Appendix 1: SMALL MESH GILL NET CHARACTERIZATION IN THE NORTH CAROLINA STRIPED MULLET FISHERY

ISSUE

The estuarine small mesh gill net fishery in North Carolina is managed and regulated by North Carolina Fishery Management Plans (FMPs) and numerous North Carolina Marine Fisheries Commission (MFC) rules and North Carolina Division of Marine Fisheries (DMF) proclamations. There are concerns about biological impacts from the use of small mesh gill nets. The primary issues to be addressed concern greater flexibility with constraining harvest of the striped mullet fishery, and to the greatest extent practical reducing conflict between gill net users and other stakeholders.

ORIGINATION

The North Carolina Marine Fisheries Commission (MFC).

BACKGROUND

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

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

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

The primary issues to be addressed concern greater flexibility with constraining harvest of the striped mullet fishery, reducing bycatch, and reducing conflict between gill net users and other stakeholders.

The striped mullet small mesh gill net fishery operates year-round, but the type of gill net used varies by season and area (NCDMF 2018). Multiple species may be landed during a single trip; however, the target species usually dominates the catch (NCDMF 2008). In North Carolina, gill nets are restricted to a minimum stretched mesh size of 2.5 inches inside stretched mesh (ISM) (15A NCAC 03J .0103 (a)). The DMF categorizes gill nets with ISM from 2.5 to less than 5 inches as small mesh (Daniel 2013). Although the rule uses “mesh length” and not “mesh size”, their meanings are identical for the purpose of this document; this helps to demarcate the discussion of “mesh size” from “net length” throughout the document. Small mesh gill nets are generally classified into three categories based on how the net is deployed and fished: set gill nets, runaround gill nets, and drift gill nets (Figure 1; Table 1) (Steve et al. 2001). For the purpose of this document, “set” gill nets, or “set nets”, includes anchored, fixed, and stationary nets.

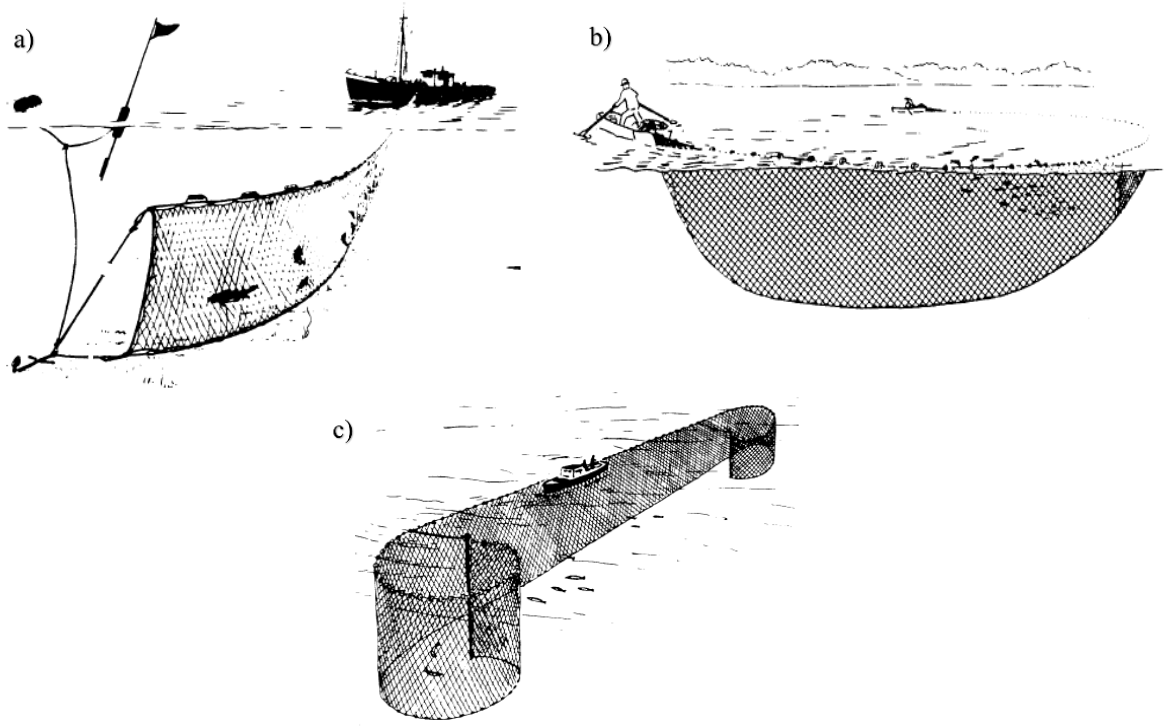

Figure 1. Illustrations of (a) set, (b) runaround, and (c) drift gill nets extracted from Steve et al. (2001).

Set nets (Figure 1a) are the second most common gill net method used for commercial striped mullet harvest in North Carolina. They are kept stationary with the use of anchors or stakes attached to the bottom or attached to some other structure attached to the bottom, at both ends of the net (15A NCAC 03I .0101). Set nets can be further classified as sink or float gill nets (Steve et al. 2001). A sink gill net fishes from the bottom up into the water column a fixed distance by having a lead line (bottom line) heavy enough to sink to the bottom. Depending on the height of the net and the depth of the water, the float line (top line) may or may not be submerged below the surface of the water. A float gill net may fish the entire water column by having the top line with buoys sufficient for floating on the surface of the water, or a portion of the water column depending on the depth of the net (number of meshes deep). Set nets are deployed by dropping

one end of the net and running out the rest of the length of net usually in a line. Once deployed, soak times for fishing set nets vary depending on factors such as target species, water temperature, season, waterbody, and regulations (NCDMF 2018).

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

Small Mesh Gill Net Gear Categories	Sub-Categories	Gear Description	Capture Method
Anchored/Fixed/ Stationary/Set	Sink	Attached to bottom or some other structure by anchors or stakes at both ends. Sink nets are fished from the bottom up into the water column.	Passively Fished - For both sink and float set nets the gear is left in place for a period of time. Fish, if appropriately sized, swim into the net and are gilled.
	Float	Attached to bottom or some other structure by anchors or stakes at both ends. Float nets are fished from the top down into the water column. Depending on target species nets fish part of the water column or the entire water column.	
Runaround	Circle	Attached to the bottom at one end. Once the end is set, the rest of the net is then fed out of a boat creating a circle and meeting back at the original set point. Generally, these nets fish the entire water column.	Actively Fished - Used to encircle a school of fish. Primary target species for this gear is striped mullet.
	Strike; Drop	Attached to the bottom at one end. Deployed along shore with the terminal end finishing at another point along the shore. The boat is driven into the blocked section to “drive” the fish into the net and are then retrieved.	Actively Fished - Used to corral or intercept a school of fish and then immediately retrieve. Primary target species for this gear is striped mullet, and spotted seatrout to a lesser extent.
Drift		Attached to boat or free-floating with close attendance. Lighter leadlines and no anchors allow the net to drift. Depending on target species and water depth, nets fish part of the water column or the entire water column. Primarily used in Pamlico Sound to target Spanish mackerel and bluefish.	Actively Fished - Drift with the water current with continuous attendance.

A runaround gill net is the most common gill net method used for commercial striped mullet harvest in North Carolina. It is an actively fished gear used to encircle schools of fish (Figure 1b). They are deployed with a weight and a buoy at one end that enables the rest of the net to be fed out, creating a closed circle around the school of fish due to the vessel’s path. Runaround gill nets tend to be deep nets capable of fishing the entire water column. Mesh sizes and net lengths vary depending on the size of the targeted species (Steve et al. 2001). Another form of runaround gill net is the strike net or drop net. Rather than deploying the net in a circle, the net is set parallel to shore, often with one end anchored to the bank. Once the net is set, the boat is driven between the net and the shore to drive fish into the net (NCDMF 2018). Soak times for all types of runaround gill nets are almost always an hour or less.

