Vibrio* species get taken up by filter-feeding shellfish and can cause life-threatening illness when consumed. Common wisdom in North Carolina has advised against consuming raw shellfish in the warm-water months for this reason, and

rising water temperatures threaten to increase this risk, potentially through longer periods of the year.

In addition to causing hypoxia, the enhanced phytoplankton growth resulting from increased rainfall and nutrient delivery to estuaries will also result in negative impacts to SAV habitat. The majority of SAV loss in North Carolina has been attributed to decreases in light availability due to increased eutrophication (nutrient enrichment) and suspended sediments, and those losses are expected to increase as eutrophication increases due to climate change (NCDEQ 2021). Further, North Carolina's dominant high-salinity SAV species, Eelgrass (*Zostera marina*), is already growing at the warmest edge of its thermal tolerance in NC, regularly experiencing stressful temperatures that affect growth and reproduction. While the response of eelgrass to increased water temperatures is complex, and the species may be more resilient in North Carolina than other states (Bartenfelder et al. 2022), projections of shifts in the range of eelgrass due to warming waters indicate that the species' southern limit is likely to move northward and potentially out of North Carolina altogether by 2100 (Wilson and Lotze, 2019).

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

WATER QUALITY MANAGEMENT THROUGH THE CHPP

Improved water quality has been a component of all editions of the CHPP, and the 2021 CHPP included a specific focus on improving water quality to protect SAV habitat, which will directly benefit the clam fishery. The 2021 CHPP proposed to follow the successful examples of management in Chesapeake Bay and Tampa Bay with a five-element strategy that includes 1) supporting efforts to improve water quality; 2) protecting and restoring SAV; 3) enhancing SAV research and monitoring; 4) improving collaboration through citizen involvement, education and outreach; and 5) addressing other contributing factors such as physical disturbance and climate change.

The 2021 CHPP's SAV protection recommendations heavily emphasize the first element, and NCDWR staff have led the Nutrient Criteria Development Process (NCDP), with collaboration from other DEQ divisions, including NCDMF habitat and enhancement staff. Because the EMC's current chlorophyll and turbidity standards are not enough to protect SAV from light limitation, the 2021 CHPP placed increased emphasis on developing new standards and updating current but deficient standards to improve water quality to protect and restore SAV. To address that, the NCDP team has developed a water clarity standard, as poor clarity is what prevents light from reaching SAV beds, and DWR staff

are beginning the process of bringing the proposed standard to the EMC within the next year. There are many potential pitfalls along the way, but if the approval process is successful, it will take approximately a year.

From there, it will take until the 2030 biennial update to the North Carolina Integrated Report (303d list), which identifies which water quality parameters are exceeded in which of the state's waterbodies, to have enough data to assess waterbodies as impaired for clarity. An impairment listing on the 303d list triggers the need to develop a Total Maximum Daily Load, or TMDL, (or another approved alternative). TMDL development also identified sources and causes of water quality degradation so that restoration efforts can target the appropriate issues (common causes are detailed in the 2021 CHPP, but include increased freshwater input and nutrient delivery from impervious surfaces, agriculture, and wastewater, among others).

Following TMDL development, then on-the-ground restoration work would begin to start improving water clarity, so the earliest potential improvements from this effort may occur in the early 2030s. The timeline of this effort is not short, but it represents the best opportunity for statewide restoration of SAV habitat through improving water quality, which will also reduce the frequency of shellfish harvest closures and provide benefits to other habitats like oyster reefs by reducing nutrient pollution and the severity of hypoxic events.

The 2026 update to the CHPP will consider progress made in this process and provide further recommendations to advance this process and other avenues for improving water quality in North Carolina's estuaries through collaboration with DWR, DCM, and other state agencies with direct jurisdiction over issues driving water quality degradation.

ENVIRONMENTAL PATHOGENS

There are various environmental pathogens that can impact shellfish and those that consume shellfish. These pathogens include Neurotoxic Shellfish Poisoning (NSP), *Vibrio*, and Green Gill.

Neurotoxic Shellfish Poisoning (NSP) is a disease caused by consumption of molluscan shellfish contaminated with brevetoxins primarily produced by the dinoflagellate, *Karenia brevis*. Blooms of *K. brevis*, called Florida red tide, occur frequently along the Gulf of Mexico. Ocean currents have transported *K. brevis* blooms up the Atlantic coast and has been carried to North Carolina, which accounted for the red tide event and NSP outbreak in 1987 (Watkins et al. 2008).

Vibrio spp are salt loving bacteria that inhabit coastal waters throughout the world, and with the exception of toxigenic *Vibrio cholera* 01, are not usually associated with pollution that triggers shellfish closures and can be ubiquitous in open shellfish growing areas. Vibrios are more common during the warmer summer months and are found throughout the coastal waters of North Carolina (Blackwell and Oliver 2008; Pfeffer et al. 2003).

Green gill in clams comes from the single-celled alga called *Haslea ostrearia*. This is a blue-green diatom found in the coastal waters of North Carolina. For more detailed information on these environmental pathogens, see [Amendment 2 of the Hard Clam FMP](#).

SHELLFISH SANITATION

The NCDMF has a contingency plan in place as required by the FDA, including a monitoring program (National Shellfish Sanitation Program, NSSP) and management plan. The purpose is to ensure quick response of any harmful algal species within State waters that may threaten the health and safety of shellfish consumers. The plan also details the system to provide early warning of any potential issues, actions to be taken to protect public health and steps to reopen areas to harvest. (Shellfish Sanitation and Recreational Water Quality Section Marine Biotoxin Contingency Plan 2022). Shellfish Sanitation and Marine Patrol are the primary Sections of NCDMF responsible for North Carolina's compliance with the NSSP.

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

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

Protected Species

A "protected species" is defined as any organism whose population is protected by federal or state statute due to the risk of extinction. In North Carolina, these species are primarily protected by the following federal statutes: the Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), and the Migratory Bird Treaty Act (MBTA). The primary marine mammal that occurs in North Carolina estuaries is the common Bottlenose Dolphin (*Tursiops truncatus*; Hayes 2018) though the West Indian Manatee (*Trichechus manatus*) seasonally occurs during warm water months (Cummings et al. 2014). The NMFS splits this fishery into two distinct Category III fisheries: the Atlantic Shellfish Bottom Trawl fishery and the Atlantic Ocean, Gulf of Mexico, Caribbean shellfish dive, hand/mechanical collection fishery. The Category III designations indicate there are no

known gear interactions with marine mammals. More information on the MMPA List of Fisheries and fisheries categorizations can be found on the National Oceanic and Atmospheric Administration (NOAA) MMPA [website](#).

North Carolina estuaries are also home to multiple ESA-listed species including the Green Sea Turtle (*Chelonia mydas*), Kemp's Ridley Sea Turtle (*Lepidochelys kempii*), Loggerhead Sea Turtle (*Caretta caretta*), Leatherback Sea Turtle (*Dermochelys coriacea*), Hawksbill Sea Turtle (*Eretmochelys imbricata*), Atlantic Sturgeon (*Acipenser oxyrinchus*), and Shortnose Sturgeon (*Acipenser brevirostrum*). These species are unlikely to be impacted as harvest methods employed largely exclude any potential for direct interactions. Due to the lack of recorded interactions and the unlikelihood of any interactions between these ESA-listed species and the clam industry, it can be assumed that any potential impacts of Hard Clam harvest on protected species populations would be primarily indirect and at the ecosystem-level.

North Carolina is home to a diverse array of migratory bird species (Potter et al. 2006). Overall, there is little evidence to suggest that any Hard Clam harvest method impacts MBTA-protected species. Some research suggests that hand and rake harvest of clams has a negligible effect on certain species of shorebirds (Navedo and Masero 2008).

FINAL AMENDMENT THREE MANAGEMENT STRATEGY

The NCMFC selected management measures

APPENDIX 1: CLAM MECHANICAL HARVEST ISSUE PAPER

Option 1: Mechanical Clam Harvest

- d. Phase out mechanical clam harvest in three years (May 2028) to be consistent with G.S. 113-221 (d).

Option 2: Mechanical Clam Harvest in Conjunction with Maintenance Dredging

- b. Discontinue allowance for mechanical clam harvest in conjunction with maintenance dredging upon adoption of this plan

APPENDIX 2: RECREATIONAL SHELLFISH HARVEST ISSUE PAPER

Option 1: Recreational Harvest

- b. Support the DMF to further explore potential options and develop a solution to estimate recreational shellfish participation and landings, with the intent to move towards a stock assessment and stock level management for both hard clams and oysters; and to establish a mechanism to provide all recreational shellfish harvesters with Shellfish Sanitation and Recreational Water Quality health and safety information outside of the FMP process.

MANAGEMENT FROM PREVIOUS PLANS

There are management measures from the original FMP to carry forward into Amendment 3 unless otherwise changed in Amendment 3. Management measures from the Hard Clam FMP Amendment 2 that will be carried forward into Amendment 3 are listed below:

- Daily harvest limit for recreational purposes is 100 clams per person per day not to exceed 200 per clams per vessel per day.
- Maintain shading requirements for clams on a vessel, during transport to a dealer, or storage on a dock during June through September. These requirements would be implemented as a public health protection measure under 15A NCAC 03K .0110.
- Maintain management of the Ward Creek Shellfish Management Area as described in the Hard Clam FMP Amendment 1.
- Maintain current daily mechanical Hard Clam harvest limits by waterbody (Table 1).
- Institute a resting period within the mechanical clam harvest area in the northern part of Core Sound.
- Take latitude/longitude coordinates of the poles marking the open mechanical clam harvest area boundary in the New River, still with the flexibility to move a line to avoid critical habitats.
- Maintain management of the mechanical clam harvest in existing areas from Core Sound south to Topsail Sound, including modifications to the mechanical clam harvest lines to exclude areas where oyster habitat and SAV habitat exist based on all available information.

RESEARCH NEEDS

The research recommendations listed below are offered by the NCDMF to improve future management strategies of the Hard Clam fishery. They are considered high priority as they will help to better understand the Hard Clam fishery and meet the goal and objectives of the FMP. This list of research recommendations is also provided in the Annual FMP Review and NCDMF Research Priorities documents.

- Develop Hard Clam sampling methodology to monitor regional adult abundance
- Map and characterize Hard Clam habitat use by bottom type
- Develop a survey to better quantify recreational harvest
- Determine natural mortality estimates
- Investigate causes of recent clam-kills and overall decline in Hard Clam abundance in the New River

APPENDICES

Appendix 1: Clam Mechanical Harvest Issue

ISSUE

The number of participants and trips in the mechanical clam fishery on public bottom have steadily declined since the 1990s to the lowest levels on record. This, along with habitat concerns associated with bottom disturbing gears, as well as significant cost to the state for management of this fishery, has led the North Carolina Division of Marine Fisheries (NCDMF) to re-examine if this fishery should still be allowed to operate.

ORIGINATION

The NCDMF

BACKGROUND

Historical Importance

Historically, harvest of Hard Clams by mechanical methods from public bottom made up a significant portion of the commercial Hard Clam landing on public bottom from its advent in the mid-1940s all the way through the early-2010's. As detailed in the Status of the Fishery section, mechanical harvest of Hard Clams began as a rudimentary version of dredging where boat propellers were used to blow sediment away and expose Hard Clams for hand harvest. This evolved through time into the modern methods of escalator dredging and clam trawling we see today (see Mechanical Harvest subsection of the Status of the Fishery section).

Historical mechanical harvest data are sparse until 1950 when commercial reporting became more regular. The mechanical harvest in the early 1950s was massive compared to recent decades, exceeding 35 million Hard Clams in 1951 (Figure 1.1). This period of high landings was followed by a steep decline in landings that lasted until the late 1960s. An increase in demand for North Carolina Hard Clams was created during the 1976–1977 season, when Hard Clam beds in the northeastern states became inaccessible due to abnormally thick ice. This period marked another large increase in mechanical harvest that would last into the mid-1980s. Since the late 1980s, Hard Clam landings have declined. This decline is likely the result of a decrease in abundance, increased closures of shellfish waters from pollution, changing market demand, several major storms, and a red tide event in 1987.

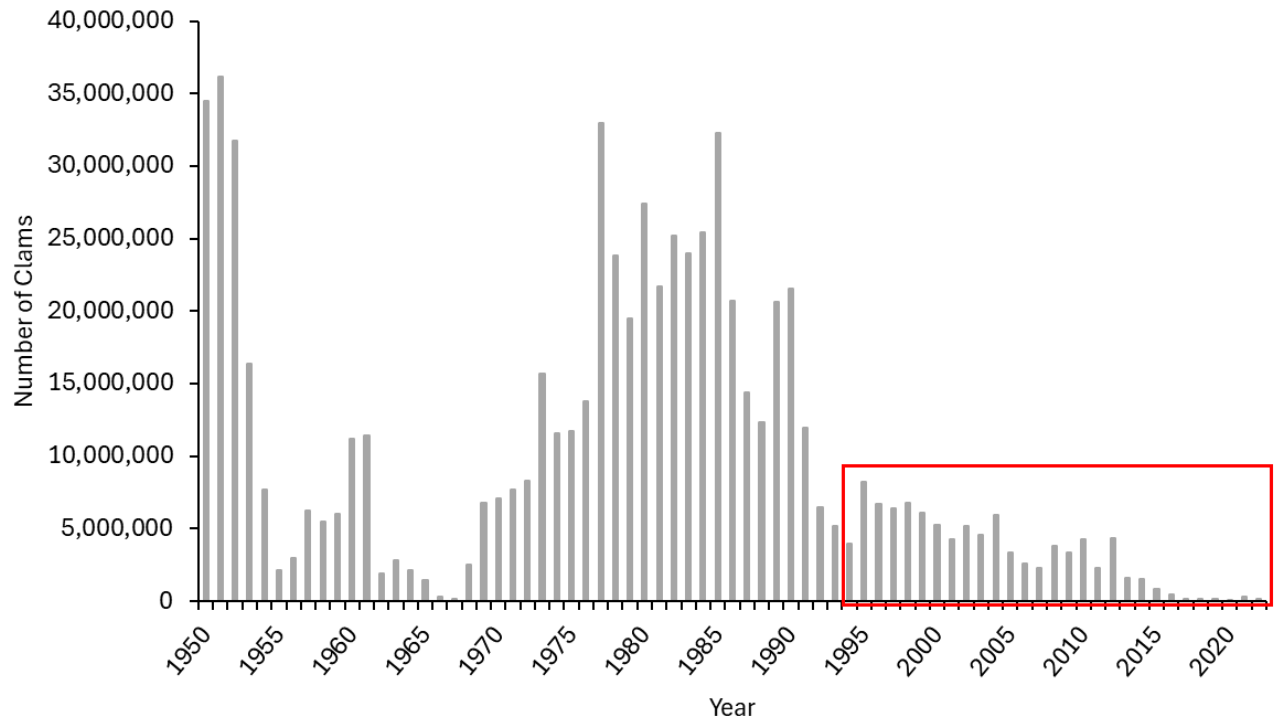


Figure 1.1. Hard Clam landings (number of clams) using mechanical gears on public bottom by year, 1950–2022. TTP data are presented in the red box.

Since 1994, the mechanical Hard Clam fishery has seen a steady decline in landings and participation to its lowest levels since clam trawls were first used in the late 1960s (Figure 1.1). Landings from this fishery have declined from a maximum harvest of over 8.7 million Hard Clams in 1995, to a level that has remained below 100,000 Hard Clams per year from 2017 to 2022. The precipitous decline in landings is mirrored by a similar decline in participation over the same period. In 1996, the fishery maxed out at 138 participants. Over the next two and a half decades, participation quickly waned with less than 10 participants per year active in the fishery from 2019 to 2022 (Figure 1.2).

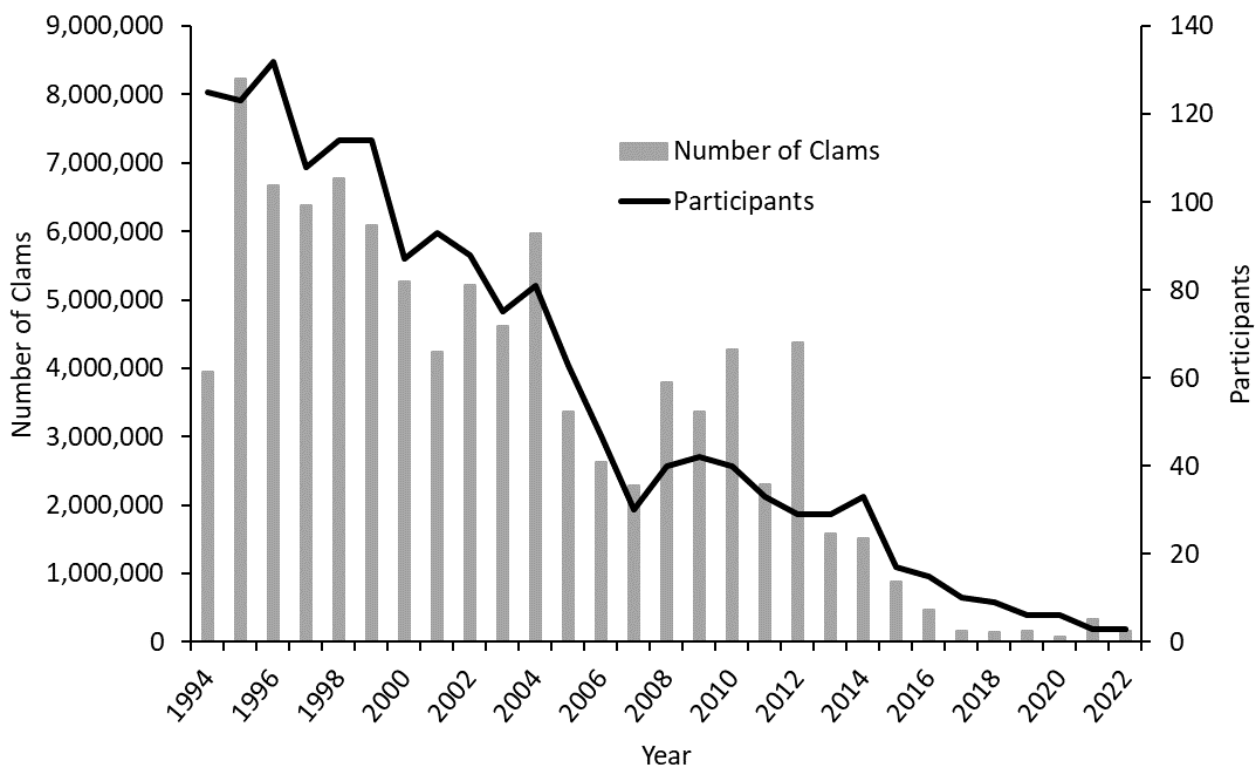


Figure 1.2. Hard Clam landings (number of clams) and number of participants using mechanical gears on public bottom by year, 1994–2022.