Drift gill nets are unanchored, non-stationary nets that are actively attended (i.e., remain attached to the vessel or the fishing operation remains within 100 yards of the gear) (Figure 1c) and tend to have shorter soak times than set nets. They are constructed with lighter lead lines to allow for the net to drift with the current. The small mesh drift gill nets currently employed in North Carolina estuaries are primarily used to target Spanish mackerel and bluefish in Pamlico Sound. This gear can also be used to target spot (as a sink net) and striped mullet (typically fishing the entire water column) in areas primarily from Core Sound and south (Steve et al. 2001). Drift nets account for less than 0.5% of striped mullet landings.

The following analysis and information are presented to characterize the striped mullet small mesh gill net fishery in North Carolina relative to time, area, configuration, and species composition of the harvested and discarded catch:

METHODS

Information specific to North Carolina's estuarine gill net fishery was gathered from two DMF sampling programs briefly described below:

N.C. Trip Ticket Program

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

Commercial Fish House Sampling

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

Data from 2017 to 2021 for these two programs were used to characterize North Carolina's striped mullet small mesh gill net fisheries. For trip ticket data, trips where striped mullet were the species of highest abundance in landings were considered targeted striped mullet trips. These trips were then defined as either small mesh or large mesh. Basing analysis on trips where striped mullet are the presumed targeted species allows for results that describe the gear parameters associated with striped mullet (see NCDMF 2008 for further description of methodology). Once mullet targeting trips were identified, the method of fishing (set net, runaround gill net, or drift gill net), mesh size, and net length were characterized based on available fish house sampling data from 1994 or 2017 through 2021 for each of the target species.

Regional analysis of the striped mullet small mesh gill net fishery was investigated by county of landing. The coastal counties were grouped into regions using distinct area boundaries or clear differences in fishing practices (Figure 2). All other counties within the state with landings were grouped into the "other" region.

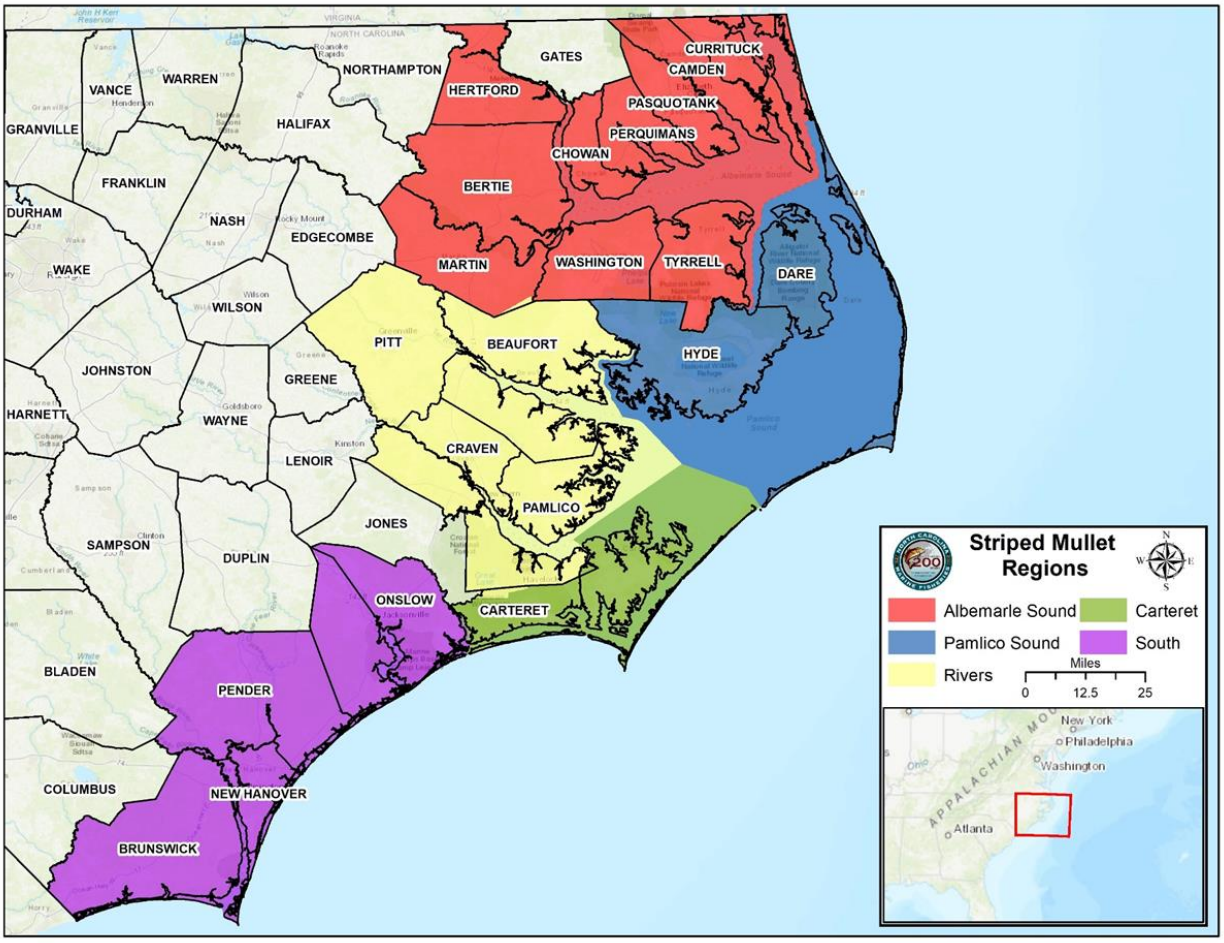

Figure 2. Map of defined regions used for regional characterization of the striped mullet small mesh gill net fishery.

RESULTS

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

Striped Mullet Fishery General Characterization

Historically, beach seines and gill nets were the two primary gear types used in the striped mullet commercial fishery, with most commercial landings prior to 1978 coming from the beach seine fishery. Gill nets (runaround, set, and drift) replaced seines as the dominant commercial gear type in 1979 and since 2017 runaround gill nets have accounted for most (>70%) striped mullet commercial landings (Figure 3). Since the trip ticket program was initiated in 1994, the striped mullet fishery has shifted from a fairly even mix of set gill nets and runaround gill nets, to one strongly dominated by runaround gill nets (Figure 4).

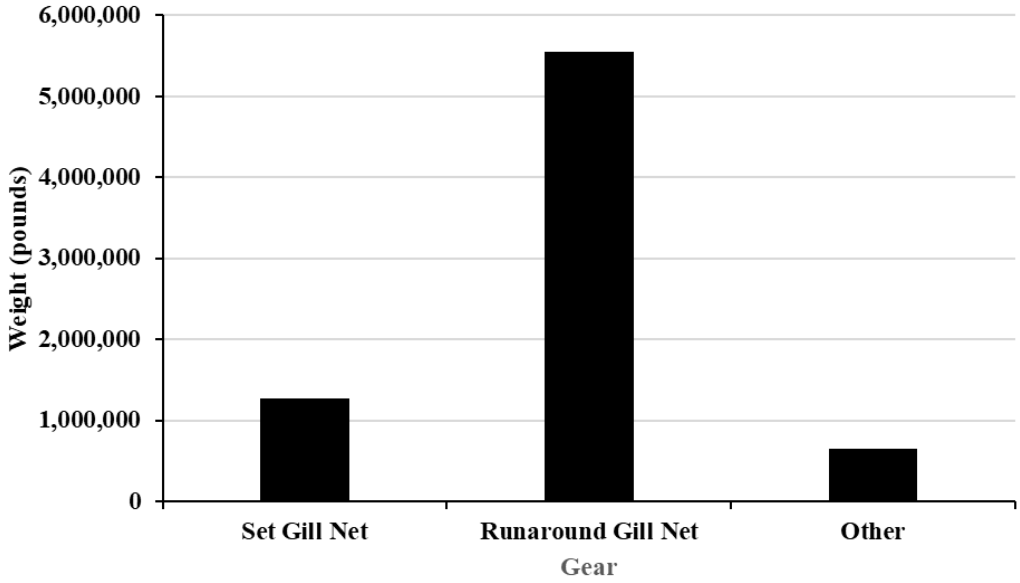

Figure 3. Percent of striped mullet commercial landings reported through the North Carolina Trip Ticket Program by gear, 2017–2021.