As detailed in the Status of the Fishery section, the mechanical Hard Clam harvest season can occur from December 1 through March 31 and is opened by proclamation in specific areas. These areas are limited to what is defined in Amendment 2. These areas include portions of Core Sound, North River, Newport River, Bogue Sound, White Oak River, New River, New River inlet, and the IWW in Onslow and Pender Counties. These areas can be reduced but cannot be expanded beyond what is outlined in Amendment 2. Since 1994, the New River and Core Sound have accounted for over 80% of the total mechanical Hard Clam harvest from 1994–2022 (Figure 1. 3). The New River was the most important waterbody for mechanical harvest from 2000 to 2016, before being overtaken by Core Sound. The New River has seen a consistent decline in overall contribution to the landings since 2012, except for 2020 which had extremely low landings overall because of the COVID-19 pandemic. The consistent decline is primarily due to a series of clam kill events that occurred in the 2010s, which decimated the population within New River, and caused fishermen to move to new waterbodies or transition to other fisheries.

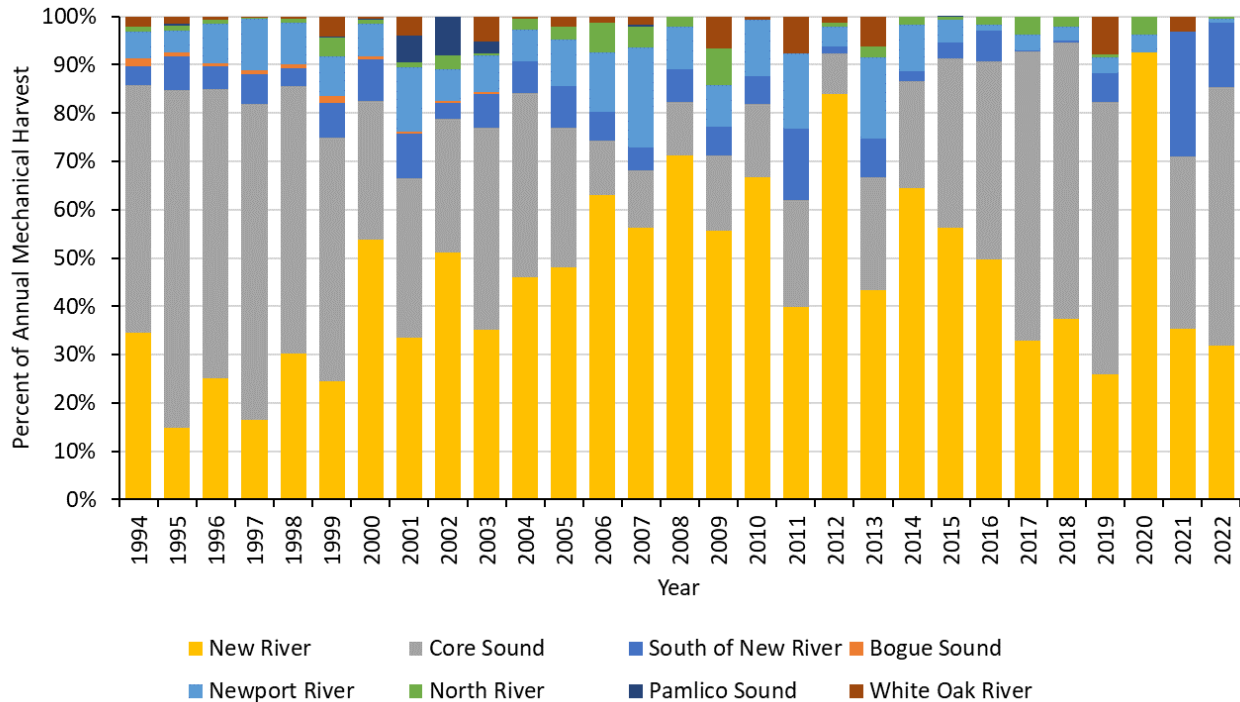


Figure 1.3. Percentage of annual mechanical Hard Clam harvest on public bottom by waterbody and year, 1994–2022.

Enforcement

Each year the NCDMF marks all the mechanical clam harvest area boundaries with posts and signs (except for the New River) to ensure enforceability of these boundaries. The staff must replace all missing or damaged posts and signs affected by weather or vandalism. The loss of posts and signs can be significant in years with major weather events such as hurricanes.

In addition to the significant cost and staff time associated with marking the mechanical harvest areas, a large force of Marine Patrol officers is required to monitor and enforce these areas. Normally, each harvest area will have several officers watching the lines with a couple on standby with vessels in case there is a violation. Then when the vessels start returning to the docks, it takes several officers to complete an inspection (i.e., count the Hard Clams, check licenses, and maintain security while counting the Hard Clams). The large volume of Hard Clams caught from these operations requires a good deal of Marine Patrol manpower, especially when several vessels return to the docks at the same time. In Core Sound, the vast area encompassed by the mechanical clam harvest area, along with its zig-zagging boundary makes enforcement difficult and resource intensive.

Maintenance Dredging

The NCDMF also allows the harvest of Hard Clams by mechanical means before maintenance dredging occurs in some navigational channels through NCMFC Rule 15A NCAC 03K .0301 (b). The purpose of this is to allow commercial fishermen access to a resource that would otherwise be destroyed during the maintenance dredging process. The execution of opening an area prior to maintenance dredging requires communication and collaboration between the NCDMF, Army Corps of Engineers (ACE), and the fishermen requesting access to mechanically harvest within the proposed dredge area. Late notice by fishermen, difficulty in communication with ACE, and the time to prepare and process proclamations to open areas have been major obstacles to this program since its inception in 1991. Due to the complicated process and limited interest from mechanical harvesters, no openings for mechanical harvest in proposed maintenance dredging areas have occurred since 2007.

AUTHORITY

N.C. General Statutes

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

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

03K .0302	Mechanical Harvest of Clams from Public Bottom
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DISCUSSION

The NCDMF recommends consideration of options to further reduce, phase out, or eliminate the mechanical clam harvest fishery due to habitat concerns with mechanical gears, declining participation in a fishery that lands just 0.1% of its historical catch, and significant cost to the state for monitoring and enforcement.

Habitat Concerns

Goal 3 of the 2016 CHPP is to “enhance and protect habitats from adverse physical impacts,” which includes reducing the impacts of mobile bottom disturbing fishing gear, the negative effects of which are described in detail in Section 8.1.1 of the 2016 CHPP. Under Goal 3, the primary relevant recommended actions are 3.3 “Protect habitat from adverse fishing gear effects through improved compliance” and 3.8 “Develop coordinated policies including management adaptations and guidelines to increase resiliency of fish habitat to ecosystem changes.” The management options presented in this issue paper support those recommended actions by simplifying compliance and contributing to the

DRAFT SUBJECT TO CHANGE

CHPP's comprehensive management strategy of managing both physical and water quality impacts to improve habitat resilience.

Summarizing information compiled in the 2016 CHPP, impacts from mobile bottom-disturbing fishing gear range from changes in community composition from removal of species to physical disruption of the habitat (Barnette 2001). Corbett et al (2004), found an increase in total suspended sediment 1.5 – 3 times above background concentrations for less than a day, and minor impacts on nutrient and chlorophyll a concentrations. Wind played a greater role in mixing the water column and altering its nutrient and sediment characteristics. Bottom trawls, dredges, and other mobile gears can cause rapid and extensive physical damage to hard bottom habitat (e.g. Auster and Langton 1999; SAFMC 1998). Habitat complexity is reduced through flattening of mounds, filling of depressions, dispersing shell hash, and removing small biotic cover such as hydrozoans and sponges (Auster et al. 1996; Løkkenborg 2005). Auster and Langton (1999), ASMFC (2000), and Collie et al. (2000) discussed impacts of fishing gears on SAV. Belowground effects, such as those from toothed dredges, heavy trawls, and boat propellers, may cause total loss of SAV, requiring months to years to recover. Excessive sedimentation from bottom disturbing fishing gear and propeller wash can bury SAV. Because of the severe bottom impacts, the MFC restricts use of this gear to open sand and mud bottoms, including areas frequently dredged for navigation, such as the AIWW, disallowing it in SAV and oyster habitats. Clam trawling, or kicking, began in Core Sound as a method involving the scouring of bottom sediment with a prop wash while towing a trawl. Anecdotal accounts indicate significant negative impacts occurred to oyster rocks prior to marking and closing areas to mechanical harvest of clams. As part of CHPP implementation, the area allowed for clam kicking was modified by proclamation to clearly avoid all SAV and oyster beds and to establish a buffer of 50–100 feet between the gear and structured habitats.

Fishing related impacts to habitat have been reviewed and compiled in fishery management plans and have been summarized in documents produced by the South Atlantic Fisheries Management Council (SAFMC), Mid-Atlantic Fisheries Management Council (MAFMC), N.C. Moratorium Steering Committee (MSC 1996), Auster and Langton (1999), NCDMF (1999), and Collie et al. (2000). Gears with the greatest potential for damage to soft bottom include dredges and trawls. However, research suggests that neither activity has a significant effect on clam recruitment (Auster and Langton 1999; NCDMF 1999; Collie et al. 2000). Dredges and trawls have a greater impact on structured habitat where clams are more abundant. Oyster rocks and cultch plantings provide excellent habitat for Hard Clam settlement and growth in areas where salinity regimes and water flow are suitable for survival. Hard Clam harvesting in oyster rocks involves overturning or sifting through shells and oysters overlying clams, possibly damaging the oysters. For this reason, oyster rocks are protected from mechanical harvest of clams and bull rakes by rule (Marine Fisheries Commission Rules 15A NCAC 03K .0304 and 03K .0102). Most harvesting of clams in relation to oysters occurs around the base of the beds where they are most abundant (Noble 1996). Clams are also harvested by mechanical methods using either hydraulic escalator dredge or clam trawl. Current fisheries regulations prohibit the use of mechanical gear in SAV beds and live oyster beds because of the destructive capacity of the gear. Mechanical harvest of clams is now only allowed

in designated harvest areas that do not contain significant SAV or oyster resources. In the 20-year period analyzed in the 2016 CHPP, trips for mechanical harvest of clams made up 18% of all trips using mobile bottom-disturbing fishing gears; however, that percentage had decreased to 6% of all trips by the terminal year of the analysis (2013), largely attributed to changes in regulations regarding gear restriction areas for mechanical harvesting of clams.

In accordance with the CHPP (e.g. 2016 CHPP action 3.3: protect habitat from adverse fishing gear effects through improved compliance), the NCDMF has already reduced the allowable mechanical clam harvest areas in the state due to concerns over encroachment with oysters and overlap with SAV beds. Beginning in 2008, the NCDMF discontinued the Pamlico Sound area in rotation with the northern Core Sound area and instituted an annual resting period between northern Core Sound and the southern Core Sound areas due to limited harvest and concerns over impacts to the crab fishery in the area (NCDMF 2017). From 2019–2020 (north of Bogue Inlet; APNEP 2022) and 2021 (south of Bogue Inlet; NCDMF 2022), a comprehensive study was conducted to map SAV beds across the state. The SAV maps generated from this study were overlaid onto the mechanical clam harvest area maps to look for areas of overlap. Significant overlap was identified in four of the harvest areas including Core Sound, North River, Bogue Sound, and New River. The mechanical clam harvest areas were then adjusted to eliminate overlap and provide a suitable buffer. An example of this overlap and subsequent area modification in 2020 for North River can be seen in Figure 1. 4. Due to the large extent of overlap with SAV, the entire mechanical clam harvest area in Bogue Sound was eliminated in 2020 (Figure 1. 5).

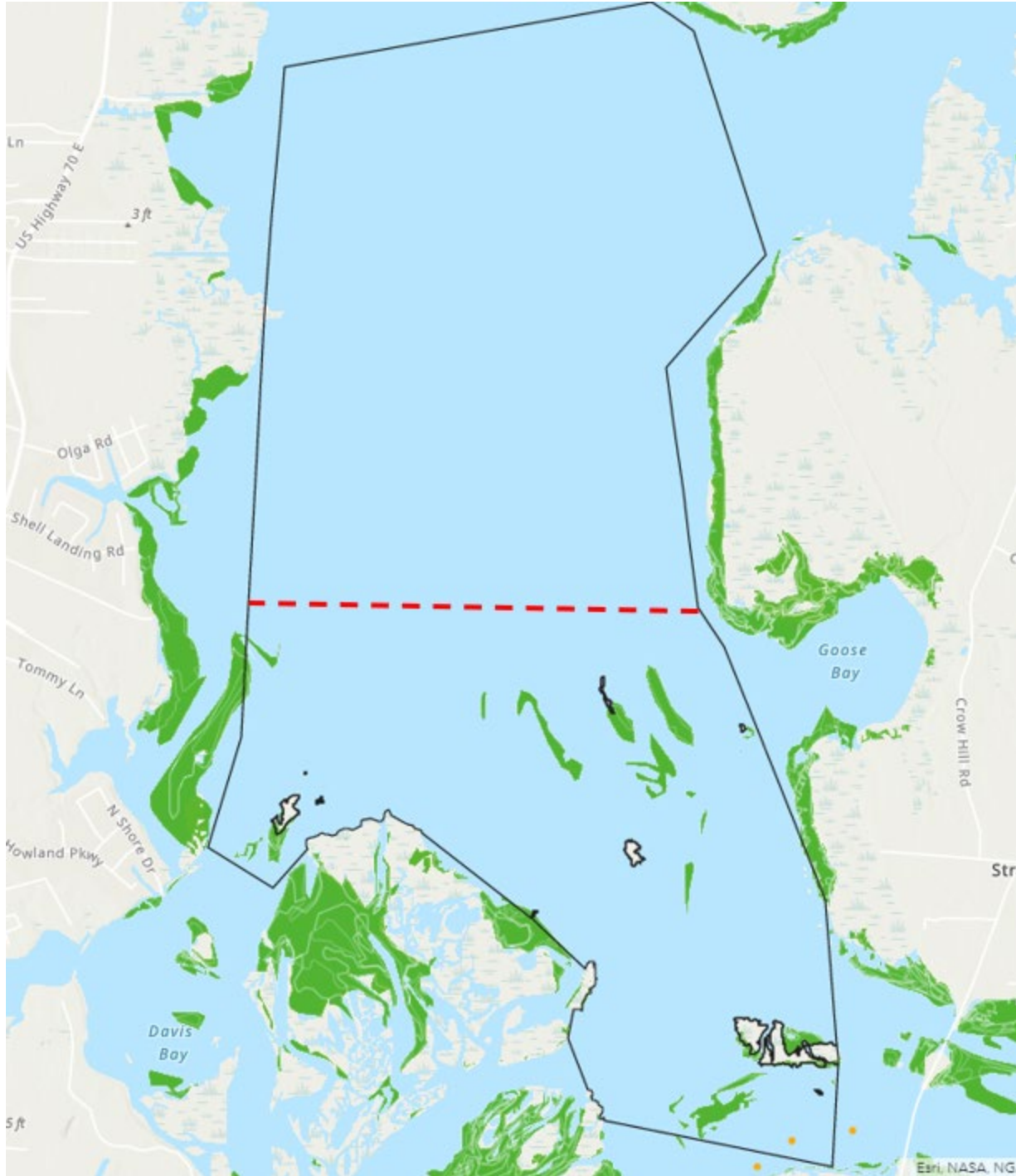


Figure 1.4. Map of the original North River mechanical clam harvest area (black line) overlaid with SAV mosaic (in green; APNEP 2022) to show SAV overlap. The dotted red line is where the new southern area boundary was established in 2020.



Figure 1.5. Map of the original Bogue Sound mechanical clam harvest area (black line) overlaid with SAV mosaic (in green; APNEP 2022) to show SAV overlap. This area was closed to mechanical clam harvest in 2020 due to the large extent of SAV overlap.

Organisms in soft bottom habitat are adapted to shifting and changing sediments. However, when sedimentation is excessive, there can be negative impacts. In addition to direct physical damage to the shell mound structure, bottom disturbing fishing gear, including hydraulic clam dredges, clam trawls (kickers), and shrimp and crab trawls can impact clam beds and oyster reefs indirectly by re-suspending sediment. High levels of suspended sediment in an estuarine or marine habitat can reduce successful settlement of larval clams and oysters and can smother other benthic invertebrates (Coen et al. 1999; AFS 2003). Excessive sedimentation can also harm shellfish by clogging gills, increasing survival time of pathogenic bacteria, or increasing ingestion of non-food particles (SAFMC 1998). Water column sediments can increase survival of fecal coliform bacteria in waterways (Schueler 1999), and while fecal coliform bacteria do not affect the viability of clams or oysters, pathogenic bacteria can make shellfish unfit for human consumption.

Socioeconomic Analysis

Commercial landings and effort data collected through the DMF trip ticket program are used to estimate the economic impact of the commercial fishing industry. For commercial fishing output, total impacts are estimated by incorporating modifiers from NOAA's Fisheries Economics of the United States reports from 2012–2020 (National Marine Fisheries Service 2023), which account for proportional expenditures and spillover impacts from related industries. By assuming the mechanical clam harvest commercial fishery's economic contribution is a proportion equal to its contribution to total commercial ex-vessel values, we can generate an estimate of the economic contribution of the clam mechanical harvest fishery statewide.

From 2012 to 2022, clam mechanical harvest on public bottom economic sales contributions have varied from a high of \$960,000 in 2012 to a low of approximately \$62,000 in 2020 and supported between 41 and 4 jobs annually. Annual sales impacts

and number of trips have consistently declined over the past decade, notably dropping sharply in 2017 and again in 2020 (Table 1.1.). The industry expanded in 2021, and to a lesser extent in 2022, but has not returned to pre-2016 landings or participation which has steadily declined over the period (Table 1.1.).

Table 1.1. Annual economic contributions from the clam mechanical harvest commercial fishery to the state of North Carolina from 2012–2022 reported in 2022 dollars.
* Indicates confidential data

Year	Trips	Participants	Ex-Vessel Value	Job Impacts	Income Impacts	Value Added Impacts	Sales Impacts
2022	41	3	< \$75,000*	4	\$44,522	\$92,392	\$105,235
2021	72	3	< \$75,000*	5	\$32,630	\$149,882	\$175,563
2020	32	6	\$18,891	7	\$29,053	\$53,201	\$62,685
2019	40	6	\$32,992	8	\$53,273	\$83,219	\$122,346
2018	56	9	\$24,752	10	\$38,595	\$69,255	\$84,564
2017	59	10	\$27,570	11	\$40,962	\$67,218	\$92,955
2016	106	15	\$83,951	19	\$123,316	\$214,598	\$268,630
2015	178	17	\$257,687	28	\$369,966	\$649,341	\$829,340
2014	360	33	\$226,378	43	\$338,399	\$554,643	\$777,574
2013	348	29	\$252,269	40	\$365,723	\$636,974	\$826,304
2012	414	29	\$284,867	41	\$423,831	\$701,532	\$960,031

Each year the NCDMF uses a large number of staff, primarily marine patrol officers, and financial resources to monitor, manage, and enforce this fishery. These costs are difficult to justify for a fishery with low participation and diminished value. The cost to the state to facilitate the execution of this fishery may be better used to fund projects more beneficial to the clam fishery as a whole, or at least one that benefits more users.

Maintenance Dredging

If the mechanical clam harvest fishery on public bottom were to be discontinued, it may be necessary to end the exception for mechanical harvest prior to maintenance dredging described in rule 15A NCAC 03K .0301 (b). If the primary mechanical clam fishery is closed, fishermen that currently participate in the fishery would likely get rid of their gear, leaving no one to participate in pre-maintenance dredging openings. This would further benefit the habitat by reducing the extent of turbidity issues associated with mechanical gears. This program has not been utilized since 2007, and with declines in the mechanical clam harvest fishery as whole, it is unlikely to be used much in the future.

Management options

Due to concerns about physical disturbance of SAV and oyster habitat by the gear, concerns about turbidity and sedimentation, dwindling participation and landings, and significant cost to demarcate, maintain, and enforce the fishery, the NCDMF re-examined the fishery in terms of whether the habitat value may outweigh the value of the fishery.

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Due to the requirements of G.S. 113 221 (d), it is unlikely that mechanical clam harvest fishery could be ended immediately upon adoption of this amendment. An immediate closure of this fishery could “result in severe curtailment of the usefulness or value of equipment in which fishermen have any substantial investment” as outlined in statute. This would require “a future effective date so as to minimize undue potential economic loss to fishermen”. Possible management options include, but are not limited to; status quo, ending the allowance for mechanical clam harvest in conjunction with maintenance dredging activities, further limiting mechanical clam harvest areas, phasing out the fishery, and ending the fishery immediately. These management options would only affect mechanical clam harvest from public bottom and would not affect their use on private bottom.

Status quo would allow the fishery to continue to operate as it currently does. The fishermen currently operating in the fishery could continue, and new harvesters could join. The cost to the state for demarcation and enforcement would remain the same, making up a significant cost compared to the total value of the fishery. Concerns about effects of bottom disturbing gears on structured habitats would not be addressed.

Discontinuing the allowance for mechanical clam harvest in conjunction with maintenance dredging could also be considered. This would end a program that has not been utilized since 2007. This option could be pursued on its own, or in conjunction with a closure or phase out of the whole fishery. This would require a change to rule 15A NCAC 03K .0301 (b).

Mechanical clam harvest areas could be further limited to create boundaries that are more easily enforceable that also create buffers around critical habitat to protect them from sedimentation associated with bottom disturbing gears, as was done in the North River (Figure 1. 4). To improve enforceability the boundaries would be based on permanent structures or known geographic features, be rectangular or rhomboid in shape without zig-zagging lines and have complete line of sight visibility. The exact boundaries for these reduced areas would be developed after adoption of Amendment 3 based on habitat protection, enforceability, and fishermen input on specific locations the industry would like to maintain. This option would be implemented through proclamation after the new, smaller areas boundaries are developed. As with status quo, fishermen currently operating in the fishery could continue, and new harvesters could join. The cost to the state for demarcation would be reduced, but the resources required for enforcement would likely remain the same, making up a significant cost compared to the total value of the fishery. This would help address habitat concerns, but sedimentation would still occur from mechanical harvesting operations.

The mechanical clam harvest fishery could be phased out over a set timeframe, as was done with the shellfish relay program. This option would allow fishermen currently operating in the fishery to continue during the phase out period, but would discourage new participants. The phase out period would allow current mechanical harvesters time to get rid of gear and transition to other clam harvesting methods or fisheries. This option would address habitat concerns from the use of the gear as well as cost concerns associated with demarcation and enforcement. This option is consistent with G.S.

113-221 (d), as it gives “a future effective date so as to minimize undue potential economic loss to fishermen”.

After hearing concerns from the FMP Advisory Committee about participants wanting the ability to re-enter the fishery, the DMF developed an option for a phase out timeframe of three years from adoption of this amendment unless minimum participation and landings increases occur in the fishery in any year prior to 2027. This increase in participation and landings would show the fishery is no longer diminishing. Historical fisheries data were examined to develop potential thresholds for the minimum participation and landings that would signal renewed participation in the fishery. A reasonable threshold for participants in the mechanical clam harvest fishery on public bottom is ten participants. Ten participants have not been active in a single year in the fishery since 2017 and is over three times the number of active participants in 2022 (three participants), but still less than a tenth of the peak participation in 1996 (132 participants). A reasonable threshold for landings in the mechanical clam harvest fishery on public bottom is one-million clams. The fishery last landed at least one-million clams in 2014 (1.5 million clams) and one-million clams is over six times the number caught in 2022 (less than 200,000 clams), but still less than an eighth of the peak landings in 1995 (8.2 million clams). In this option, if both thresholds are met in any single year prior to January 2027, the issue would be brought back to the MFC for consideration at their May 2027 business meeting, or the next meeting that participation and harvest estimates are available from 2026, where they would decide whether to move forward with phase out of the fishery. This timing ensures that if following May 2027 the phase out continues as planned, fishermen would still have had three years to sell their gear and exit the fishery before the phase out is complete and the fishery closes in 2028, which would be consistent with G.S. 113-221 (d) (Figure 1. 6).



Figure 1.6. Proposed timeline for the phase out of the Mechanical Clam Harvest Fishery on public bottom if number of participants and landings triggers in this management option are met.

There is a potential that setting participation and landing thresholds that trigger reconsideration by the MFC for phasing out the fishery may have an unintended consequence. Fishermen may re-enter this fishery in the near term in an effort to maintain it as an option in the long term. Based on the habitat degradation effects of mechanical clam harvest, along with the aforementioned DMF resources needed for demarcation and enforcement of management areas, the DMF recommends the phasing out of this gear within three years without triggers for reconsideration of the phase out.

MANAGEMENT OPTIONS

Option 1: Mechanical Clam Harvest

- a. Status quo
- b. Further limit mechanical clam harvest areas to improve enforceability and protect habitat
 - Make mechanical areas rectangular with straight lines for enforcement like was done in North River.
 - Focus on specific areas the industry would like to maintain
 - There are only a small number of overlaps with current SAV mosaics. Most of which is on the western banks of Core Sound
 - Could look into overlap with oysters or other SHAs and critical habitat
- c. Phase out mechanical clam harvest in three years (May 2028) to be consistent with G.S. 113 221 (d) unless two metrics are met that signify increased participation in the fishery
 - Phase out needed to comply with G.S. 113-221 (d)
 - Would allow fishermen to plan ahead and sell gear, transition to other fisheries
- d. Phase out mechanical clam harvest in three years (May 2028) to be consistent with G.S. 113 221 (d) without participation and landing triggers

Option 2: Mechanical Clam Harvest in Conjunction with Maintenance Dredging

- a. Status quo
- b. Discontinue allowance for mechanical clam harvest in conjunction with maintenance dredging upon adoption of this plan

RECOMMENDATIONS

The NCDMF recommends Option 1.d, a phase out of the mechanical clam harvest fishery to be completed three years from the adoption of this plan. The DMF also recommends Option 2.b, the immediate end to the allowance for mechanical clam harvest in conjunction with maintenance dredging.

Advisory Committee Recommendations and Public Comment: see [Appendix 5](#)

NCMFC Selected Management Options

Option 1: Mechanical Clam Harvest

- d. Phase out mechanical clam harvest in three years (May 2028) to be consistent with G.S. 113 221 (d).

Option 2: Mechanical Clam Harvest in Conjunction with Maintenance Dredging

- b. Discontinue allowance for mechanical clam harvest in conjunction with maintenance dredging upon adoption of this plan

Appendix 2: Recreational Shellfish Harvest Issue Paper

ISSUE

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

ORIGINATION

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

BACKGROUND

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

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

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

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

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

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

Some recreational fishers may purchase a commercial shellfish license rather than a CRFL because the license is easy to obtain (available to any NC resident), is relatively inexpensive (\$50.00), and allows fishers to harvest more shellfish than allowed under

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

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

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

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

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

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- Polluted Area Proclamations and Temporary Closure Maps – In addition to the permanently closed areas described above, studies have found that water quality in certain areas can be negatively impacted by stormwater runoff, and shellfish can become temporarily unsafe for harvest under certain conditions. SSRWQ has developed management plans describing rainfall thresholds that can generate negative impacts and require temporary closures of these impacted areas. Temporary closures are put in place via proclamation and shown visually on the NCDMF website through a [web map](#) updated as closed areas change.
- Articles and Fact Sheets on Safe Handling Practices – Temperature abuse or improper handling practices can render shellfish unsafe to eat. To provide the public with information on how to safely store and handle shellfish, SSRWQ has prepared articles, fact sheets, and pamphlets available through the NCDMF [website](#).
- Information on *Vibrio* Bacteria – *Vibrio* bacteria are naturally occurring bacteria that can be found in North Carolina waters and can cause severe illness in certain susceptible populations if consumed or through exposure to open wounds. Notably, these bacteria can proliferate within harvested shellfish even after they've been removed from the water, if the shellfish are held in warm/hot temperatures for extended periods of time. Proper handling/cooling of harvested shellfish is a critical step towards avoiding illness. SSRWQ has made available pamphlets and articles describing risks associated with these types of bacteria, and best practices for shellfish handling.

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

AUTHORITY

N.C. General Statute

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

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

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

DISCUSSION

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

Table 2.1. Recreational shellfish harvest license requirements for east coast states.

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

License requirements for recreational shellfish harvesting varies by state along the United States east coast (Given North Carolina's shellfish fisheries are exclusively under state jurisdiction, lack of recreational shellfish harvest data makes conducting stock assessments and addressing potential management issues such as harvest limits, size

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

Table 2.1). Most states require some type of license while in Maine, Massachusetts, New York, and Connecticut individual towns and cities require a license to recreationally harvest shellfish. North Carolina and Virginia are the only states without some form of license, local permitting, or residency requirements.

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

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

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

Although creating a specific type of CRFL, adding shellfish under the existing CRFL, or developing a recreational shellfish permit would be the most efficient mechanisms to determine effort in the fishery, another way to obtain these data would be to capture this activity in MRIP. The MRIP does capture some non-fish activity, but those data are broad and not available to shellfish at the species level and MRIP agents rarely encounter those types of recreational fishing trips. Most recreational shellfishing effort is by coastal

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residents using private docks and access points as opposed to public access points. Because MRIP is a nationwide program, any changes to methodology designed to intercept more recreational shellfishing activity would need to undergo extensive review process and if implemented could take away from intercepts in other target fisheries.

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

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

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

MANAGEMENT OPTIONS

Option 1: Recreational Harvest

- a. Status Quo
 - Does not provide reliable estimates of recreational shellfish harvest or effort.
 - Does not provide a mechanism to ensure recreational shellfish harvesters are provided with SSRWQ health and safety information and links to harvest area closures.
- b. Support the NCDMF to further explore potential options and develop a solution to estimate recreational shellfish participation and landings, with the intent to move towards a stock assessment and stock level management for both hard clams and oysters; and to establish a mechanism to provide all recreational shellfish harvesters with SSRWQ health and safety information outside of the FMP process.

RECOMMENDATIONS

The DMF recommends that the NCMFC support the NCDMF to further explore potential options and develop a solution to quantify recreational shellfish participation and landings, with the intent to move towards a stock assessment and stock level management for both hard clams and oysters; and to establish a mechanism to provide all recreational shellfish harvesters with SSRWQ health and safety information outside of the FMP process.

Advisory Committee Recommendations and Public Comment: see [Appendix 5](#)

NCMFC Selected Management Options

Option 1: Recreational Harvest

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

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Appendix 3: Hard Clam Management in Other States

Hard Clam management in other states. Bushels abbreviated as 'bu.'

State	Fishery	License Requirements	Trip Limit	Size Limit	Gear Limit	Open Season Area
Maine	Recreational	No state license. License by town.	1 peck per person/day (peck is 1/4 of a bushel)	1 inch hinge width	Limited to hand rakes and tongs	-
	Commercial	State license	-	-	-	-
New Hampshire	Recreational	State license	No open season for <i>Mercenaria mercenaria</i> . Regs for other clam species	No limit	-	No open season
	Commercial	-	-	-	-	-
Massachusetts	Recreational	No state license, towns have local restrictions & permits	Consult town regs	1 inch shell thickness	-	-
	Commercial	Town permit and shellfish ID card issued by Mass DMF	40 Bu/Day	1 inch thickness (wild)	-	-
Rhode Island	Recreational	Required only for non-residents	(Shellfish management areas) Resident limit: 1 peck/person. Non resident: 1/2 peck/person. (Non-management areas) Resident: 1/2 BU/person. Non resident: 1 peck/person	1 inch hinge width	-	-
	Commercial	-	Bay Quahog: Shellfish management areas: 3 BU/person/day with exceptions. Non management areas: 12 BU/person/day	-	Bay Quahog: No person shall dig and/or take any bay quahogs from the waters of this State by dredge(s), rakes, or other apparatus operated by mechanical power or hauled by power boats, unless otherwise provided for in these regulations.	-

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Connecticut	Recreational	No State, towns have local restrictions and permits	1/4 - 1/2 BU variable by town	1.5–2 inches variable by town	-	-
	Commercial	State license	-	-		
New York	Recreational	No State, towns have local restrictions on permits, and residency requirements	100 clams/day	1 inch thickness	Only rakes and tongs allowed	Open areas - year round
	Commercial	Shellfish digger permit required	No limit	-	No mechanical	-
New Jersey	Recreational	State license	150 clams	1.5 inches length	Hand implements only	No harvest on Sundays
	Commercial	State license + training course	-	1- 1.5 inches length	No mechanical or motive power	-
Delaware	Recreational	State license. For >100 but <500 clams need a non-commercial clamming permit.	Residents: 100 clams/day. Non Residents: 50 clams/day	1.5 inches or larger	Hand held rake only	Clamming prohibited 30 min before sunrise and after sunset.
	Commercial	Commercial clam tong/rake license	2,500 clams/day	-	-	-
		Commercial dredge clam license	no limit			
Maryland	Recreational	None, must be state resident.	250 clams/day	1 inch transverse measurement	Hand operated gear only. No mechanical harvesting.	-
	Commercial	State license	No limit	1 inch transverse measurement	Hydraulic Dredge: sunrise to 4pm. Other gear: sunrise to sunset	Harvest only in Pocomoke and Tangier Sound. 1/1 - 5/31 & 9/15 - 12/31
Virginia	Recreational	None	250 clams/day by hand or tongs from open areas	-	Hand or ordinary tongs	-
	Commercial	State license	-		-	
North Carolina	Recreational	None	100 clams/person/day	1 inch thick	Hand or rake	Year round
	Commercial	State license	Hand harvest 6,250 clams/ trip. Mechanical harvest limits vary by open water body	1 inch thick	Hand or mechanical implements	Hand harvest open year-round. Mechanical harvest is second Monday in Dec – March 31

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South Carolina	Recreational	State license	1/2 BU clams/person/day	1 inch thick	Hand operated gear	No harvest from 5/15 - 9/1
	Commercial	State license	No limit	-	-	-
Georgia	Recreational	State license and free permit	1 BU clams/person/day	3/4-inch depth (perpendicular to hinge)	Hand or handheld implements	Clamming prohibited 30 min before sunrise and after sunset. Approved locations
	Commercial	State license	No limit			
Florida	Recreational	State license	One 5-gallon bucket/person/day	1 inch thick across the hinge	-	Year round
	Commercial	Aquaculture license	-	-		-

Appendix 4: Hard Clam Fishery Management Plan Advisory Committee Workshop Summary

ISSUE

Summarize stakeholder input received during the Oyster & Clam Fishery Management Plans Advisory Committee Workshop.