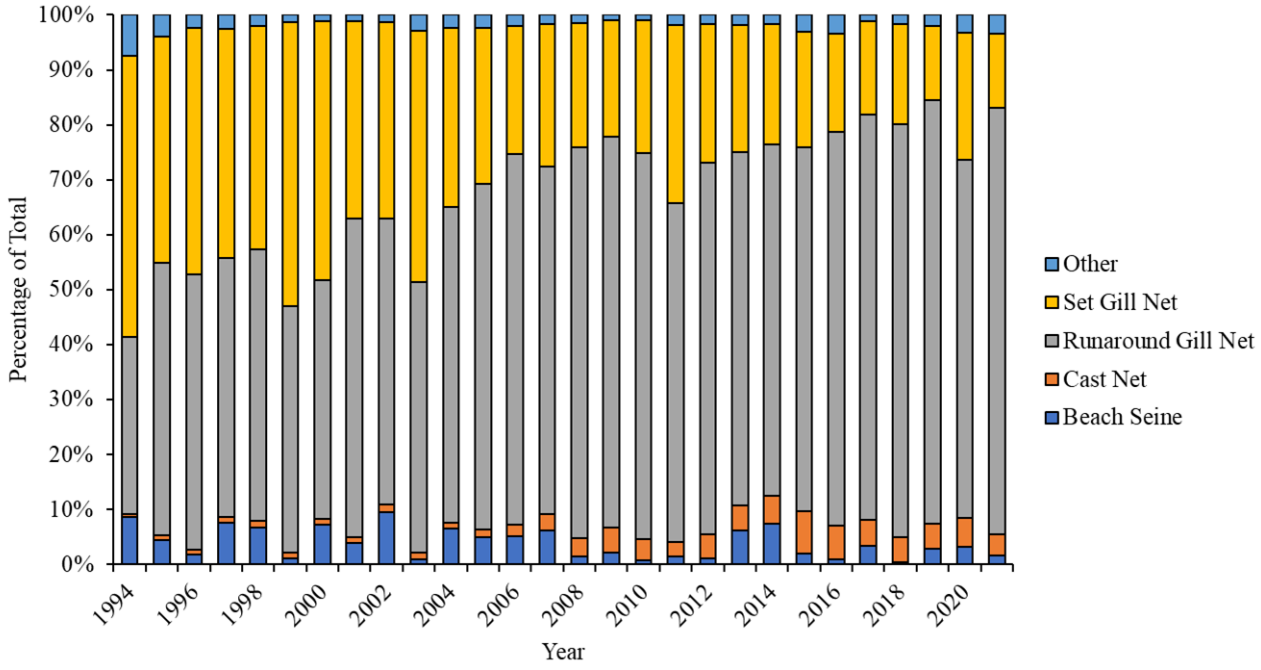

Figure 4. Percentage of striped mullet commercial landings by year and gear reported through the North Carolina Trip Ticket Program by gear, 1994–2021.

Because the commercial fishery primarily targets striped mullet for roe, the fishery is seasonal with the highest demand and landings occurring in October and November when large schools form during their spawning migration to the ocean and females are ripe with eggs (Figure 5). During this time, runaround gill nets are the primary gear used to harvest striped mullet. After the spawning migration striped mullet are no longer found in large aggregations, making runaround gill nets a less effective gear for harvest. Subsequently, from December through April set gill nets

become a much more important gear used in the fishery (Figure 6). During this time, striped mullet may be harvested in set gill nets targeting the species, or as bycatch in other targeted fisheries such as white perch in the Albemarle Sound.

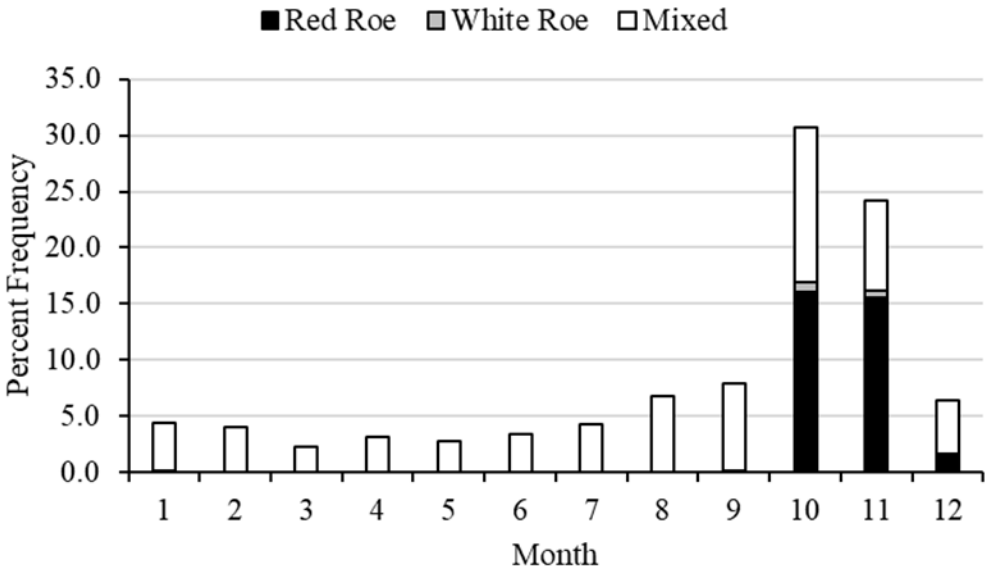

Figure 5. Percent frequency of striped mullet commercial landings by market grade and month, 2017-2021. Red Roe includes striped mullet graded as Red Roe and Roe. White Roe includes striped mullet graded as White Roe. Mixed includes striped mullet graded as Jumbo, Large, Medium, Mixed, Small, and X-Small.

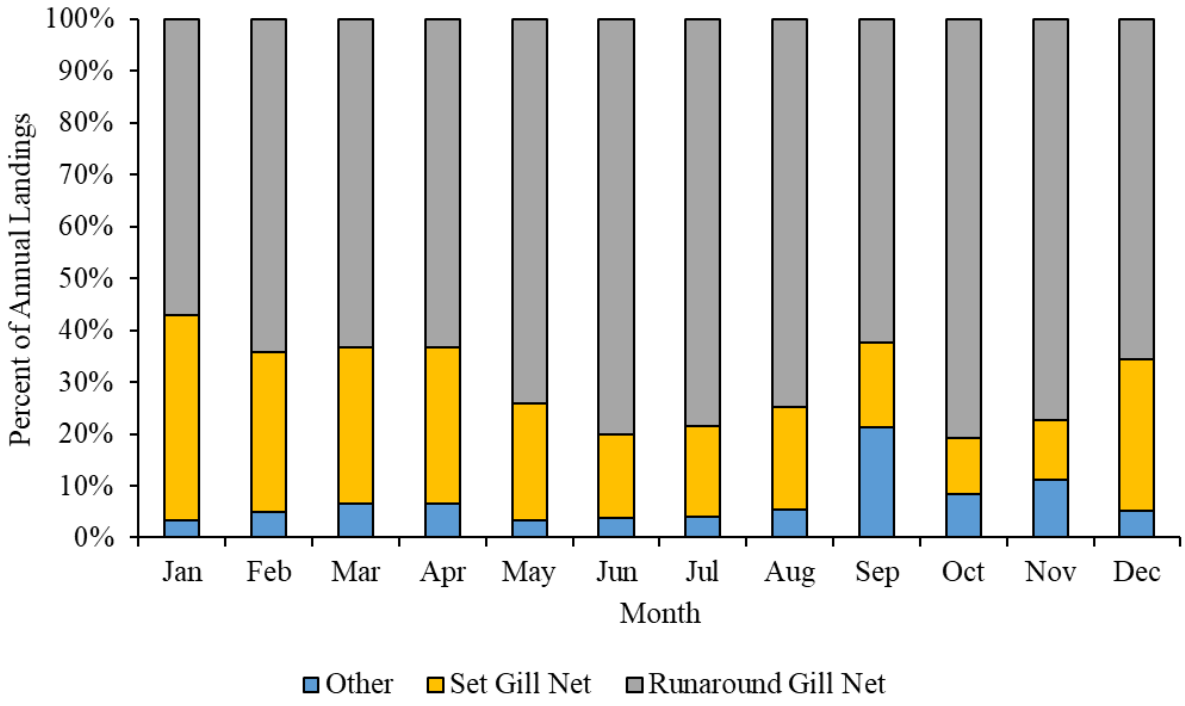

Figure 6. Percentage of striped mullet commercial landings by month and gear reported through the North Carolina Trip Ticket Program by gear, 2017–2021.

Mesh size is the most important gear parameter that affects the size of striped mullet caught in small mesh gill nets. As stretched mesh size increases, the average size of the striped mullet increases (Figure 7). Fishermen use stretched mesh sizes ranging from 2.75 ISM to 4.5 ISM to target striped mullet in North Carolina. This relationship between mesh size and striped mullet captured size makes it feasible to use mesh size restrictions to protect or select for different sized striped mullet. For more information on possible management applications of mesh size restrictions, please refer to Appendix 2 Sustainable Harvest Issue Paper.

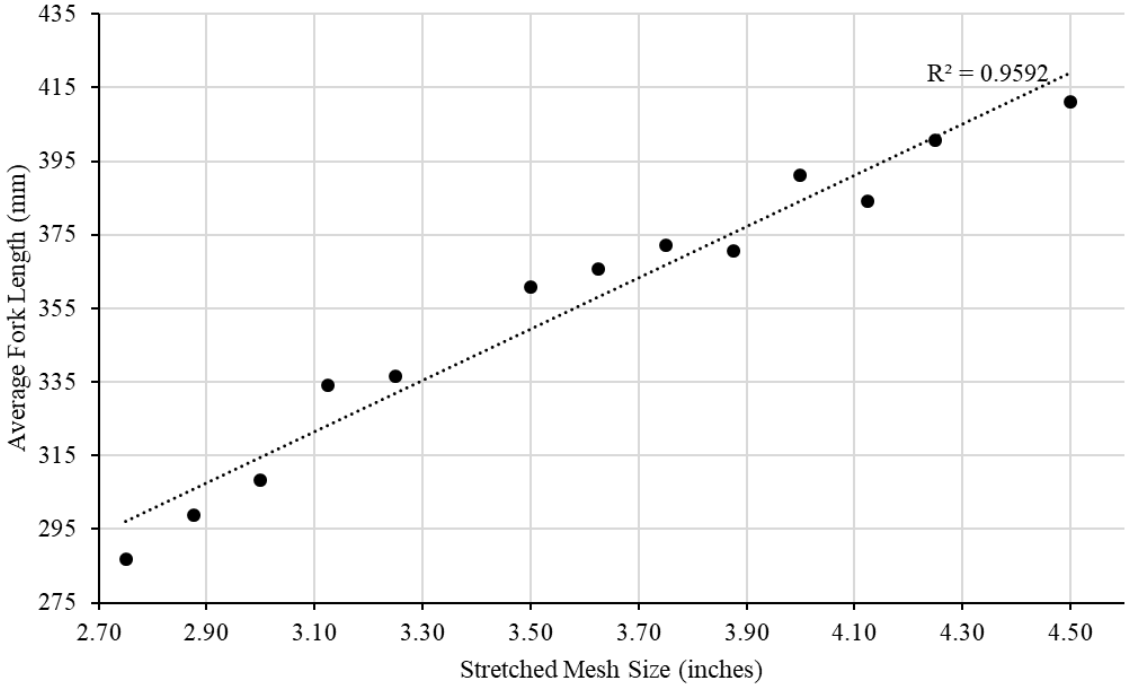

Figure 7. Relationship of stretched mesh size versus average fork length of striped mullet captured using data from the commercial fish house sampling program (1991-2021). A trendline and R squared value are provided for reference.

Regional Characterization

In the mid 1990's, the striped mullet small mesh gill net fishery was fairly evenly split between the Pamlico Sound, Carteret, and South regions (Figure 8). Since then the fishery has experienced an expansion and retraction of the fishery in the Rivers region, a contraction in the South region, and a small expansion in the Albemarle Sound region. These shifts in regional contribution have led to a fishery that is currently dominated by the Pamlico Sound and Carteret regions. These two regions have made up over 70% of the total striped mullet small mesh gill net fishery since 2017. The expansion of the fishery in the Albemarle region has been largely driven by the development of a small mesh set gill net fishery for white perch where striped mullet are primarily captured as bycatch. Set gill nets make up over 80% of striped mullet landings in this region (Figure 9). Runaround gill nets strongly dominate the fishery in the rest of the state.

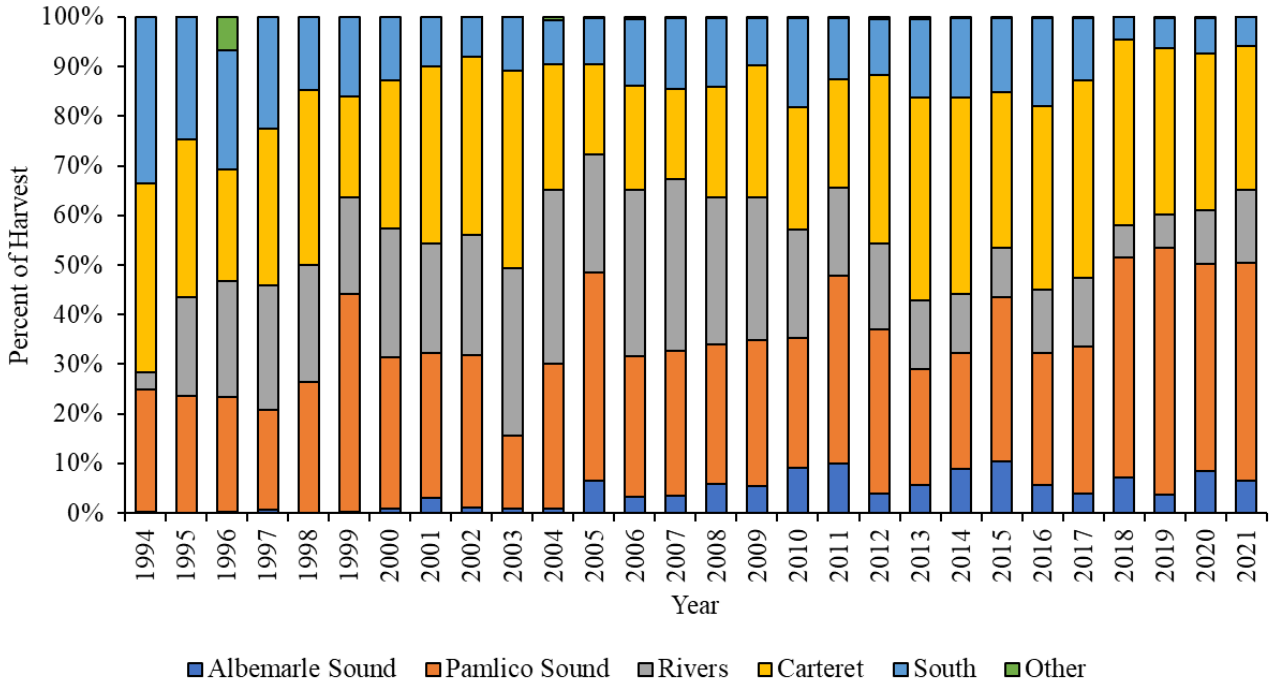

Figure 8. Percentage of striped mullet commercial landings by region and year reported through the North Carolina Trip Ticket Program by gear, 1994–2021.