ORIGINATION

The North Carolina Division of Marine Fisheries (DMF).

BACKGROUND

The Oyster-Clam Fishery Management Plans (FMPs) Advisory Committee (AC) met for a three-day workshop July 15, 16, and 27 at Craven Community College in New Bern. As these two fisheries share considerable overlap in their ecology and management, these FMPs are revised simultaneously though written separately. The purpose of the workshop was for the AC to assist DMF staff in evaluating management issues and options included in the draft documents of Amendment 5 for the Eastern Oyster FMP and Amendment 3 for the Hard Clam FMP. Specifically, DMF sought to solicit feedback and input on the impacts of management options on the oyster and clam resources and user groups. It is important to note the aim of the AC workshop was to receive input from committee members based on their experiences, expertise, and sector relationships, not to build a consensus among AC members or to recommend specific management strategies.

For the Hard Clam FMP, DMF staff presented overviews of the base plan (life history, stock status, description of the fisheries, habitat impacts, and environmental threats), mechanical clam harvest issue paper, and the recreational shellfish harvest issue paper. Each presentation was followed by an opportunity for the AC to ask clarifying questions and discuss the content and management options included in each paper or section of the draft. Below is a summary of the input and subsequent discussions for the base plan and issue papers of Amendment 3. These ideas represent options the AC suggested the NCDMF explore. NCDMF staff explored these options and discussed where they could be incorporated into the base plan and issue papers.

DISCUSSION

Base Plan

Members of the AC suggested adding more demographic information in the mechanical and hand harvest fishery. The AC also suggested more graphs comparing private harvest and commercial harvest. They noted clam aquaculture has been slow to grow due to limited seed supply in NC.

Similar to oyster, the AC emphasized the importance of water quality and its importance to SAV. Since water quality issues are explored extensively in the Coastal Habitat Protection Plan and enforced by the Division of Water Resources, the AC suggested strengthening ties to the CHPP in the base plans.

Mechanical Clam Harvest

The NCDMF brought forward several options to AC members to address the mechanical clam harvest issue. Options included phase out of the fishery and further reducing the mechanical clam harvest areas to make enforcement easier. The NCDMF also presented an option to end the allowance for mechanical clam harvest in conjunction with maintenance dredging operations.

Members of the AC expressed concerns with discontinuing the mechanical clam harvest fishery. They noted this fishery is an important source of supplemental income for a small group of mostly retired people. Members also stated the fishery has an important historical significance to the state and to their heritage and should, therefore, be preserved. They also stated many of the participants in this fishery are aging out and hope to pass the tradition and equipment on to their children to continue the practice.

Members of the AC expressed support for changing the boundaries of the mechanical clam harvest areas to be more easily enforced. They were open to areas being reduced in size if input from fishermen was considered when defining the new boundaries.

AC members did not believe the mechanical clam harvest fishery was a major source of turbidity, SAV degradation, or any other water quality concerns. They felt protecting these habitats should not come at the cost of the clam fishery. There was broad support for further protections and research on SAV, but the focus should be on large-scale threats, such as prop scarring from recreational vessels.

Recreational Shellfish Harvest

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

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Appendix 5: Summary Of Management Recommendations and Comment

Table 5.1. Summary of management recommendations from Division of Marine Fisheries (DMF), the Northern, Southern, Shellfish Crustacean, and Habitat & Water Quality Advisory Committees (AC).

	DMF	Northern AC	Southern AC	Shellfish & Crustacean AC	Habitat & Water Quality AC
Appendix 1: Clam Mechanical Harvest					
<i>MCH</i>	<p><u>Initial Recommendation: Option 1.c.</u> The Division recommends a phase out to be completed three years from the adoption of this plan unless fishery participation increases to 10 participants and landings increase to 1 million clams in any year prior to 2027. If these increases are met, the issue would be reconsidered by the MFC at their May 2027 business meeting, or the next meeting that participation and harvest estimates are available from 2026.</p> <p><u>Final Recommendation: Option 1.d.</u> The Division recommends a phase out to be completed three years from the adoption of this plan, without participation and landings triggers.</p>	<u>Option 1.a.</u> Mechanical clam harvest to stay at status quo.	<u>Option 1.a.</u> Maintain status quo in the mechanical clam fishery.	<u>Option 1.c.</u> Recommend the Division's <u>initial</u> recommendation regarding phasing out the mechanical clam harvest as described in the mechanical clam harvest issue paper	<u>Option 1.c.</u> Endorse the Division's <u>initial</u> recommendation in the Mechanical Clam Harvest Issue Paper
<i>MCH with Maintenance Dredging</i>	<u>Option 2.b.</u> The Division recommends the immediate end to the allowance for mechanical clam harvest in conjunction with maintenance dredging.	<u>Option 2.a.</u> Mechanical clam harvest to stay at status quo.	<u>Option 2.a.</u> Maintain status quo in the mechanical clam fishery.	<u>Option 2.b.</u> Recommend to discontinue the allowance of mechanical clam harvest in conjunction with maintenance dredging	<u>Option 2.b.</u> Endorse the Division's recommendation in the Mechanical Clam Harvest Issue Paper

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Appendix 2: Recreational Shellfish Harvest

Option 1.b. Support the NCDMF to further explore potential options and develop a solution to quantify recreational shellfish participation and landings, and to establish a mechanism to provide all recreational shellfish harvesters with SSRWQ health and safety information outside of the FMP process.

Option 1.b. Endorse the MFC tasking the DMF with exploring options for a recreational shellfish license/permit outside of the FMP process.

Option 1.b. Recommend that the MFC task the DMF to further explore potential options and develop a solution to quantify recreational shellfish participation and landings, as all of Option 1. b. is written.

Option 1.b. Recommend that the MFC task the DMF to further explore potential options and develop a solution to quantify recreational shellfish participation and landings, as all of Option 1. b. is written.

Option 1.b. Recommend that the MFC task the DMF to further explore potential options and develop a solution to quantify recreational shellfish participation and landings, as all of Option 1. b. is written.

In addition: the AC supports the expansion of monitoring efforts and the establishment of sentinel sites as a critical step in validating the success of FMPs, and to prioritize the proper funding and partnerships with research institutions.

Online Clam and Oyster Public Questionnaire

The online Spotted Seatrout Public Questionnaire opened on December 11, 2024, and closed January 15, 2025. In total, the questionnaire had 8 participants, 3 comments for both clam and oyster, 2 comments for clam, and 3 comments for oyster.

Of the open response comments received, the 2 comments specifically for clam were advocating for status quo of the mechanical clam fishery. Comments received for both clam and oyster were advocating to promote the stocking of shellfish to help rebuild natural populations, promoting sustainable methods like aquaculture, and protecting habitat from bottom disturbing gear.

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NC Marine Fisheries Commission

Southern Flounder Fishery Management Plan

May 2025 Quarterly Business Meeting

Documents

Southern Flounder Amendment 4 Memo

Draft Southern Flounder FMP Amendment 4

Southern Flounder Amendment 5 Memo



JOSH STEIN
Governor

D. REID WILSON
Secretary

KATHY B. RAWLS
Director

May 7, 2025

MEMORANDUM

TO: North Carolina Marine Fisheries Commission

FROM: Jeffrey Dobbs, Fishery Management Plan Coordinator
Anne Markwith, Southern Flounder Co-Lead
Holly White, Southern Flounder Co-Lead

SUBJECT: Southern Flounder Fishery Management Plan Amendment 4

Issue

Consider input received during the public comment period and Advisory Committee (AC) review of Southern Flounder Fishery Management Plan (FMP) Amendment 4 and vote on preferred management options.

Supporting Documents

- [Draft Amendment 4 to the Southern Flounder FMP](#)
- [Northern, Southern, and Finfish Advisory Committee meeting minutes](#)
- [Public comments submitted online for Amendment 4 to the Southern Flounder FMP](#)

Action

Vote on preferred management options for Southern Flounder FMP Amendment 4.

Background

At their August 2024 business meeting the North Carolina Marine Fisheries Commission (MFC) passed a motion “*to ask the DMF Director to ask the DEQ Secretary to modify the Annual FMP Review Schedule to amend the Southern Flounder FMP for the review of the plan to begin in 2024. The intent is to allow for more recreational access while maintaining the rebuilding requirements of Amendment 3*”. The Secretary subsequently approved this schedule change along with a request from the DMF to begin concurrent development of Amendment 5 to explore long-term solutions to the issue of recreational access while maintaining Amendment 3 rebuilding requirements. The primary purpose of Amendment 4 is to immediately address the August 2024 MFC motion by implementing the 50/50 sector allocation in 2025, instead of in 2026 as prescribed in Amendment 3 (Table 1). Expediting the shift to 50/50 reduces the possibility of recreational catch overages that may mitigate the need for future season closures, as the allocation shift will provide an additional buffer for catch. The shift in allocation will not increase the length of the recreational season.

Table 1. Amendment 3 annual allocations, in pounds, for the Southern Flounder commercial and recreational fisheries and associated sub-allocations for each sector that maintains a 72% overall reduction and the current pound net sub-allocation. An asterisk (*) indicates catch from Recreational Commercial Gear License holders is not included in the Total Allowable Landings.

Year	Allocation	Total Allowable Catch	Dead Discards	Total Allowable Landings	Commercial Fisheries			Recreational Fisheries*		
					Total Allowable Landings	Mobile Gears	Pound Nets	Total Allowable Landings	Hook and Line	Gigs
2021	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2022	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2023	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2024	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2025	60/40	548,034	15,682	532,352	319,411	132,953	186,458	212,941	189,608	23,333
2026	50/50	548,034	15,682	532,352	266,176	79,718	186,458	266,176	237,010	29,166

Following an accelerated timeline allows for adoption of Amendment 4 to the Southern Flounder FMP by the MFC in August 2025 at the earliest (Table 2). If any step in this timeline is not completed as shown, it will result in an implementation date after the allowed window for a recreational season (August 16–September 30) negating any possible gain in recreational access this amendment could provide.

Table 2. Timeline for development and adoption of Amendment 4 to the Southern Flounder FMP.

Milestones	Completion Date
DMF drafts FMP Amendment 4	October 31–December 20, 2024
AC review of draft FMP Amendment 4 (Finfish AC)	January 27, 2025
MFC votes to send draft FMP for AC review and public comment	March 21–23, 2025
Public and MFC AC review (Northern, Southern, Finfish)	April 1–30, 2025
MFC selects preferred management option	May 21–23, 2025
Legislative review of draft FMP	June–July, 2025
MFC votes on final adoption of FMP Amendment 4	August 20–22, 2025
Division implements management strategies	August 2025

Development and adoption of Amendment 4, as proposed, is a short-term solution to address recreational access. Amendment 5 will explore long-term solutions to the issue of recreational access while maintaining Amendment 3 rebuilding requirements.

Management Options

Status Quo: Maintain Amendment 3 allocation transition schedule.

Expedite Allocation Shift: Expedite the sector (commercial/recreational) allocation transition to 50/50 in 2025 rather than in 2026 as prescribed in Amendment 3.

Advisory Committee Recommendations and Public Comment

The Northern, Southern, and Finfish ACs met in April 2025 to review and provide recommendations for Amendment 4. The Northern and Finfish ACs passed motions to remain at Status Quo, which maintains the Amendment 3 allocation transition schedule. The Southern AC made separate motions to maintain status quo and to expedite the allocation shift; both failed due to ties. Additionally, the Northern AC passed a motion to “*recommend that the Marine Fisheries Commission ask the DEQ Secretary to allow Amendment 5 to the Southern Flounder Fishery Management Plan to change the 72% reduction that was adopted in Amendment 3 to a 52% reduction and split the total allocation equally between the commercial and recreational sectors*”.

The online public comment form was open April 1–30, 2025. The Division received 30 responses during this period. Most commentors expressed broad support for the expedited shift to 50/50 allocation in 2025. Some expressed concern about commercial gears’ effect on the Southern Flounder population.

Next Steps

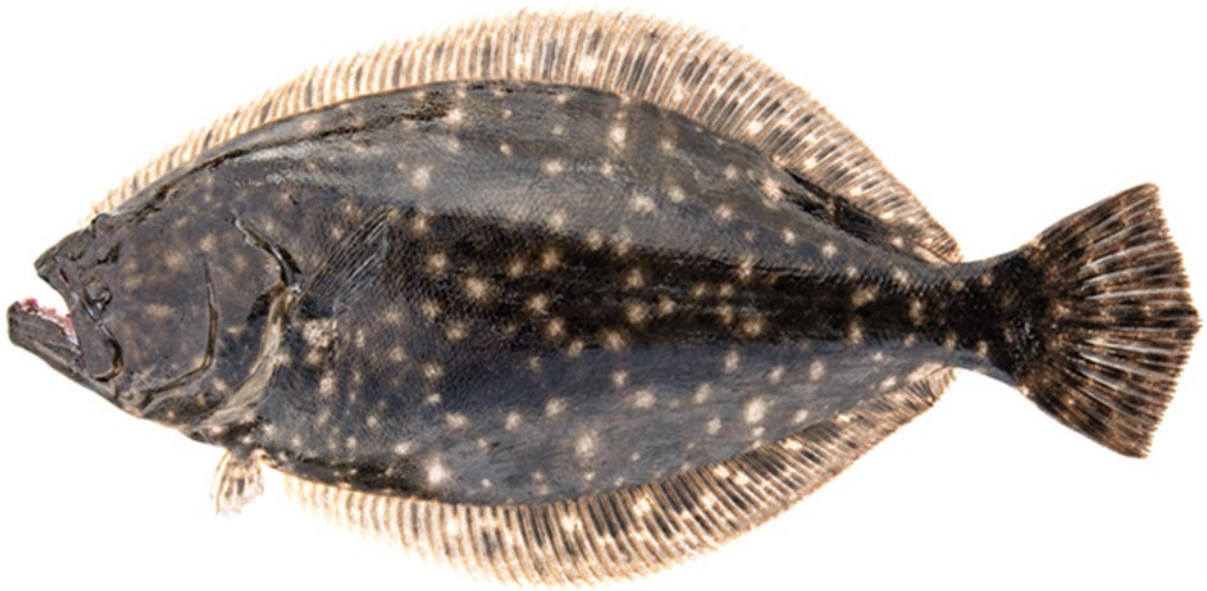
Following MFC selection of preferred Amendment 4 management, draft Amendment 4 will be sent for DEQ Secretary and legislative committee review. The MFC will vote on final adoption of Amendment 4 at their August 2025 business meeting. Concurrently, the Division will continue developing the first draft of Amendment 5.

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

Amendment 4

By

North Carolina Division of Marine Fisheries



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

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Amendment 4 to the North Carolina (NC) Fishery Management Plan (FMP) was developed by the NC Department of Environmental Quality (NCDEQ), Division of Marine Fisheries (NCDMF) under the auspices of the NC Marine Fisheries Commission (NCMFC) with the advice of the Finfish Advisory Committee acting as the Southern Flounder Advisory Committee (AC). Deserving special recognition are the members of the Finfish AC and the NCDMF Plan Development Team (PDT) who contributed their time and knowledge to this effort.

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EXECUTIVE SUMMARY

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

DRAFT

INTRODUCTION

This is Amendment 4 to the Southern Flounder Fishery Management Plan (FMP). By law, each FMP must be reviewed at least once every five years (G.S. 113-182.1). The NC Division of Marine Fisheries (DMF) reviews each FMP annually and a comprehensive review is undertaken about every five years. The last comprehensive review of the plan (Amendment 3; NCDMF 2022) was approved by the NC Marine Fisheries Commission (NCMFC) in 2022. FMPs are the ultimate product that brings all information and management considerations into one document. The DMF prepares FMPs for all commercially and recreationally significant species or fisheries that comprise state marine or estuarine resources adopted by the NC Marine Fisheries Commission (NCMFC). The goal of these plans is to ensure long-term viability of these fisheries. All management authority for the North Carolina Southern Flounder fishery is vested in the State of North Carolina. The NCMFC adopts rules and policies and implements management measures for the Southern Flounder fishery in Coastal Fishing Waters in accordance with 113-182.1. Until Amendment 4 is approved for management, Southern Flounder are managed under Amendment 3 (NCDMF 2022).

Fishery Management Plan History

Original FMP Adoption:	February 2005	
Amendments:	Amendment 1 February 2013	
	Amendment 2 August 2019	
	Amendment 3 May 2022	
Revisions:	None	
Supplements:	Supplement A to the FMP	February 2011
	Supplement A to Amendment 1	August 2017
Information Updates:	None	
Schedule Changes:	Scheduled review was moved up from 2027 to begin concurrent development of Amendments 4 and 5 in 2024	
Comprehensive Review:	Five years after adoption of Amendment 5	

Past versions of the Southern Flounder FMP (NCDMF 2005, 2011, 2013, 2017, 2019, 2022) are available on the [DMF website](#).

Management Unit

The management unit of this FMP includes all Southern Flounder inhabiting North Carolina coastal and joint fishing waters including the Atlantic Ocean.

Goal and Objectives

The goal of Amendment 4 is to manage the Southern Flounder fishery to achieve a self-sustaining population that provides sustainable harvest using science-based decision-making processes. The following objectives will be used to achieve this goal:

- Implement management strategies within North Carolina and encourage interjurisdictional management strategies that maintain/restore the Southern Flounder spawning stock with expansion of age structure of the stock and adequate abundance to prevent overfishing.
- Restore, enhance, and protect habitat and environmental quality necessary to maintain or increase growth, survival, and reproduction of the Southern Flounder population.