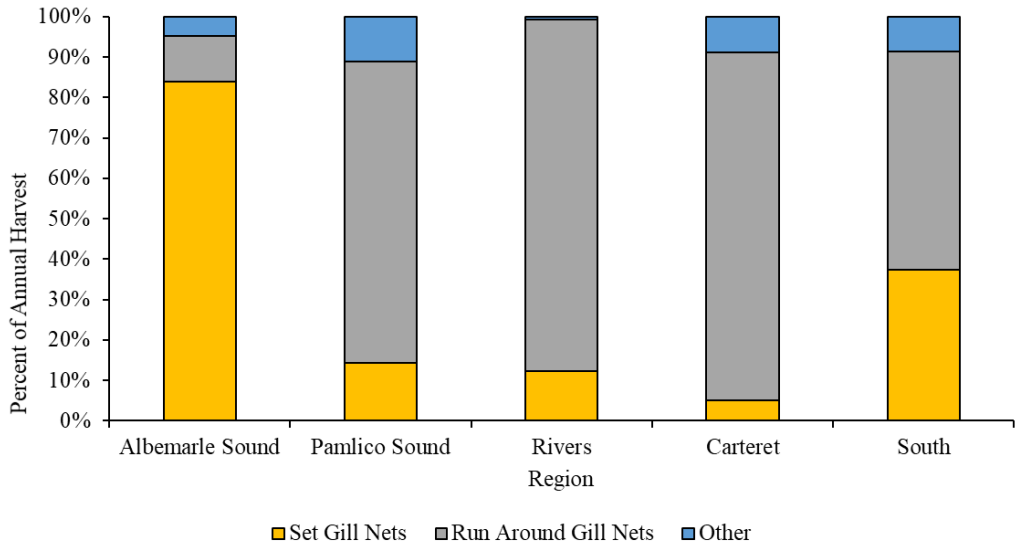

Figure 9. Percentage of annual striped mullet commercial landings by gear and area reported through the North Carolina Trip Ticket Program by gear, 2017–2021.

Set gill nets

Striped mullet are the third most important species targeted in the North Carolina small mesh set gill net fishery behind bluefish and spotted seatrout (Figure 9A). They make up the largest proportion of monthly runaround trips in November and December.

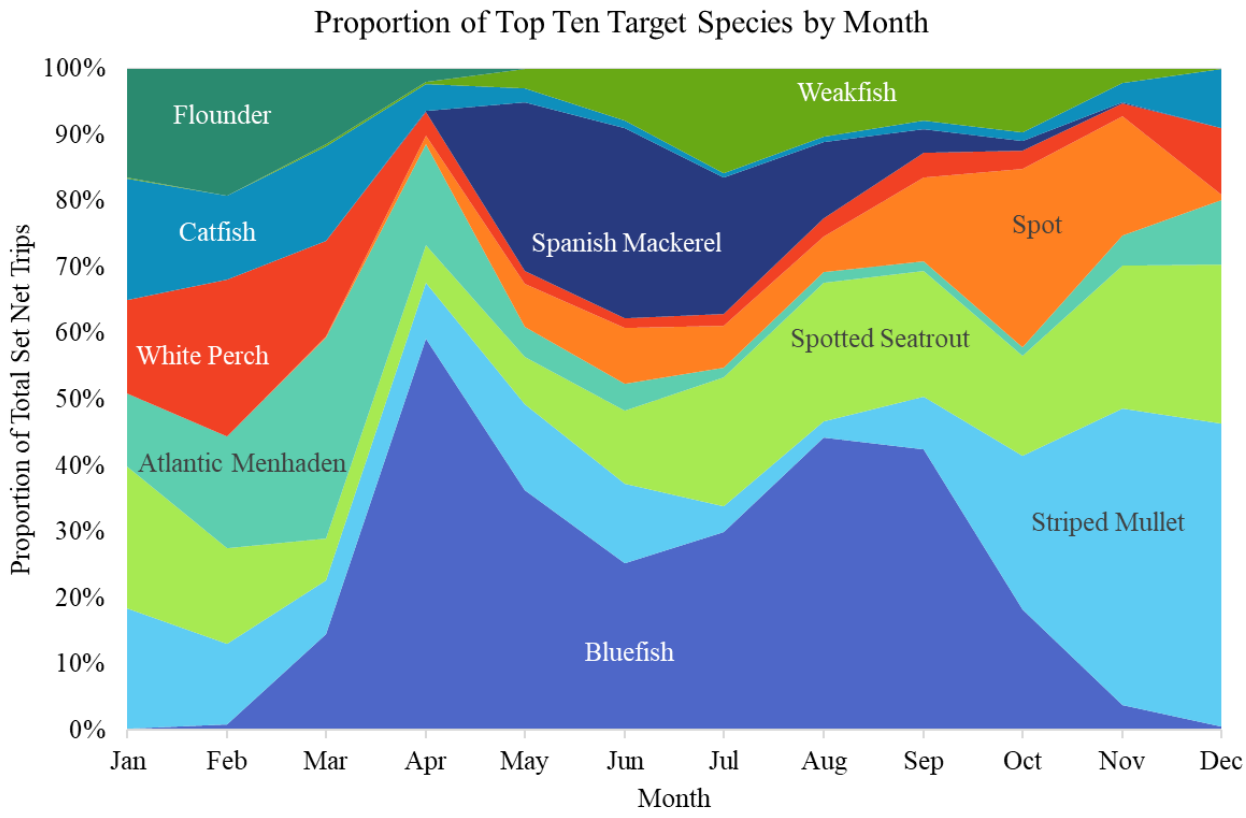

Figure 9A. Percentage of total set gill net trips for each of the 10 primary target species across months in N.C. waters during 2017-2021.

Set small mesh gill nets are the second most common gear used to capture striped mullet (Figures 3;4) in North Carolina and are the dominant gear in the Albemarle Sound region (Figure 9). Striped mullet are primarily landed as bycatch in the set gill net fishery. They are typically not targeted with set gill nets as they move around in schools that are more easily targeted with runaround gill nets. Since 1994 their use has been in decline as both trips made and participants in the fishery have waned (Figure 10). This decline in participants and trips matches well with the decreased landings and increase in runaround gill net dominance in the striped mullet fishery over the same time period.

Set gill nets tend to be a low volume fishery for striped mullet. The average trip lands just over 76 pounds of striped mullet (Figure 11). Nearly 60% of set gill net trips that target striped mullet land less than 100 pounds. However, the 42% of trips that land more than 100 pounds account for over 80% of the total set gill net landings (Figure 12). The modal mesh size used to catch striped mullet in the set gill net fishery was 3.5 ISM (Table 2). Average total net length was 567 yards, with a maximum of 3,000 yards. Over 45% of all set gill net trips fished more than 500 yards (Figure 13). Yardage restriction could be an effective way to reduce harvest in this fishery. For more information on possible management applications of set gill net yardage restrictions, please refer to Appendix 2 Sustainable Harvest Issue Paper.

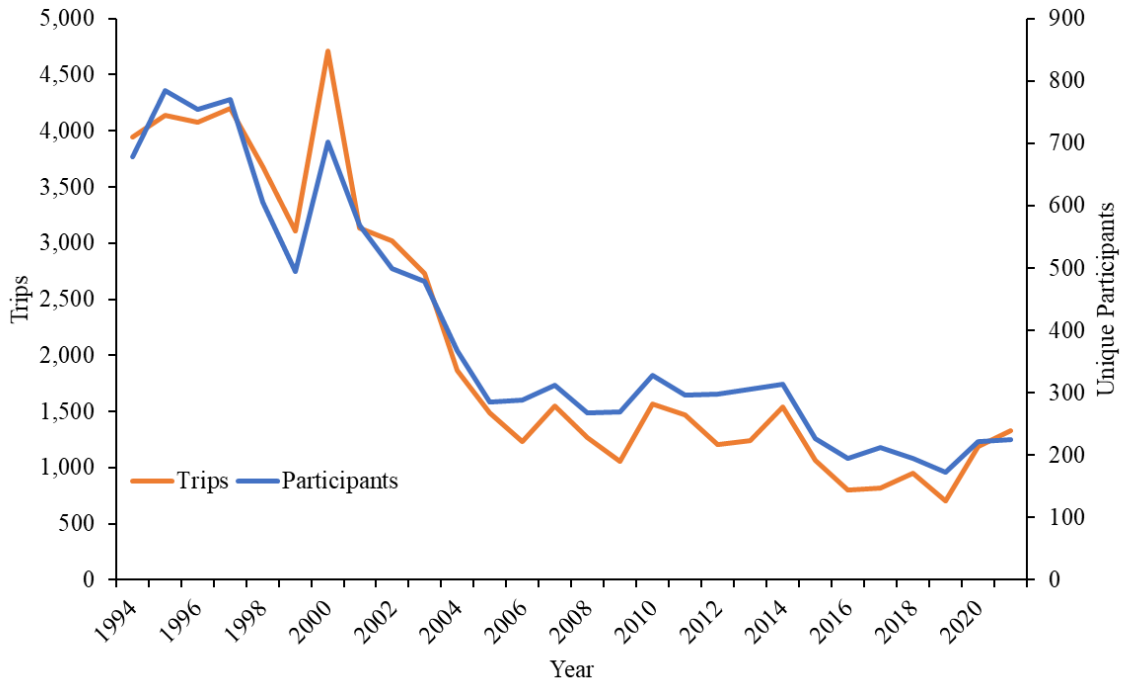

Figure 10. Targeted trips and participants in the set small mesh gill net striped mullet fishery by year reported through the North Carolina Trip Ticket Program by gear, 1994–2021.

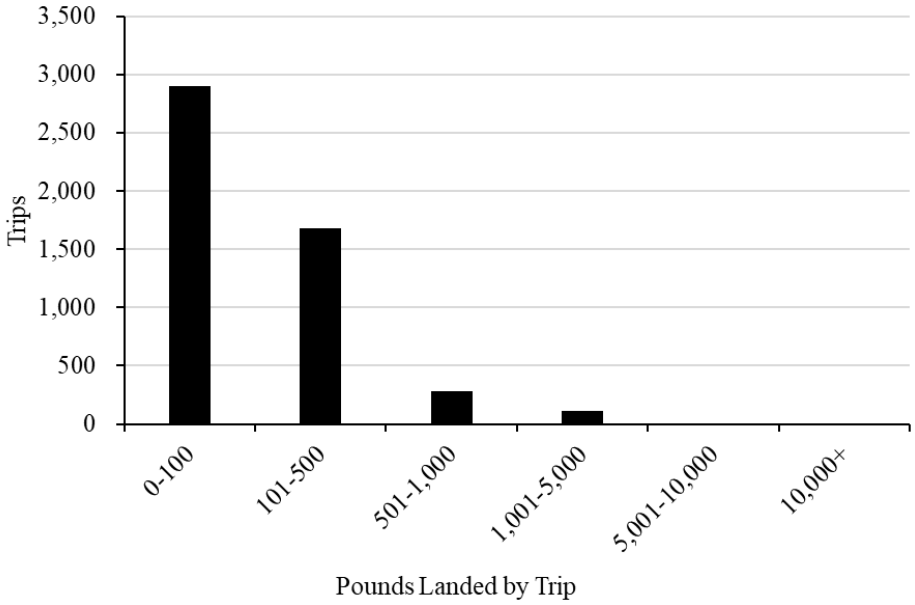

Figure 11. Number of targeted Trips grouped by pounds landed per trip in the set small mesh gill net striped mullet fishery reported through the North Carolina Trip Ticket Program by gear, 2017–2021.

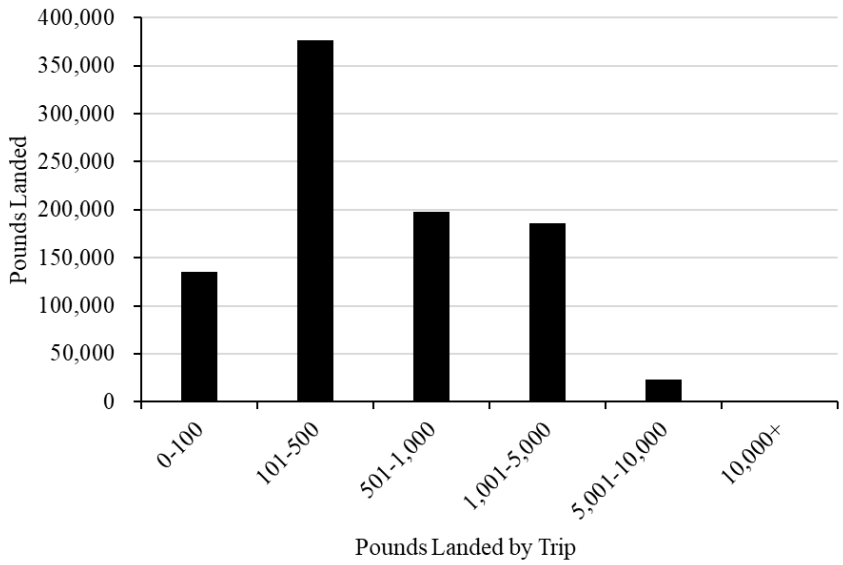

Figure 12. Total pounds landed grouped by pounds landed per targeted trip in the set small mesh gill net striped mullet fishery reported through the North Carolina Trip Ticket Program by gear, 2017–2021

Table 2. Number of small mesh (<5 inch ISM) set net trips in North Carolina using data from the N.C. Trip Ticket Program with associated gear characteristics from fish house during 2017-2021.

Species	Trips	Avg/Yr	Modal Mesh	Avg Yds	Max Yds
Striped mullet	14,282	2,856	3.5	567	3,000

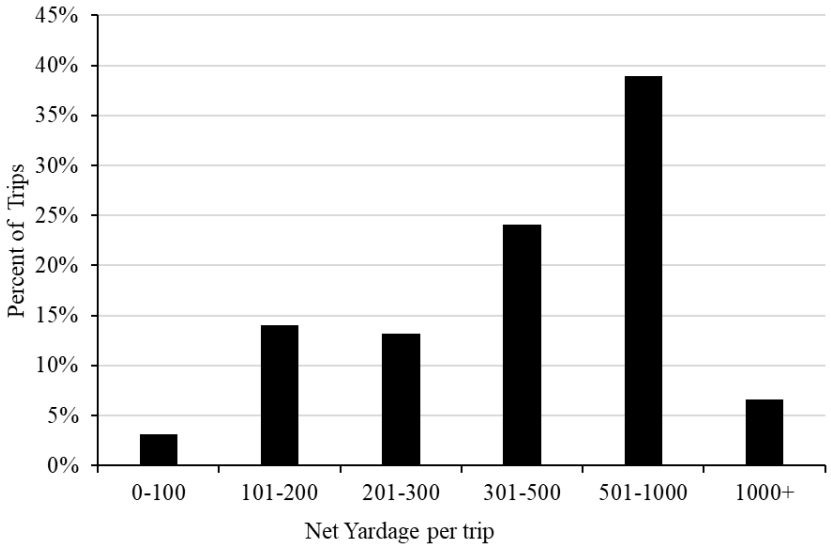

Figure 13. Percent of total trips grouped by yards fished per trip in the set small mesh gill net striped mullet fishery using data from the commercial fish house sampling program 2017–2021.