- Use biological, environmental, habitat, fishery, social, and economic data needed to effectively monitor and manage the Southern Flounder fishery and its ecosystem impacts.
- Promote stewardship of the resource through increased public outreach and interjurisdictional cooperation throughout the species range regarding the status and management of the Southern Flounder fishery, including practices that minimize bycatch and discard mortality.
- Promote the restoration, enhancement, and protection of habitat and environmental quality in a manner consistent with the Coastal Habitat Protection Plan.

DESCRIPTION OF THE STOCK

Biological Profile

Southern Flounder (*Paralichthys lethostigma*) is a bottom dwelling species of left eyed flounder found in the Atlantic Ocean, Gulf of Mexico, and estuaries from Virginia to northern Mexico (Blandon et al. 2001). This species is one of three commonly caught left eyed flounder in North Carolina; Southern Flounder, Gulf Flounder (*P. albigutta*), and Summer Flounder (*P. dentatus*). Southern Flounder supports important commercial and recreational fisheries along the U.S. South Atlantic and Gulf coasts and is particularly important to fisheries in North Carolina. Based on tagging, genetic, and age structure morphology data, the biological unit stock for Southern Flounder includes fish from North Carolina to the east coast of Florida. Evidence also suggests some adult Southern Flounder return to the estuaries after spawning in the ocean, while others remain in the ocean (Watterson and Alexander 2004; Taylor et al. 2008; NCDMF 2024a). Tagged fish are typically recaptured south of original tagging locations and often in other states once in the ocean (Craig et al. 2015; Loeffler et al. 2019). Limited data from South Carolina and Georgia tagging programs suggest a low probability of adult movement from South Carolina or Georgia to North Carolina waters (Wenner et al. 1990; SCDNR Inshore Fisheries Section, unpublished data; Flowers et al. 2019).

DMF data indicates with the onset of maturity in the fall, females migrate to ocean waters to spawn. Spawning locations in the Atlantic Ocean are unknown; however, Benson (1982) observed the pelagic larval stage over the continental shelf where spawning is reported to occur. Data from satellite tagged Southern Flounder indicate a potential suite of migratory behaviors and habitat uses ranging from inshore estuarine environments to offshore outer continental shelf habitats (NCDMF 2024a). Southern Flounder can produce approximately 3 million eggs per female during multiple spawning events in a season, and spawning is thought to take place between November and April (Gunther 1945; Hettler and Barker 1993; Watanabe et al. 2001; Midway and Scharf 2012; Hollensead 2018). Larval Southern Flounder pass through inlets within 30 to 45 days of hatching and settle throughout the sounds and rivers in the winter and early spring (Burke et al. 1991; Miller et al. 1991; Daniels 2000; Glass et al. 2008; Taylor et al. 2010; Lowe et al. 2011). Juveniles likely spend at least one year in inshore waters before migrating to the ocean (McKenna and Camp 1992; Hannah and Hannah 2000; Watterson and Alexander 2004; Taylor et al. 2008).

Nearly half of female Southern Flounder are mature by ages 1 and 2 (at approximately 16 inches TL; Monaghan, Jr. and Armstrong 2000; Midway and Scharf 2012). Females grow larger than males and Southern Flounder collected in the ocean tend to be larger and older than fish caught in estuarine waters. The largest female Southern Flounder observed in North Carolina was 33-inches TL and the largest male was 20-inches TL (Lee et al. 2018; Flowers et al. 2019; Schlick et al. 2024). The maximum observed age was 9 years for females and 6 years for males. Southern Flounder captured in North Carolina represent the oldest ages observed throughout the range (Lee et al. 2018; Flowers et al. 2019; Schlick et al. 2024).

For additional information about Southern Flounder life history and biology see [NCDMF \(2019\)](#) and [NCDMF \(2022\)](#).

Assessment Methodology

For additional assessment history see [Lee et al. \(2018\)](#) and [Flowers et al. \(2019\)](#).

Commercial and recreational landings and dead discards and data from eight fishery-independent surveys, were incorporated from all states across the biological unit stock (North Carolina south to the east coast of Florida). When considering population size and long-term viability, stock assessments most often use a measure of female spawning stock biomass (SSB) to determine the population's health. Female spawning stock biomass includes mature female fish capable of producing offspring. Fishing mortality (F) is a measure of how fast fish are removed from the population by fishing activities. Removals include fish that are kept, discarded dead, or die after release.

The stock assessment estimates of female SSB and F were compared to levels, or reference points, that are considered sustainable. Reference points include a target and threshold. The threshold is the minimum level required for sustainability and when that level is achieved, the stock is considered healthy. The target is a level that minimizes risk and increases the probability of rebuilding or maintaining stock. If female SSB is less than the biomass threshold ($SSB_{25\%}$), the stock is overfished. If the harvest rate is greater than the F threshold ($F_{25\%}$), the rate of removals is too high, and overfishing is occurring. Overfishing is the removal of fish at an unsustainable rate that will ultimately reduce female SSB and result in an overfished stock.

Stock Status

The South Atlantic Southern Flounder stock is overfished, and overfishing is occurring as of 2017, the terminal year of the 2019 coastwide stock assessment update (Flowers et al. 2019). Results indicate SSB has decreased since 2006 and recruitment, while variable, has generally declined. Fishing mortality is less variable and decreased slightly in 2017.

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

The female SSB that represents the minimum level of sustainability for Southern Flounder was estimated at 8.6 million pounds. The stock assessment estimate of female SSB in 2017 was 2.3 million pounds (Figure 1). Because the 2017 estimate of female SSB is below the threshold reference point, the stock is considered overfished. The probability the 2017 estimate of SSB is below the threshold is 100%.

The assessment model estimated the F threshold at 0.53 (Figure 2). The 2017 F estimate was 0.91, which is above the F threshold. Because the 2017 F estimate is above the threshold, overfishing is occurring. The probability the 2017 F estimate is above the threshold is 96%. For additional information about the 2019 coastwide stock assessment see [NCDMF \(2019\)](#).

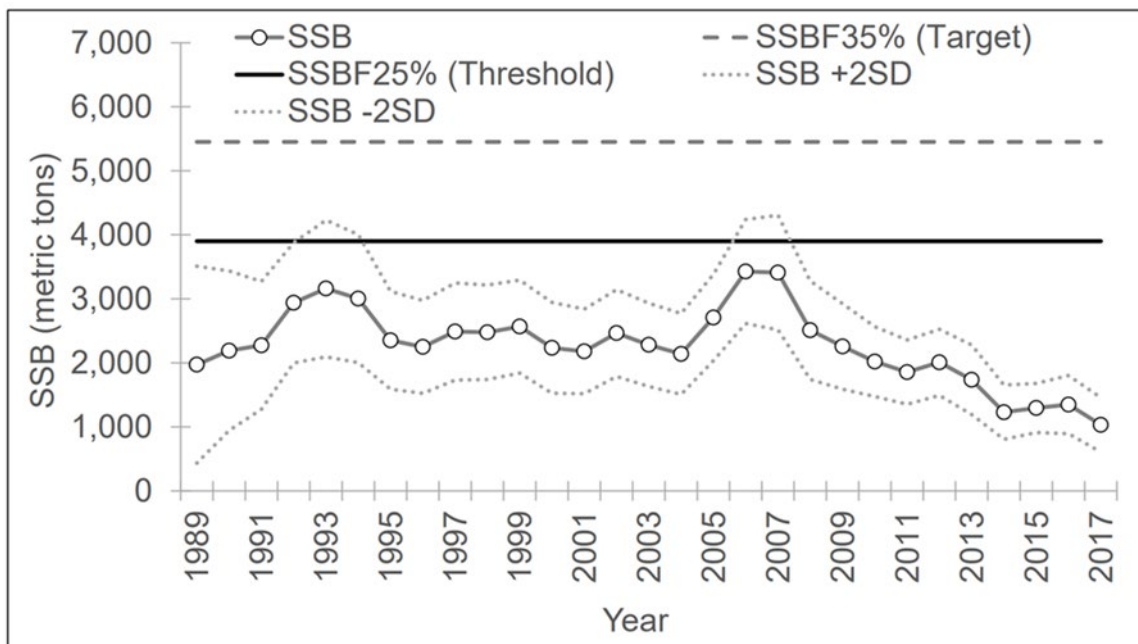


Figure 1. Estimated spawning stock biomass compared to established reference points, 1989–2017 (Flowers et al. 2019).

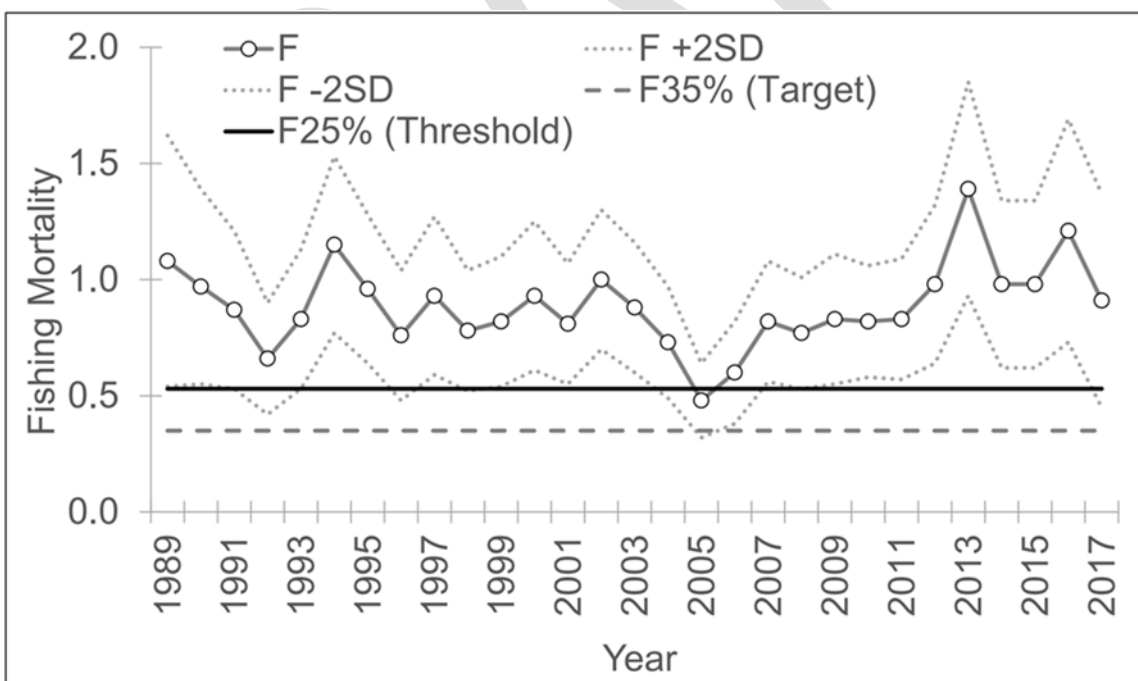


Figure 2. Estimated fishing mortality rates (numbers-weighted, ages 2-4) compared to established reference points, 1989–2017 (Flowers et al. 2019).

A second update to the ASAP model, with data through 2022, was completed in 2024. The update continued to show declining trends in SSB and recruitment since 2006; however, F decreased significantly in the last two years of the assessment ([Schlick et al. 2024](#)). Several trends and

diagnostics from the model raised concerns, and division staff and partners from the other states decided to not use the new update for management. A new benchmark assessment is recommended no sooner than 2026.

DESCRIPTION OF THE FISHERY

Additional in-depth analyses and discussion of North Carolina's historical commercial and recreational Southern Flounder fisheries can be found in previous versions of the Southern Flounder FMP ([NCDMF 2005](#), [NCDMF 2019](#), [NCDMF 2022](#)). Commercial and recreational landings can be found in the [License and Statistics Annual Report](#) (NCDMF 2024b).

Discussion of socio-economic information in the License and Statistics Annual Report describes the fishery as of 2023 and is not intended to be used to predict potential impacts from management changes. This and other information are legislatively mandated and included to help inform decision-making regarding the long-term viability of the state's commercial and recreationally significant species and fisheries. For a detailed explanation of methodology used to estimate economic impacts, refer to the [License and Statistics Section Annual Report](#) (NCDMF 2023).

For additional discussion of commercial and recreational Southern Flounder fishery landings trends see Appendix 1: Increasing Recreational Access to Southern Flounder Through Sector Allocation Parity.

Commercial Fishery

All flounder landings reported as caught in inshore waters are considered Southern Flounder by the DMF Trip Ticket Program. Data from fishery-dependent sampling indicate Summer Flounder and Gulf Flounder account for approximately two percent or less of the flounder harvested from internal waters, while Southern Flounder make up less than one percent of the catch from ocean waters (NCDMF, unpublished data).

Most Southern Flounder commercial landings are from gill nets and pound nets, although gigs and other inshore gears (e.g., trawls) land flounder in smaller numbers. Between 1972 and 2022, peak commercial landings occurred in 1994 (Figure 3). Over this timeframe, there have been fluctuations in whether pound nets or gill nets were the dominant gear in terms of pounds landed (Figure 3). Historically, pound nets were the dominant gear, but gill nets became the dominant gear from 1994 to 2013 (Figure 3). The dominant gear switched back to pound nets from 2014 through 2020. Declining landings trends since 2010 were due, in part, to gill net regulations implemented to reduce the number of sea turtle and Atlantic Sturgeon interactions in this gear (78 FR 57132¹, 79 FR 43716²). Though less harvest overall comes from the gig fishery, harvest from this gear has generally increased over time, especially since 2010. Harvest by other commercial inshore gears decreased to its lowest point in 2023.

¹ <https://www.federalregister.gov/documents/2013/09/17/2013-22592/endangered-species-file-no-16230>

² <https://www.federalregister.gov/documents/2014/07/28/2014-17645/endangered-species-file-no-18102>

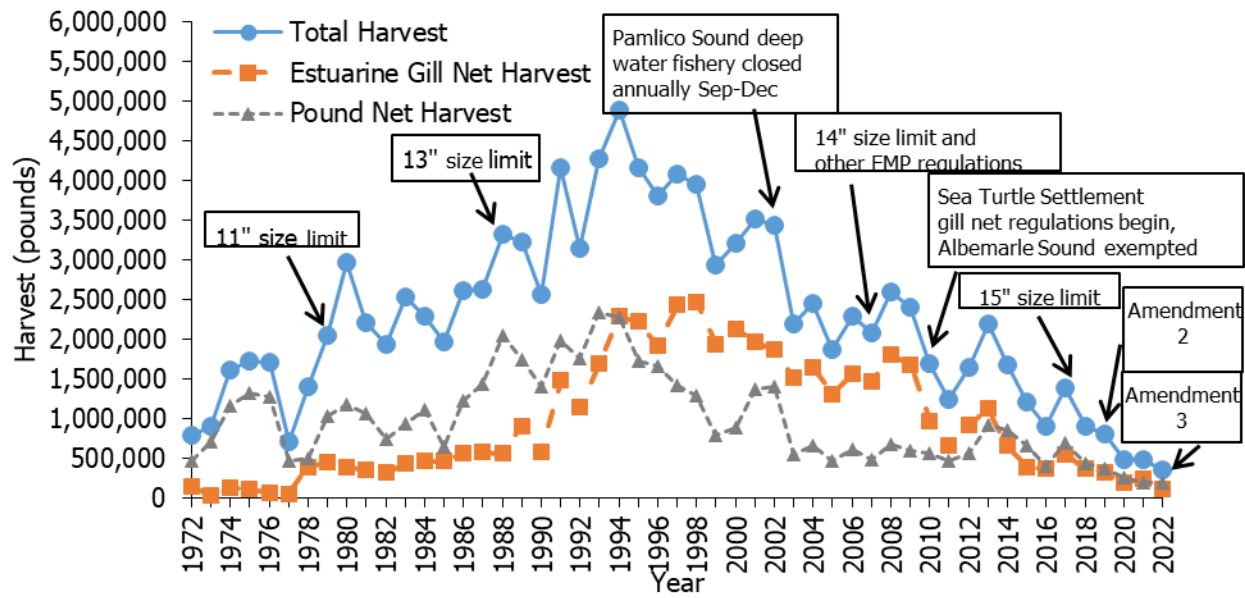


Figure 3. Southern Flounder landings (pounds) for total commercial fishery and top two gears (gill nets and pound nets) from the NC Trip Ticket Program 1972-2023 with major fishery regulation changes noted. Noted regulation changes do not represent a comprehensive list. For additional regulation changes see [Lee et al. \(2018\)](#).

Commercial harvest from 2019 to 2023 was impacted by regulations implemented through Amendments 2 and 3 to the NC Southern Flounder FMP. Amendment 2 implemented seasons in the commercial Southern Flounder fishery for the first time, and Amendment 3 introduced quota management of the fishery. Under Amendment 2, the commercial fishing season was open for a maximum of 33 days in 2020 ([Proclamation FF-25-2020](#)) and 21 days in 2021 ([Proclamation FF-40-2021](#)) depending on management area. Under Amendment 3 the commercial fishery was separated into two mobile gear management areas (northern and southern) and three-pound net management areas. During 2022–2024, the commercial fishery was open between six and 28 days, depending on management area and gear type. For mobile gears, however, gill nets were not necessarily open all of those days.

Table 1. Number of days the Southern Flounder commercial fishery was open in 2022–2024 by gear type and management area: mobile gear, northern and southern management areas; pound nets, northern, central, and southern management areas.

Year	Mobile Gear		Pound Nets		
	Northern Days open	Southern Days open	Northern Days open	Central Days open	Southern Days open
2022	28	11	23	21	6
2023	21	21	21	24	8
2024	11	10	28	19	12

Trends in commercial trips reported between 1994 and 2023 have generally followed landings trends (Figure 4). Trips include the number of trip ticket records with landings reported; some trips may represent more than one day of fishing. The number of trips for all gears targeting Southern

Flounder has decreased since regulatory changes due to Amendment 2 (seasonal management) and Amendment 3 (quota management) were implemented limiting the number of days flounder could be harvested.

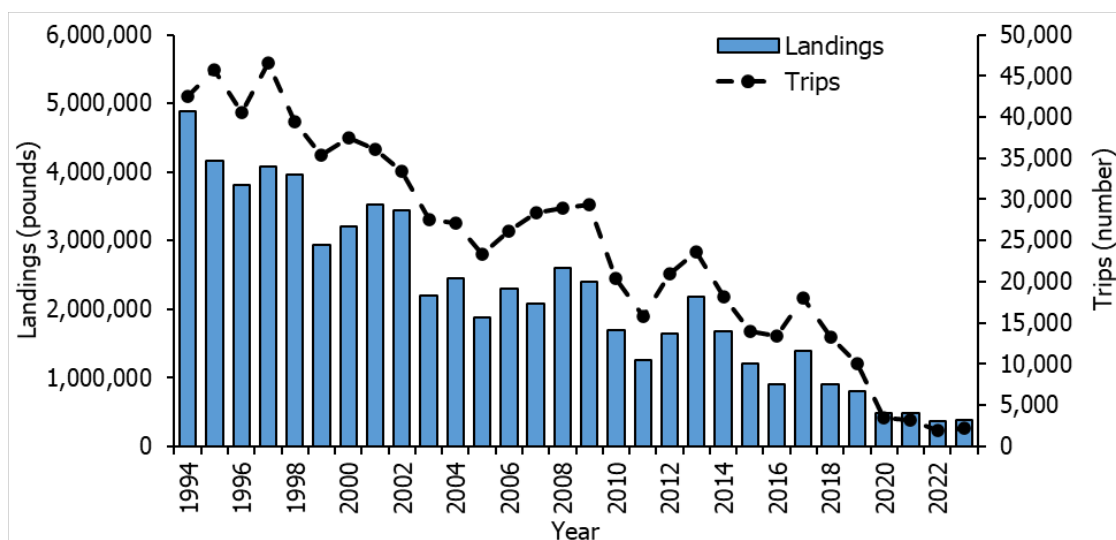


Figure 4. Southern Flounder commercial trips (numbers) and landings (pounds) from NC Trip Ticket Program, 1994–2023.

Recreational Fishery

Recreational harvest of Southern Flounder is mainly by hook-and-line and [gigs](#), with a small amount of harvest by spearfishing or Recreational Commercial Gear License (RCGL) gears (prior to 2022).

Hook-and-line harvest can be split into ocean and inshore harvest, with most Southern Flounder harvested inshore. Between 1989 and 2023, hook-and-line harvest peaked in 2010 (Figure 5). Seasonal closures implemented through Amendment 2 to the NC Southern Flounder FMP impacted recreational harvest in 2020 and 2021. The season was shortened from 45 days in 2020 to 14 consecutive days in 2021 due to excessive overages that occurred during the 2020 season. Amendment 3 implemented fishing seasons to maintain recreational harvest within a quota and added paybacks to the following year for overages. The season in 2022 was 30 days and the 2023 season was shortened to 14 days. Due to overages in 2022, the 2023 TAC (landings plus dead discards) was adjusted from 170,655 pounds to 114,315 pounds. In 2023, 192,168 pounds of Southern Flounder were caught recreationally by hook-and-line, exceeding the expected catch by 127,294 pounds. Because of these overages, there was no recreational flounder season in 2024.

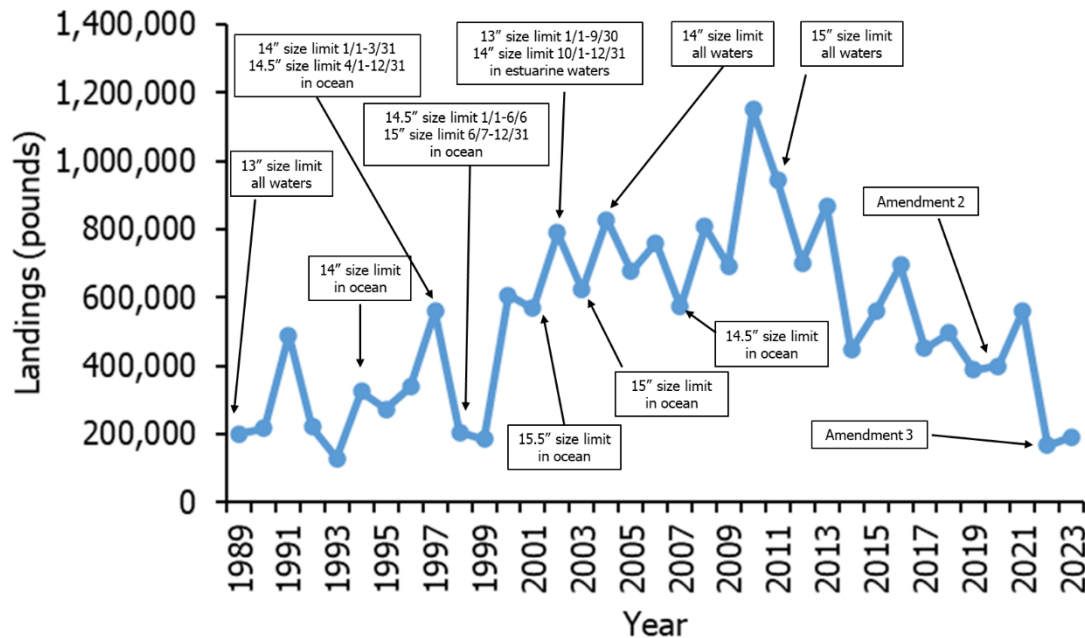


Figure 5. MRIP estimates of recreational hook-and-line Southern Flounder harvest (pounds) and major fishery regulation changes, 1989–2023. Noted regulation changes do not represent a comprehensive list. For additional regulation changes see [Lee et al. \(2018\)](#).

Trends in recreational trips are difficult to interpret because they represent all recreationally important Paralichthyid flounder species commonly caught in North Carolina (Southern, Summer, and Gulf flounder). This is because anglers only report targeting ‘flounder’ rather than a particular flounder species. Trips can be defined in several ways, but in this document all trips that harvested or released any Paralichthyid flounder species were included. Trends in trips and harvest are similar throughout the time-series, but trips have declined since 2014 while harvest has varied (Figure 6). Recreational estimates across all years have been updated and are now based on the 2018 MRIP Fishing Effort Survey-based calibrated estimates. For more information on MRIP see <https://www.fisheries.noaa.gov/topic/recreational-fishing-data>.

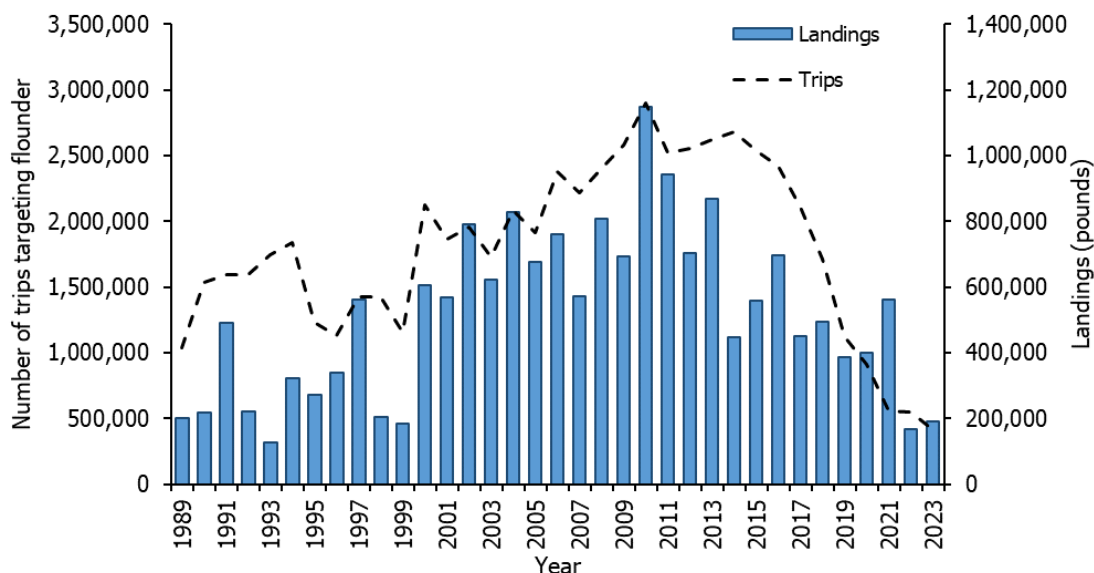


Figure 6. MRIP estimates of recreational hook-and-line harvest (pounds) and all trips that harvested or released Paralichthyid flounder species, 1989–2023. Data prior to 2004 were calibrated to align with MRIP estimates post-2004.

SUMMARY OF ECONOMIC IMPACT

For detailed discussion of economic impacts of the commercial and recreational Southern Flounder fisheries see Appendix 1. For additional information see [NCDMF \(2022\)](#).

Commercial Fishery

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

In addition to broader dynamics of supply and demand that influence North Carolina's flounder market, there are specific factors that can adjust product value on different time scales. Method of catch often influences price, as consumers seek product caught with gears perceived to be more environmentally friendly, or gears that produce higher-quality flounder (Asche and Guillen 2011). This can lead to increased prices on flounder caught with certain gears.

Additionally, enterprise level marketing can impact product value. Fishermen and dealers market their business and product as they wish. When marketing strategies are successful, prices and value can increase, though this is on an individual level and demonstrates the volatility within the market. Such changes in value are demonstrated by the positive effects local product branding

and direct-to-consumer strategies have produced in North Carolina (NCREDC 2013; Stoll et al. 2015). While these are just two examples of the variety of factors influencing value of North Carolina's flounder industry, they demonstrate the complicated dynamics at play, as many factors driving the price of flounder are not dictated by fishery managers, but by consumers and producers within the market.

Recreational Fishery

The top industries impacted by recreational Southern Flounder fishing in terms of output sales and employment are retail gasoline stores, retail sporting goods stores, retail food and beverage stores, real estate, and wholesale trade businesses. Due to the magnitude and popularity of the recreational flounder fishery in North Carolina, changes in access may lead to tangible, yet unquantifiable impacts to the value of other sport fisheries (Scheld et al. 2020). Broadly, participants target or catch flounder more than other recreational species due to higher personal satisfaction gained from fishing for this species over others. However, it is unknown whether this benefit from flounder fishing would transfer to other fisheries if effort restrictions were put in place. There is a possibility that when faced with reduced access to flounder fishing, some anglers may choose not to fish, rather than seek out new target species, while others may target other species more frequently or switch to catch-and-release flounder fishing.

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

ECOSYSTEM PROTECTION AND IMPACT

Habitat use patterns of Southern Flounder vary by life stage over time and space. Growth and survival of Southern Flounder within the habitats they use is maximized when water quality parameters, such as temperature, salinity, and dissolved oxygen, are within optimal ranges. Good water quality is essential for supporting the various life stages of Southern Flounder (Figure 7) and maintaining their habitats. Natural processes and human activities can alter salinity or temperature conditions, elevate toxins, nutrients, turbidity, as well as lower dissolved oxygen levels which can degrade water quality.

For additional information about habitat use by life stage and optimal water quality parameters, see the Description of the Stock section of this FMP, [NCDMF \(2019\)](#), or [NCDMF \(2022\)](#). For a comprehensive review of ecosystem impacts from the Southern Flounder fishery, including habitat degradation and loss, water quality degradation, gear impacts on habitat, bycatch and discards of non-target species, protected species, climate change and resiliency, and habitat protection, see [NCDMF \(2022\)](#).

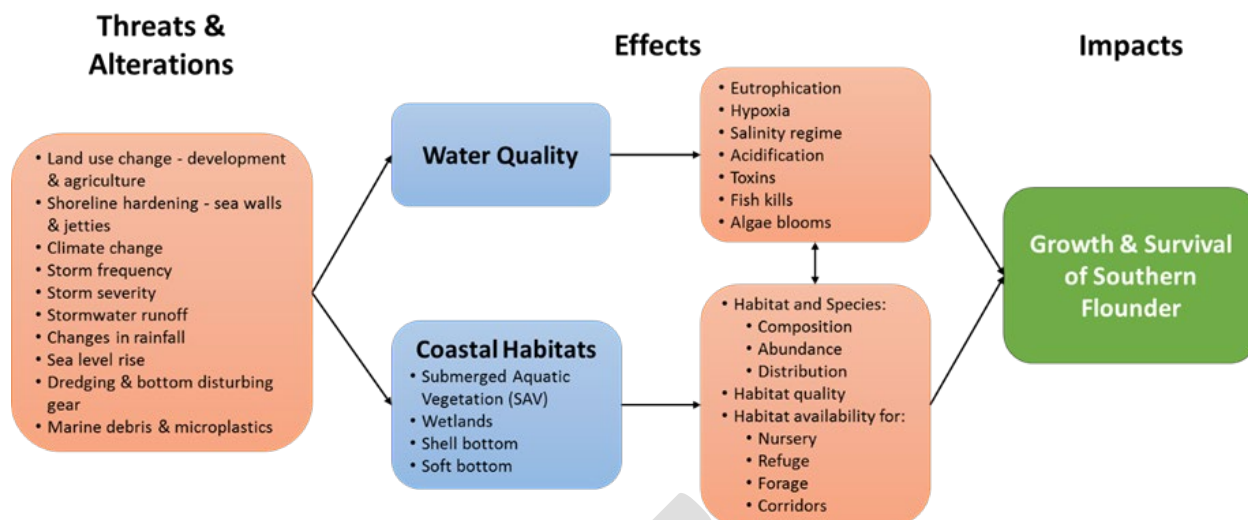


Figure 7. Effects of threats and alterations on water quality and coastal habitats and their ultimate impact on the growth and survival of Southern Flounder.

Coastal Habitat Protection Plan

The Fisheries Reform Act statutes require a CHPP be drafted by the NCDEQ and reviewed every five years (G.S. 143B-279.8). The CHPP is a resource and guide compiled by NCDEQ staff to assist the NCMFC, Environmental Management (EMC), and Coastal Resources commissions (CRC) in developing goals and recommendations for the continued protection and enhancement of fishery habitats in North Carolina. These commissions are required by state law (G.S. 143B-279.8) to adopt and implement management strategies specified in the CHPP as part of a coordinated management approach. Habitat recommendations related to fishery management can be addressed directly by the NCMFC. The NCMFC has passed rules providing protection for Southern Flounder habitat including the prohibition of bottom-disturbing gear in specific areas, and designation of sensitive fish habitat such as nursery areas and submerged aquatic vegetation (SAV) beds with applicable gear restrictions. Habitat recommendations not under NCMFC authority (e.g., water quality management and shoreline development) can be addressed by the other commissions through the CHPP process. The CHPP helps to ensure consistent actions among these commissions as well as their supporting NCDEQ divisions. The CHPP also summarizes the economic and ecological value of coastal habitats to North Carolina, their status, and potential threats to their sustainability ([NCDEQ 2016](#)).

FINAL AMENDMENT 4 MANAGEMENT STRATEGY

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

RESEARCH NEEDS

The research recommendations listed below are offered by the DMF to improve future management strategies. They are considered high priority as they will help to better understand the Southern Flounder fishery and meet the goal and objectives of the FMP. A more comprehensive list of research recommendations is provided in the [Annual FMP Review](#) and DMF [Research Priorities](#) documents.

- Conduct studies to quantify fecundity and fecundity-size/age relationships in Atlantic Southern Flounder.
- Improve estimates of the discard (B2) component (catches, lengths, and ages) for Southern Flounder from MRIP.
- Expand, improve, or add fisheries-independent surveys of the ocean component of the stock.
- Determine locations of spawning aggregations of Southern Flounder.
- Complete and age validation study using known age fish.

MANAGEMENT FROM PREVIOUS PLANS

There are several management measures from Amendment 3 to carry forward in Amendment 4 that address fishing behavior and potential changes in effort to minimize the possibility of catching Southern Flounder in greater volume than predicted.