When targeting striped mullet with small mesh set gill nets, it is common to catch other species incidentally. The most common species landed incidentally when targeting striped mullet in set gill nets are spotted seatrout, red drum, catfish, bluefish, white perch, and gizzard shad (Figure 13A). Conversely, striped mullet are most commonly caught incidentally when set gill net fishermen are targeting spotted seatrout, bluefish, and white perch (NC trip ticket data). This overlap between the striped mullet and spotted seatrout, bluefish, and white perch set gill net fisheries could have management implications for all these fisheries if gear restrictions are put in place to restrict striped mullet harvest.

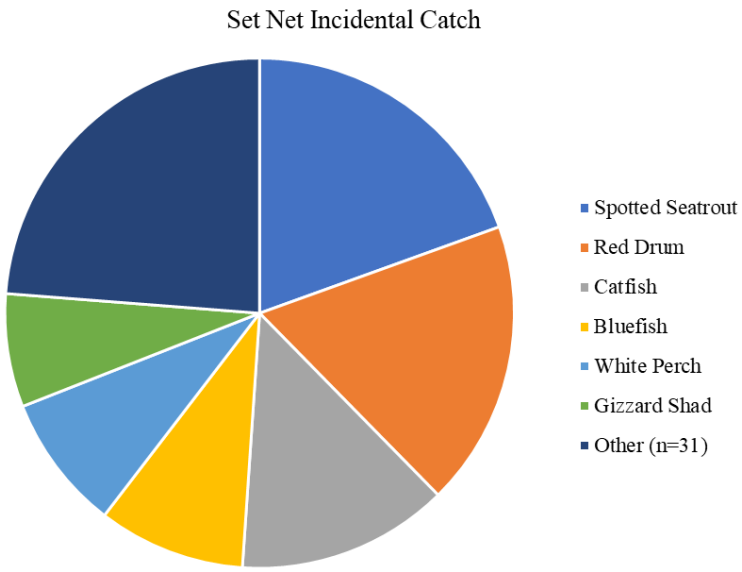

Figure 13A. Proportion of incidental catch landed by species in the set small mesh gill net striped mullet fishery reported through the North Carolina Trip Ticket Program, 2017–2021.

Striped mullet discards in the set gill net fishery are difficult to characterize due to limited data but are presumed to be minimal since there are no restrictions on their commercial harvest. Increased restrictions on striped mullet harvest could increase discards in this fishery. For more information on striped mullet bycatch in the set gill net fishery, please refer to the Striped Mullet Bycatch section of the Base Plane.

Discards of other species from striped mullet targeted set gill net small mesh trips could not be characterized due to a lack data.

Runaround Gill Nets

Striped mullet are the most important species targeted in the North Carolina runaround gill net fishery (Figure 13B). They make up the largest proportion of monthly runaround trips from April to November and are second to spotted sea trout the rest of the year.

Runaround gill nets are the predominant gear used to catch striped mullet in North Carolina (Figures 3;4) and the dominant gear in every region except the Albemarle Sound (Figure 9). The runaround gill net fishery is much more targeted than the set net fishery and is the main gear used to catch striped mullet when they form their spawning aggregations in October and November. During this time catches from runaround gill nets can be very high as fishermen target striped mullet for their valuable roe (Figure 5). Over 50% of the average yearly landings of striped mullet come from this two-month period. Since 1994 effort and participation in this fishery have remained

relatively consistent until 2021 when a significant spike in both trips and participants was observed (Figure 14). This sudden increase could be due to fishermen shifting to the fishery from other more restrictive fisheries.

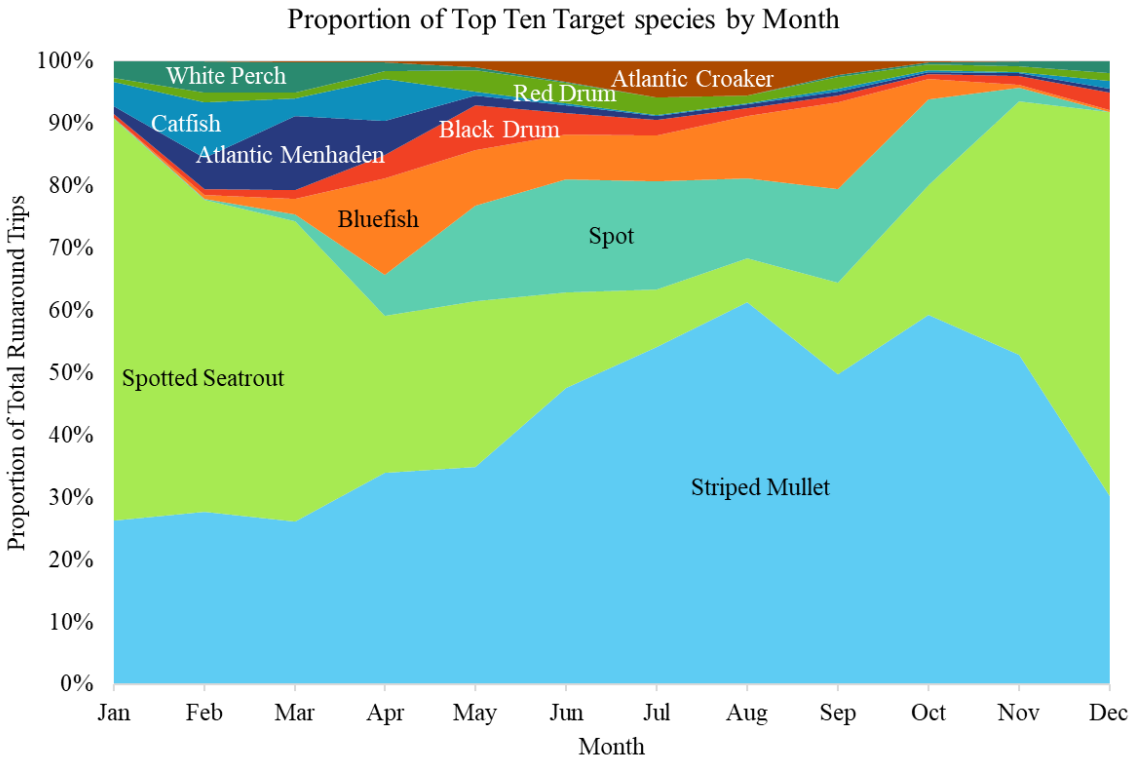

Figure 13B. Percentage of total runaround gill net trips for each of the 10 primary target species across months in N.C. waters during 2017-2021.

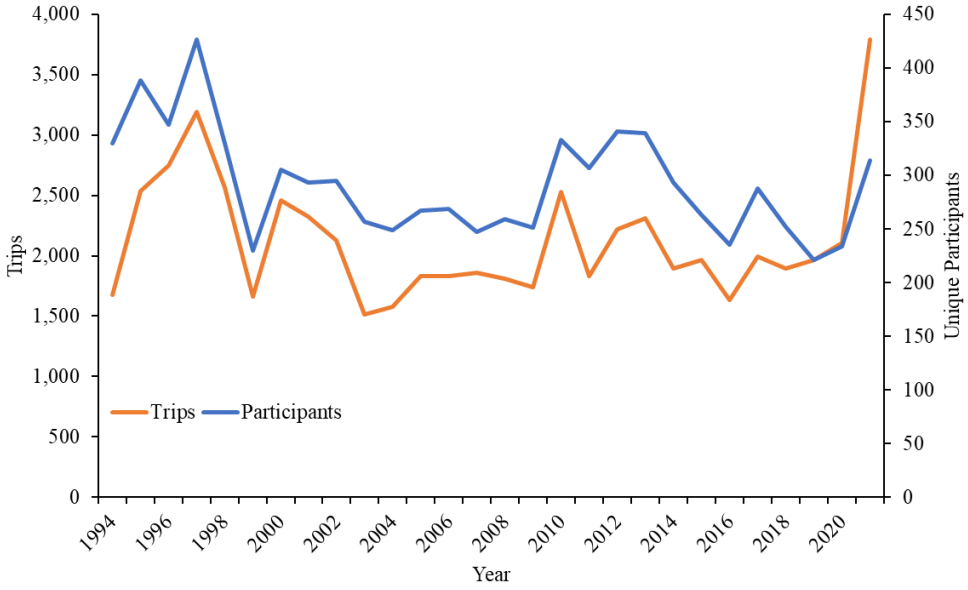

Figure 14. Targeted trips and participants in the runaround gill net striped mullet fishery by year reported through the North Carolina Trip Ticket Program by gear, 1994–2021.