Unless otherwise stated, all Southern Flounder Amendment 3 management measures will be carried forward in Amendment 4 and remain in effect including, but not limited to, the following:

- A commercial and recreational minimum size limit of 15 inches TL;
- A minimum mesh size of 6.0-inch stretched mesh (ISM) for anchored large-mesh gill nets used in the taking of flounder;
- A minimum mesh size of 5.75-ISM for pound net escape panels;
- Reduced commercial anchored large-mesh gill-net soak times to single overnight soaks where nets may be set no sooner than one hour before sunset and must be retrieved no later than one hour after sunrise the next morning;
- For anchored large-mesh gill nets with a 4.0 through 6.5 ISM, maintain a maximum of 1,500-yards in Management Units A, B, and C and a maximum of 750-yards in Management Units D1, D2, and E unless more restrictive yardage is specified through adaptive management or through the sea turtle or sturgeon Incidental Take Permit (ITP);
- Removal of all commercial gears targeting Southern Flounder from the water (e.g., commercial and RCGL anchored large-mesh gill nets and gigs) or make them inoperable (flounder pound nets) in areas and during times outside of an open season with exceptions for commercial large-mesh gill-net fisheries that target American shad (*Alosa sapidissima*), hickory shad (*A. mediocris*) and catfish species if these fisheries are only allowed to operate during times of the year and locations where bycatch of Southern Flounder is unlikely.
- Unlawful to use any method of retrieving live flounder from pound nets that causes injury to released fish (e.g., picks, gigs, spears, etc.);
- Unlawful for commercial fishery to possess any species of flounder harvested from the internal waters of the state during the closed Southern Flounder season;
- Combine mobile gears (gill nets, gigs, and “other” gears) into one gear category and maintain pound nets as their own separate commercial fishery;
- Divide mobile gears into two areas using the ITP boundary line for management sub-units Northern D1 and Southern D1, maintaining consistency with Amendment 2 and Amendment 3 boundary line;
- Divide the pound net fishery into three areas maintaining consistency with areas in Amendment 2 and 3;
- Maintain 72% reduction and current sub-allocation for the pound net fishery.
- Implement trip limits for pound nets, gigs, and hook and line only to maximize reopening after reaching division closure threshold;

- Implement a single season for the recreational gig and hook-and-line fisheries to constrain them to an annual quota;
- Maintain the recreational bag limit of flounder at one fish per person per day;
- Do not allow harvest of Southern Flounder using RCGL;
- Should landings be available, allow potential for spring ocellated flounder season to occur from March 1-April 1 in ocean waters only using hook-and-line gear with one-fish ocellated only bag limit;
- Maintain the adaptive management framework based on the peer-reviewed and approved stock assessment

DRAFT

APPENDICES

Appendix 1: Increasing Recreational Access to Southern Flounder Through Sector Allocation Parity

Issue

Provide the North Carolina Marine Fisheries Commission (NCMFC) with an option to increase recreational access to the Southern Flounder fishery by accelerating the shift to sector allocation parity in 2025 rather than in 2026 as originally scheduled in the Southern Flounder Fishery Management Plan (FMP) Amendment 3.

Origination

At the August 2024 NCMFC business meeting, the NCMFC passed a motion “to ask the DMF Director to ask the DEQ Secretary to modify the Annual FMP Review Schedule to amend the Southern Flounder FMP for the review of the plan to begin in 2024. The intent is to allow for more recreational access while maintaining the rebuilding requirements of the North Carolina Southern Flounder FMP Amendment 3 (Amendment 3)”.

Background

A coast-wide stock assessment update of Southern Flounder completed in 2019 concluded the stock was overfished and overfishing was occurring (Flowers et al. 2019). To rebuild the spawning stock biomass (SSB) to the target by 2028, a 72% coast-wide reduction in Total Allowable Catch (landings and dead discards; TAC), measured in pounds, was adopted.

Amendment 3 was adopted in May 2022 and implemented a quota-based approach to reduce North Carolina’s portion of the catch from the terminal year (2017) of the assessment by 72% to help rebuild the stock to the target SSB (NCDMF 2022). The quota was set so the Total Allowable Landings (TAL) that establishes annual maximum fishing limits (in pounds) for all participants does not exceed a pre-determined amount. Quota management includes paybacks for more precise management and to account for quota overages. The quota that met the required reductions and the NCMFC allocation motion was 548,034 pounds of TAC, which results in 532,352 pounds of TAL. This TAL was further divided into commercial and recreational sector allocations. The allocation was set to 70% commercial and 30% recreational for 2021 through 2024, moving to 60% commercial and 40% recreational in 2025, and 50% commercial and 50% recreational beginning in 2026 (Table 1.1).

Commercial Fisheries

The TAL allocated to the commercial sector from the overall quota are 372,646 pounds of southern flounder for 2021 through 2024, 319,411 pounds in 2025, and 266,176 pounds beginning in 2026 (Table 1.1).

Table 1.1. Allocation in pounds for commercial and recreational fisheries for the North Carolina Southern Flounder Fishery that maintains overall reductions of 72%. An asterisk (*) indicates that Recreational Commercial Gear License (RCGL) gear removals are not included in the Total Allowable Landings.

Year	Allocation	Total Allowable Catch	Dead Discards	Total Allowable Landings	Commercial Fisheries	Recreational Fisheries*
					Total Allowable Commercial Landings	Total Allowable Recreational Landings
2021	70/30	548,034	15,682	532,352	372,646	159,706
2022	70/30	548,034	15,682	532,352	372,646	159,706
2023	70/30	548,034	15,682	532,352	372,646	159,706
2024	70/30	548,034	15,682	532,352	372,646	159,706
2025	60/40	548,034	15,682	532,352	319,411	212,941
2026	50/50	548,034	15,682	532,352	266,176	266,176

Commercial Gear Sub-Allocations

Given the large reduction needed to achieve sustainable harvest and the importance of maintaining each sector within its allowed landings, it was most practical to separate the commercial gears into two categories: pound nets and mobile gears. Mobile gears include those that target Southern Flounder, primarily gigs and gill nets, and “other” gears that do not target Southern Flounder such as shrimp trawls, crab pots, and fyke nets.

Allowed landings in the commercial sector were sub-allocated into the two commercial gear categories. Due to the scheduled shift in allocation between commercial and recreational sectors, it was prudent to evaluate the sub-allocations for the commercial fishery. Amendment 3 adopted sub-allocations so the pound net fishery could maintain its 2017 harvest of 186,458 pounds because of the increased monetary investment of operating and maintaining pound net gear (Table 1.2).

Table 1.2. Allocation in pounds for the North Carolina Southern Flounder commercial and recreational fisheries and associated sub-allocations for each sector that maintains overall reductions of 72% but maintains the current level of sub-allocation for the pound net fishery. An asterisk (*) indicates that RCGL gear removals are not included in the Total Allowable Landings.

Year	Allocation	Total Allowable Catch	Dead Discards	Total Allowable Landings	Total Allowable Commercial Landings	Commercial Gear		Total Allowable Recreational Landings	Recreational Gear*	
						Mobile Gears	Pound Nets		Hook-and-line	Gigs
2021	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2022	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2023	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2024	70/30	548,034	15,682	532,352	372,646	186,188	186,458	159,706	142,206	17,500
2025	60/40	548,034	15,682	532,352	319,411	132,953	186,458	212,941	189,608	23,333
2026	50/50	548,034	15,682	532,352	266,176	79,718	186,458	266,176	237,010	29,166

Commercial Areas Allocation

Because of the migratory nature of Southern Flounder, management areas were established in Amendment 3 to allow more equitable access by fishermen across the state with seasonal openings varying by area (Figure 1.1). After investigating North Carolina Trip Ticket data by waterbody, the fishery was split into two areas for mobile gears and three areas for pound nets. Management area sub-allocations were determined by 2017 landings (Table 1.3)

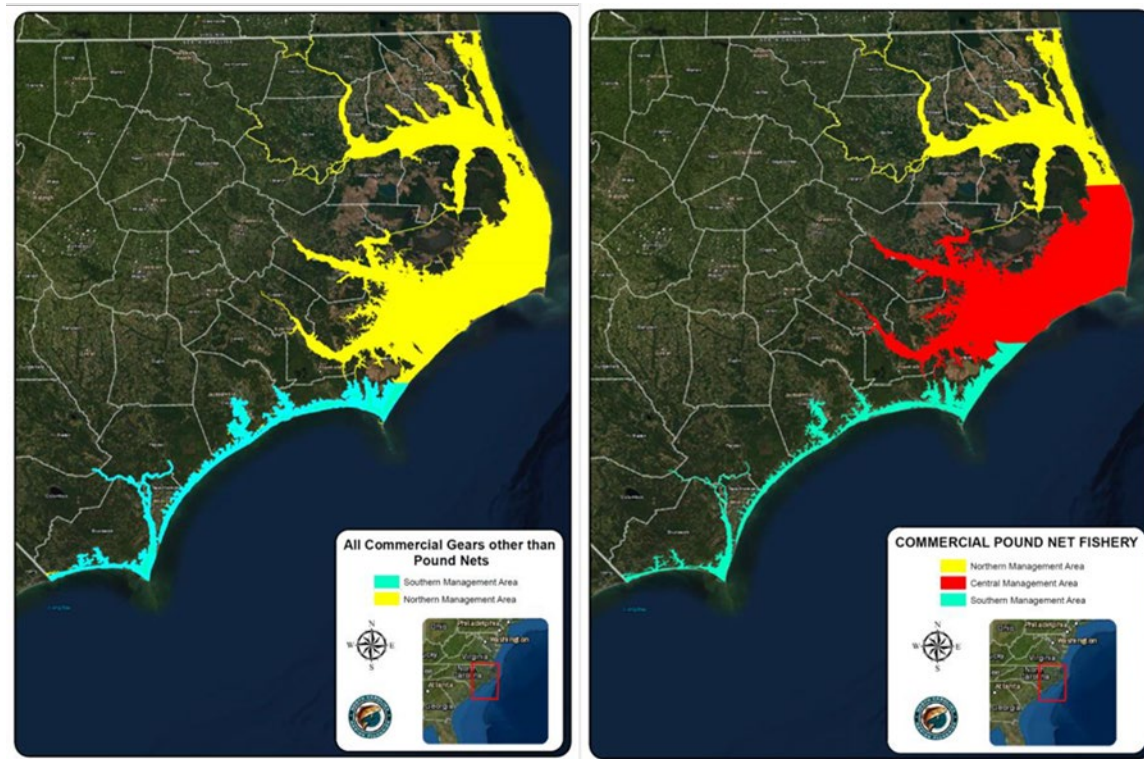


Figure 1.1. Boundary descriptions for the two mobile gear (left) and three pound net (right) management areas adopted in Amendment 3.

Table 1.3. Total allowable landings (in pounds) for the North Carolina Southern Flounder commercial fishery and associated sub-allocations for each gear management area adopted in Amendment 3.

Commercial Gear Sector	Allocation %	Management Area/Total Allowable Landings			
		Northern	Central	Southern	Total Allowable Landings
Mobile Gears	70	123,879	-	62,309	186,188
	60	88,460	-	44,493	132,953
	50	53,040	-	26,678	79,718
Pound Nets	70	39,700	121,756	25,002	186,458
	60	39,700	121,756	25,002	186,458
	50	39,700	121,756	25,002	186,458

Recreational Fisheries

The TAL allocated to the recreational sector, including hook-and-line and gigs, from the overall quota will change from 159,706 pounds in 2021 through 2024, to 212,941 pounds in 2025, and from 2026 onward the TAL will be 266,176 pounds (Table 1.1).

The recreational allocation was further refined to allow an annual harvest of 89% of the recreational TAL for the hook-and-line fishery and 11% of the recreational TAL for the recreational gig fishery. However, it was determined that concurrent seasons for the recreational hook-and-line and gig fisheries be maintained to keep from undermining the success of achieving necessary harvest reductions.

Landings and Reductions

Under Amendment 3, commercial landings have been closely monitored by the Trip Ticket Program to maintain total landings near the quota in near real-time for each gear and management area sub-allocation. This approach is not realistic for the recreational sector; thus, a one-fish bag limit and restricted harvest seasons have been used to constrain recreational landings. Total recreational landings are estimated through the Marine Recreational Information Program (MRIP) and the DMF Gig Mail surveys and those data are not available until after the fishing season. A restructuring of the license database in 2023 disrupted the division's ability to establish a sampling of eligible anglers for mail surveys. As a result, the mail surveys could not be administered, and survey estimates are not available for 2023. Since the mail survey estimates are used in determining if the recreational fishery exceeded their TAC, recreational gig data from 2022 was used as a proxy for 2023. Dead discards for both sectors are not available until after the fisheries close but are added to make sure that the sector's total allowable catch is not exceeded each year. Management under Amendment 3 achieved a 59% harvest reduction in 2022, and 68% in 2023 (Table 1.4). However, the 72% target reduction has not been met through 2023 due to overages in the recreational fishery (Table 1.5).

In 2022, total removals from the recreational fishery (226,995 pounds) exceeded its TAC by an estimated 56,340 pounds (Table 1.5). This overage was deducted from the 2023 recreational TAC and the season was reduced to two weeks ([Proclamation FF-31-2023](#)). Despite this adjustment, recreational removals increased to 241,609 pounds in 2023, resulting in an overage of 127,294 pounds. The overage was deducted from the 2024 recreational TAC (170,655 pounds), leaving 43,361 pounds in adjusted TAC which was less than the predicted recreational dead discards (47,291 pounds), causing the DMF to not open the recreational season in 2024. A major contributor to recreational overages has been dead discards in the hook-and-line fishery, which have remained at or above the level observed in 2017 (39,080 pounds) despite shortened seasons. Regardless of the closed season in 2024, estimated dead discards and landings that were allowed by the NC Wildlife Resources Commission in internal waters will be used to adjust the TAC for the 2025 season.

Table 1.4. Catch estimates with target and actual reductions from the North Carolina Southern Flounder fishery, 2017–2023. (North Carolina Trip Ticket Program and MRIP).
*Target reductions under Amendment 2.

Year	Total Landings	Dead Discards	Total Removals	2017 Total Removals	Target reduction	Actual reduction
2017	1,901,256	56,008	1,957,264	1,957,264	.	.
2018	1,452,590	36,670	1,489,259	1,957,264	.	.
2019	1,233,695	41,309	1,275,003	1,957,264	62%*	34.9%
2020	905,149	45,266	950,415	1,957,264	72%*	51.4%
2021	1,071,541	52,132	1,123,673	1,957,264	72%*	42.6%
2022	540,494	62,668	603,162	1,957,264	72%	69.2%
2023	576,013	48,457	624,470	1,957,264	72%	68.1%

Table 1.5. Recreational Total Allowable Catch (TAC) and catch estimates in pounds with adjusted TAC based on overage reductions, 2022–2024. Estimates are based on data from the Marine Recreational Information Program (MRIP) and recreational gig survey. An asterisk (*) indicates that the value is estimated from the previous year.

Year	TAC	Adjusted TAC	MRIP Landings	Gig Landings	Total Landings	MRIP Dead Discard	Gig Dead Discard	Total Dead Discard	Total Removals	Overage deducted from next year's TAC
2022	170,655	170,655	166,091	7,882	173,973	52,771	251	53,022	226,995	56,340
2023	170,655	114,315	192,168	7,882*	200,050	41,308	251*	41,559	241,609	127,294
2024	170,655	43,361	not yet available							

In response to the closed recreational season in 2024, at the August 2024 NCMFC business meeting, the NCMFC passed a motion to request modification of the Annual FMP Review Schedule to amend the Southern Flounder FMP for the review of the plan to begin in 2024 to allow more recreational access to the fishery while maintaining Amendment 3 rebuilding requirements.

Socioeconomic Analysis

Commercial

Southern Flounder has historically been one of the top harvested species by the commercial fleet in North Carolina. From 2014 until 2021 Southern Flounder was in the top five species ranked by ex-vessel value (point of sale value). In 2022 and 2023 the ex-vessel value dropped below one million dollars from a high of over seven million dollars in 2017 (Table 1.6). Participation in the fishery decreased from 1,759 participants in 2014 to 492 in 2023.

Using IMPLAN modelling software and expenditure estimates from NOAA's Fisheries Economics of the U.S. (FEUS) report, the indirect impacts of the Southern Flounder fishery to the state economy at-large can also be estimated. By assuming the flounder industry contributes to these expenditure categories at a proportion equal to their contribution to total commercial ex-vessel values, estimates of the total economic impact of flounder harvest can be generated. For a detailed explanation of the methodology used to estimate the economic impacts please refer to the NCDMF's [License and Statistics Section Annual Report](#).

Overall, the large economic impact of Southern Flounder to the state's commercial fishing industry is reflected in its effect on the state economy. Total impacts vary slightly year-over-year, though these values remain relatively consistent from a state-impact perspective until 2020. The ex-vessel value has declined significantly since 2014, with a precipitous decline in 2020 due to restrictive management and high supply of Summer Flounder. This reduced value has persisted through 2022 and 2023. These years had the lowest landings and ex-vessel value of Southern Flounder in the last ten years.

Flounder landings as a proportion of total commercial catch has decreased from a peak of 7% in 2017 to the current low of 2% (Figure 1.2).

Table 1.6. Commercial Southern Flounder economic contribution estimates from 2023–2014 reported in 2023 dollars.

Year	Pounds Landed	Ex-Vessel Value	Job Impacts	Income Impacts	Value Added Impacts	Sales Impacts
2023	375,963	\$837,570	492	\$1,633,087	\$2,854,513	\$3,665,223
2022	366,510	\$979,684	568	\$2,190,945	\$3,699,221	\$4,939,489
2021	485,024	\$1,626,653	674	\$3,820,854	\$6,005,097	\$8,767,231
2020	479,905	\$1,244,878	630	\$3,128,717	\$5,072,299	\$7,024,328
2019	800,080	\$3,669,245	1,086	\$9,300,809	\$13,624,054	\$21,729,471
2018	903,842	\$4,640,012	1,263	\$10,491,007	\$17,252,260	\$23,825,993
2017	1,396,384	\$7,039,608	1,662	\$18,245,416	\$27,209,451	\$42,008,243
2016	899,932	\$4,593,509	1,357	\$12,121,629	\$18,679,737	\$27,651,565
2015	1,202,952	\$4,916,044	1,463	\$12,849,015	\$19,860,767	\$29,247,840
2014	1,673,511	\$6,229,650	1,759	\$15,135,194	\$22,775,298	\$34,894,849

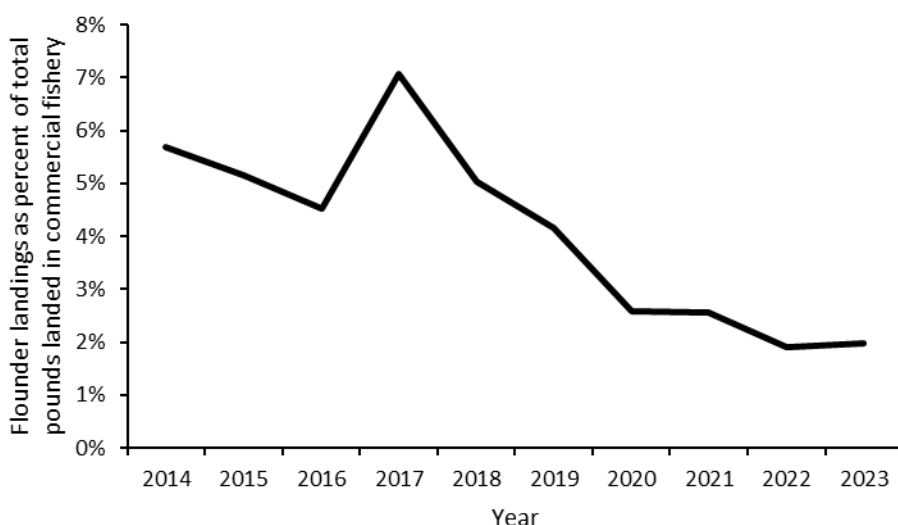


Figure 1.2. Pounds of Southern Flounder landed as a percent of total commercial finfish landed in North Carolina from 2014–2023.

Recreational

The economic impact estimates of Southern Flounder recreational fishing represent the economic activity generated from trip expenditures. These estimates are a product of annual trip estimations originating from the NOAA Fisheries Marine Recreational Information Program (MRIP) effort data by area and mode (i.e., shore, for-hire, private/rental vessel, and man-made), and trip expenditure estimates from the NCDMF economics program biennial socioeconomic survey of Coastal Recreational Fishing License holders (Dumas et al. 2009; Crosson 2010; Hadley 2012; Stemle 2018). The product of these estimates provides an annual estimate of trip expenditures made by all licensed anglers for a given year. For this analysis, a recreational flounder trip is defined as any trip in which flounder was the primary or secondary target species by the angler, or if Southern Flounder was caught during that trip.

Additionally, these data are used to generate state-level economic impact estimates of recreational flounder fishing in North Carolina. Using IMPLAN statistical software, these direct expenditure estimates for recreational flounder fishing produce indirect output impacts to the state economy across four categories: sales, labor income, value-added impacts, and employment. Additionally, all imputed expenditure estimates are adjusted for inflation based on 2023 prices, as this was the most recent year of expenditure survey data. For a detailed explanation of the methodology used to estimate the economic impacts please refer to the NCDMF's [License and Statistics Section Annual Report](#).

Since 2020 trips have declined with 2023 having the lowest number of trips in the time series (Table 1.7). The number of flounder trips as a percentage of total recreational trips ranged from a high of 5% in 2015 to a low of 1% in 2022 (Figure 1.3). The relative number of flounder trips increased to 3% in 2023.

Table 1.7. Recreational flounder economic contribution estimates from 2023–2014 reported in 2023 dollars.

Year	Trips	Expenditure	Job Impacts	Income Impacts	Value Added Impacts	Sales Impacts
2023	414,322	\$107,560,907	736	\$33,825,714	\$52,588,610	\$91,413,988
2022	515,638	\$111,446,340	711	\$33,956,950	\$52,603,145	\$92,802,221
2021	518,636	\$124,895,817	736	\$37,060,764	\$57,416,999	\$103,850,738
2020	891,057	\$236,224,061	1,521	\$76,653,218	\$109,987,034	\$195,316,448
2019	1,118,505	\$291,045,600	1,880	\$88,935,317	\$135,155,036	\$244,036,124
2018	1,179,891	\$308,646,579	2,003	\$96,804,743	\$146,722,413	\$261,904,279
2017	1,234,219	\$313,229,181	2,066	\$97,779,917	\$147,510,316	\$270,355,489
2016	1,676,500	\$435,414,429	2,935	\$139,973,659	\$208,013,684	\$377,002,717
2015	1,723,014	\$446,698,257	2,901	\$138,075,359	\$224,369,794	\$373,979,472
2014	1,619,852	\$435,654,166	2,887	\$135,636,199	\$201,597,395	\$360,751,939

It should be noted that not included in these estimates, but presented in NCDMF overall recreational impacts models, are the durable good impacts from economic activity associated with the consumption of durable goods (e.g., rods and reels, other fishing related equipment, boats, vehicles, and second homes). Durable goods represent goods that have multi-year life spans and are not immediately consumable. Some equipment related to fishing are considered durable goods. However, we cannot estimate the durable good expense of anglers for a given species.

Durable good expenses and impacts are estimated on an annual basis and serve to supplement angler expenditures outside of trip-based estimates.

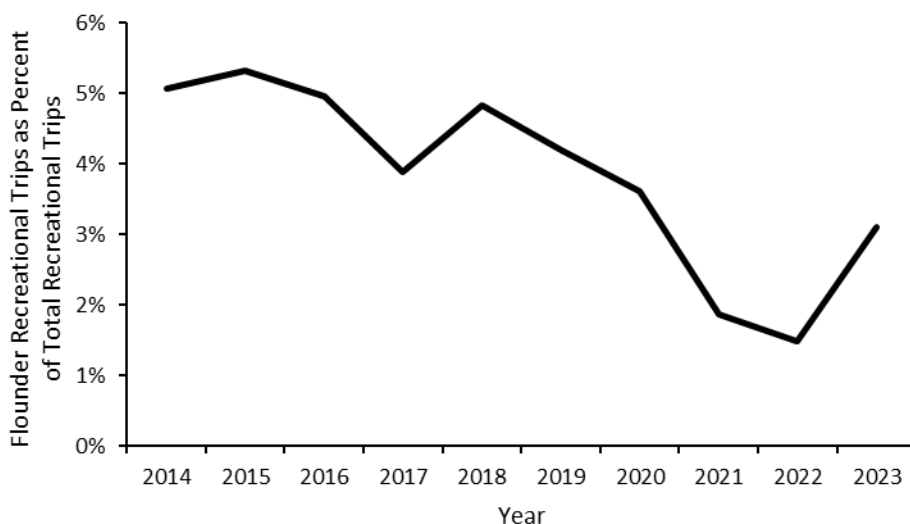


Figure 1.3. Number of flounder trips as a percent of total recreational fishing trips in North Carolina from 2014–2023.

Authority

North Carolina General Statutes

G.S. 113-134 RULES

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

G.S. 113-182.1 FISHERY MANAGEMENT PLANS

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

North Carolina Marine Fisheries Commission Rules

15A NCAC 03H .0103 PROCLAMATIONS, GENERAL

15A NCAC 03M .0503 FLOUNDER

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

Discussion

Expediting the sector (commercial/recreational) allocation transition to 50/50 in 2025 rather than 2026 as prescribed in Amendment 3 immediately address recreational access in time for a 2025 recreational season while maintaining Amendment 3 rebuilding requirements. This would result in a 66.7% increase in recreational TAL by adding 106,470 pounds from the commercial sector to the recreational sector allocation in 2025 (Table 1.2). Under the Amendment 3 allocation shift schedule to 60/40 in 2025, there would likely be a short recreational season in 2025. Expediting the shift to 50/50 in 2025 reduces the possibility of recreational catch overages that may mitigate

the need for future season closures, though may not increase the length of the recreational season. However, maintaining Amendment 3 rebuilding requirements does not provide substantial harvest opportunities for any fishing sector regardless of allocation, and given recreational landings and discard levels in recent years, even with a shift to 50/50 allocation, season closures in 2026 and beyond remain a possibility due to overages. This allocation shift is a short-term approach to address recreational access. Long-term, more comprehensive approaches for recreational and commercial management will be addressed during subsequent development of Amendment 5.

Recreational Season

Estimated recreational landings from 2022 and 2023 indicate an increase in catch over shorter seasons (Tables 1.8). More successful trips are to be expected on a rebuilding stock that has taken such a large reduction. Angler reports of seeing more flounder than ever provide indication management is working. Even with a shift to 50/50 allocation, a recreational season that maintains the one fish bag limit from Amendment 3 would need to be brief (e.g., between two and four weeks) to maintain allowable landings (266,176 pounds; Table 1.2) while accounting for dead discards. The recreational catch estimates from 2024 will be available in 2025. These estimates will be used to determine if recreational catch estimates exceeded the adjusted TAC (43,361 pounds) in 2024. Any overages will be subtracted from the 2025 TAL.

Table 1.8. Recreational harvest estimates during 2022 and 2023 from the Marine Recreational Information Program (MRIP) and recreational gig survey. An asterisk (*) indicates the 2022 estimate was used because data from 2023 were not available.

Year	Hook-and-line Landings	Gig Landings	Total Landings	Hook-and-line Dead Discard	Gig Dead Discard	Total Dead Discard	Total Catch	Season length
2022	166,091	7,882	173,973	52,771	251	53,022	226,995	4 weeks
2023	192,168	7,882*	200,050	41,308	251*	41,559	241,609	2 weeks

Commercial Implications

The Amendment 3 management strategy provides guidance on the shift in landings from the commercial to the recreational sector. Per Amendment 3, the pound net TAL allocation will be maintained at 186,458 pounds and the poundage shifted to recreational landings will come from the commercial mobile gear TAL allocation (Tables 1.2; 1.3). This will leave 79,718 pounds of TAL for mobile gears, minus any overages that may have occurred in 2024. While the number of participants in the Southern Flounder commercial fishery declined precipitously following adoption of Amendment 2 (2019) and declined further following adoption of Amendment 3 (2022), participation remains relatively high considering the constrained season (Table 1.9). Based on recent mobile gear landings trends, the scheduled allocation shift will result in a mobile gear season that will likely last one or two days, which may be non-consecutive.

Table 1.9. Commercial Southern Flounder pounds landed, number of trips landing southern flounder, and number of commercial participants and dealers participating in the fishery, 2018–2023.

Year	Pounds	Trips	Participants	Dealers
2018	903,842	13,320	912	186
2019	800,080	10,036	781	175
2020	479,905	3,485	522	144
2021	485,024	3,142	541	139
2022	366,510	1,927	485	125
2023	375,963	2,157	430	118

The 70% commercial, 30% recreational allocation (Tables 1.1; 1.2) from Amendment 3 is based on historical harvest for each sector through 2017. Different allocation scenarios have the potential to significantly reduce available harvest in a sector which may have ramifications for the viability of those sectors. Under the Amendment 3 allocation schedule, and the shift proposed in this Amendment, allocations for some sectors may be too low to viably prosecute.

Shifting allocation between sectors is within the authority of the MFC (G.S. 113-134, 113-182, 113-182.1, and 143B-289.52). Allocation changes may have positive or negative impacts on different sectors of the southern flounder fishery. Amendment 5 will further examine long-term management for both sectors.

Management Options

Status Quo

Status quo would maintain the allocation transition schedule from Amendment 3, moving to 60% commercial and 40% recreational in 2025, and 50% commercial and 50% recreational beginning in 2026. This does not immediately address the NCMFC motion to increase recreational access to the Southern Flounder fishery. The motion would be addressed by a more comprehensive amendment process.

Expedited Allocation Shift

Expedite the sector (commercial/recreational) allocation transition to 50/50 in 2025 rather than in 2026 as prescribed in Amendment 3. This option immediately addresses the NCMFC motion to increase recreational access to Southern Flounder. Long-term, more comprehensive approaches for recreational and commercial management will be addressed during subsequent development of Amendment 5 to the NC Southern Flounder FMP.

Recommendations

The DMF does not have a recommendation for this issue.

Appendix 2: Summary Of Management Recommendations and Comment

Table 2.1. Summary of management recommendations from NCDMF, the Northern, Southern, Shellfish & Crustacean, and Habitat & Water Quality Advisory Committees (AC).

	NCDMF	Northern AC	Southern AC	Finfish AC
<i>Increasing Recreational Access to Southern Flounder Through Sector Allocation Parity</i>	No Recommendation	Recommend to the Marine Fisheries Commission to remain status quo regarding southern flounder allocation	No recommendation	Recommend to the Marine Fisheries Commission to remain status quo in regard to the allocation schedule in Southern Flounder Fishery Management Plan Amendment 3
<i>Other Issues</i>	No Recommendation	Recommend that the Marine Fisheries Commission ask the DEQ Secretary to allow Amendment 5 to the Southern Flounder Fishery Management Plan to change the 72% reduction that was adopted in Amendment 3 to a 52% reduction and split the total allocation equally between the commercial and recreational sectors	No Recommendation	

Online Southern Flounder Amendment 4 Public Comment

The online public comment period was opened April 1, 2025, and closed April 30, 2025. The division received 21 responses during this period. Most commentors expressed broad support for the expedited shift to 50/50 allocation in 2025. Some commentors expressed concern over commercial gears' effect on the Southern Flounder population.

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DRAFT



JOSH STEIN
Governor

D. REID WILSON
Secretary

KATHY B. RAWLS
Director

May 7, 2025

MEMORANDUM

TO: North Carolina Marine Fisheries Commission

FROM: Jeff Dobbs, Fishery Management Plan Coordinator
Anne Markwith, Southern Flounder FMP Co-Lead
Holly White, Southern Flounder FMP Co-Lead

SUBJECT: Development of Southern Flounder Fishery Management Plan Amendment 5

Issue

Review Southern Flounder Fishery Management Plan (FMP) Amendment 5 goal and objectives, initial list of issues to be addressed, and public comment received during the scoping period.

Supporting Documents

- [Public comments submitted online for Amendment 5 to the Southern Flounder FMP scoping period](#)
- [Amendment 5 Scoping Document](#)

Action

Provide input on management options to explore in the drafting of the Southern Flounder FMP Amendment 5.

Background

The purpose of Amendment 5 is to comprehensively address the August 2024 North Carolina Marine Fisheries Commission (MFC) motion “*to ask the DMF Director to ask the DEQ Secretary to modify the Annual FMP Review Schedule to amend the Southern Flounder FMP for the review of the plan to begin in 2024. The intent is to allow for more recreational access while maintaining the rebuilding requirements of the North Carolina Southern Flounder FMP Amendment 3*”. While Amendment 4 includes the option to shift sector allocation to 50/50 (i.e., parity) one year earlier than prescribed in Amendment 3 (2025 instead of 2026), this change is not a long-term solution for addressing recreational access. Broad topics to be addressed in Amendment 5 include recreational access, strategies to address the effects of lower commercial sector quota on management, and changes to the adaptive management.

Goal and Objectives

The goal of Amendment 5 is to manage Southern Flounder (*Paralichthys lethostigma*) to achieve a self-sustaining population that provides opportunities for sustainable harvest using science-based decision-making processes. The following objectives will be used to achieve this goal.

- Implement management strategies within North Carolina that maintain/restore the Southern Flounder population with adequate abundance to prevent overfishing while balancing access to the resource.
- Monitor and manage the Southern Flounder fishery in a manner that utilizes biological, socioeconomic, fishery, habitat, and environmental data.
- Promote outreach and interjurisdictional cooperation regarding the status and management of Southern Flounder in the South Atlantic, including practices that minimize bycatch and discard mortality.
- Ensure efforts to maintain or increase growth, survival, and reproduction of the Southern Flounder stock are consistent with the Coastal Habitat Protection Plan regarding critical habitat and environmental quality.

Public Comment

The Amendment 5 scoping period was open March 1–March 31, 2025. During this period the Division received 93 online comments and conducted four scoping meetings which were attended by 39 members of the public. These meetings took place in Raleigh, Manteo, Morehead City, and Wilmington.

Scoping Meetings

Public feedback at the scoping meetings varied, but several topics had broad support. The public strongly supported moving to single species management to improve access to all flounder species. Most felt that anglers could learn to identify the different species if it meant increased fishing opportunities. The public expressed their desire to have a season for the two ocellated species in the ocean, prior to the fall Southern Flounder season. The Division repeatedly heard comments that full year closures needed to be prevented at all costs. There was some concern about effectiveness of multi-state management as many stakeholders believed our management partners were not doing their part to reduce harvest and rebuild the stock. Several commercial fishermen expressed the need to maintain access for all segments of the commercial fishery, including set gill net, and an interest in re-evaluating commercial sub-sector allocations and seasons to better align with current participation and market conditions. There was also some support for moving gigs to a commercial only gear type and replacing the fall set gill net season with a summer runaround season.

Online Comments

During the 31-day scoping period 93 public comments were submitted online. These comments mirrored the strong support for single-species management the Division heard at the in-person meetings. Online commentors also expressed strong support for an ocean only season for the ocellated species to occur prior to the fall Southern Flounder season, preventing full year closures, and concern about multi-state management. Additionally, many online comments expressed support for phasing out large mesh gill nets in the Southern Flounder fishery.

Issues to be Addressed in Amendment 5

Prior to scoping, the DMF identified several broad topics for initial discussion. The topics came from previous MFC, public, and AC feedback about ways to improve recreational access and management. These topics can be found in the [Amendment 5 Scoping Document](#).

Following the scoping period, the Division identified an initial list of issues that will be addressed in Amendment 5, including:

Recreational Topics

- Managing Southern Flounder separate from the other two left-eyed flounder, Summer and Gulf Flounder.
- Altering the timing of the recreational Southern Flounder season to optimize access and season length.

Commercial

- Address the best use of the extremely limited mobile gear allocation left when the fishery moves to 50/50 (commercial/recreational) allocation parity
 - Re-evaluate commercial sub-allocations based on recent participation
 - Phase out anchored large mesh gill nets?
 - Evaluate trip limits and gear restrictions
 - Re-evaluate seasons

General

- Adaptive management to adjust management in response to a rebuilding stock

Next Steps

Due to the broad range of topics discussed during the scoping period, and feedback received, the preliminary Amendment 5 timeline will be revised to allow sufficient time to fully evaluate these topics. The Division will provide the commission an updated timeline at its August business meeting. The Division will consider scoping input and input provided by the MFC at their May 2025 business meeting to develop a first draft of Amendment 5, a Southern Flounder FMP AC will be solicited, and the first draft of Amendment 5 will be reviewed during the FMP AC workshop.