Runaround gill nets are a higher volume fishery than set nets, with the average trip landing over 450 pounds (Figure 15). This is likely due to runaround gill nets being a more targeted gear for striped mullet. Most trips that target striped mullet land less than 500 pounds of mullet. However, the 12% of trips that catch over 1,000 pounds account for over 50% of total landings from runaround gill nets.

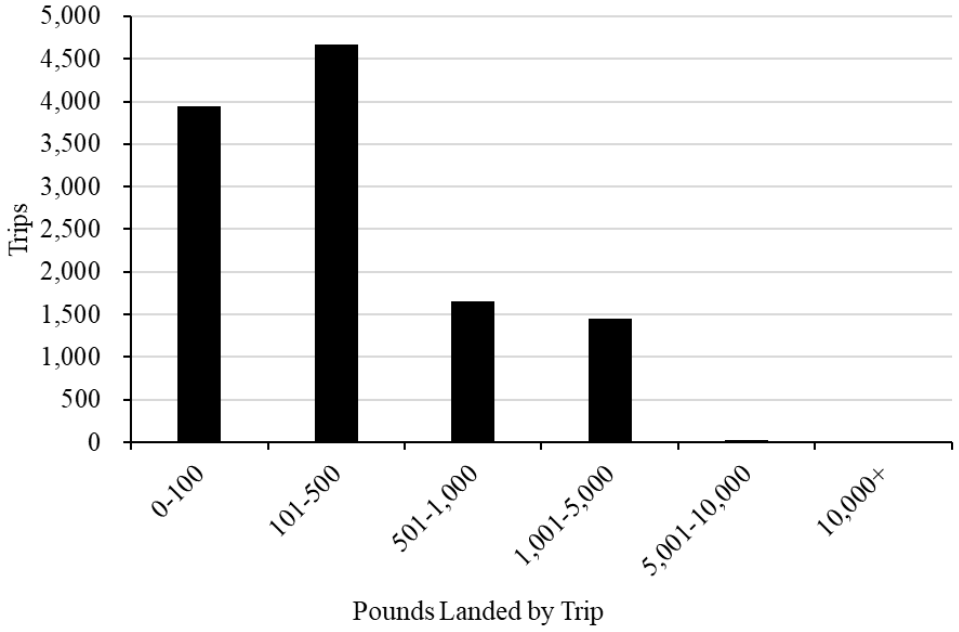

Figure 15. Number of targeted trips grouped by pounds landed per trip in the runaround gill net striped mullet fishery reported through the North Carolina Trip Ticket Program by gear, 2017–2021.

Runaround gill nets have a higher modal mesh size (3.75 ISM) than set small mesh gill nets (3.5 ISM) (Table 3). This is likely due to the fact that most runaround gill net trips occur in October and November during the roe season when fishermen are targeting the larger females. The average net length is 366 yards with a maximum of 1,000 yards, with nearly half of all trips setting less than 300 yards of net (Figure 16). Runaround gill nets tend to be much shorter than set gill nets because runaround gill nets are actively fished to encircle schools of striped mullet. This allows for much less yardage needed to catch the fish than the passively fished set gill nets. Since the gill nets are already significantly shorter, and nets can be fished several times consecutively, maximum yardage restrictions may not be effective in managing harvest in this fishery. For more information on possible management applications of runaround gill net yardage restrictions, please refer to Appendix 2 Sustainable Harvest Issue Paper.

Table 3. Number of small mesh (<5 inch ISM) runaround gill net trips in North Carolina using data from the N.C. Trip Ticket Program with associated gear characteristics from fish house during 2017-2021.

Species	Trips	Avg/Yr	Modal Mesh	Avg Yds	Max Yds
Striped mullet	20,763	4,153	3.75	366	1,000

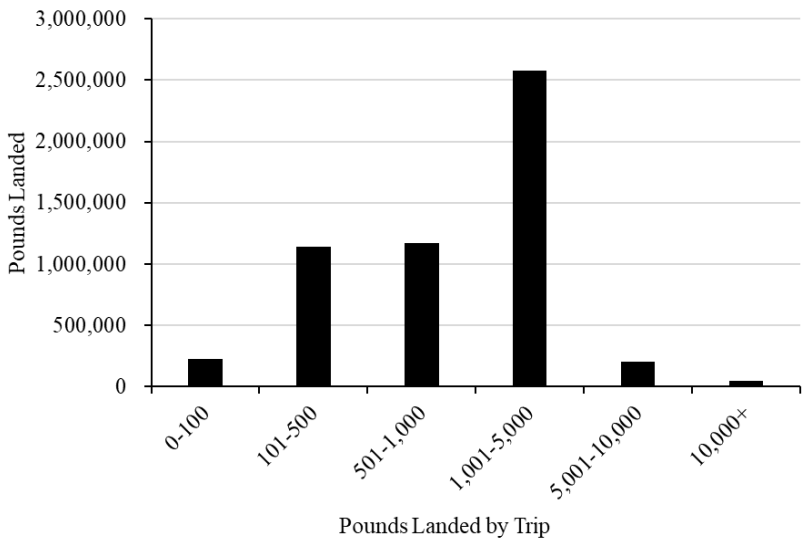

Figure 16. Total pounds landed grouped by pounds landed per targeted trip in the runaround gill net striped mullet fishery reported through the North Carolina Trip Ticket Program by gear, 2017–2021.

When targeting striped mullet with runaround gill nets, it is common to catch other species incidentally. The most common species landed incidentally when targeting striped mullet in set gill nets are spotted seatrout, red drum, bluefish, spot, black drum, and blue crab (Figure 17). Conversely, striped mullet are most commonly caught incidentally when runaround gill net fishermen are targeting spotted seatrout, bluefish, and spot (NC trip ticket data). This overlap between the striped mullet and spotted seatrout, bluefish, and spot runaround gill net fisheries could have management implications for all of these fisheries if gear restrictions are put in place to restrict striped mullet harvest.

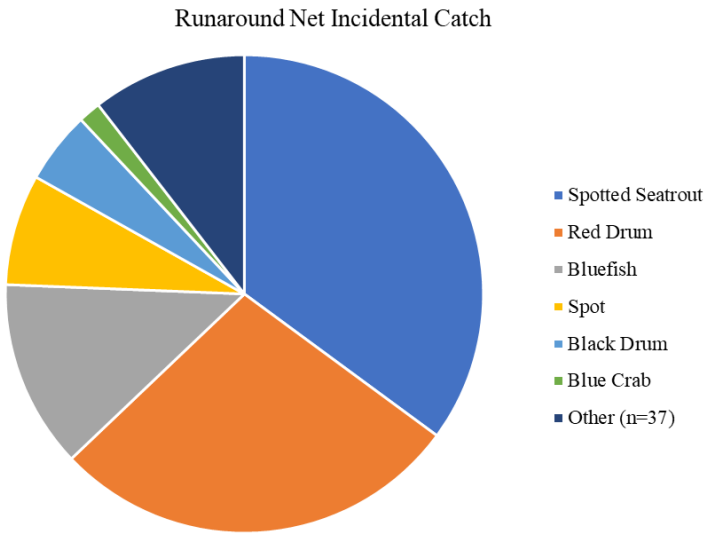

Figure 17. Proportion of incidental catch landed by species in the runaround net striped mullet fishery reported through the North Carolina Trip Ticket Program, 2017–2021.

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