# SKIMMER TRAWL MODIFICATIONS TO REDUCE BYCATCH IN THE INSHORE BROWN AND PINK SHRIMP FISHERY IN NORTH CAROLINA

Final Report for

S-K Project 93-SEO-049

to

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**Abstract-**A study was conducted during May-June 1995 comparing catch composition of a standard high profile skimmer trawl net (12 ft) and a low profile skimmer trawl net (3 ft) in the North and Newport Rivers, North Carolina. Each gear type was alternately rigged on the port and starboard sides of a commercial shrimping vessel and the catch was sampled according to criteria established by the Southeast Area Monitoring and Assessment Program. The objective of the study was to determine if modifying skimmer trawl nets by decreasing the vertical height of the net would lower bycatch rates, yet maintain shrimp catch. Total shrimp catch in the low profile net was significantly lower than that in the control net (-32.9%, p = 0.0001), and significantly lower for brown shrimp (*Penaeus aztecus*) by -39.1% (p = 0.0001), but pink shrimp (*P. duorarum*) catches were not significantly different (-17.1%, p = 0.1934). In the sample, weight of finfish biomass to total catch biomass excluding debris was similar (47.5% finfish in the low profile net and 44.8% finfish in the high profile net). The low profile net was not effective in reduction of bycatch under most conditions. Because of increased catch rates of brown shrimp by the high profile net, results suggest that shrimpers may find it advantageous to utilize a high profile skimmer net during the brown and pink shrimp seasons, rather than a low profile net. Also, the low profile net may be advantageous to fishermen under conditions of: (1) high wind, (2) shrimping in areas where tight turns are mandated, (3) presence of large amounts of floating debris, and (4) shallow water.

## Introduction

In the southeastern United States, the commercial shrimp fishery (family Penaeidae) is the most valuable in terms of U.S. dollars. In 1994, shrimp catch in the Gulf and South Atlantic regions totaled 106,654 metric tons valued at $531 million (U.S. National Marine Fisheries Service 1995). In 1995, North Carolina's shrimp catch had an estimated value of more than $8 million (N.C. Division of Marine Fisheries 1996). The bulk of North Carolina shrimp trawling (85%) occurs in the sounds, bays and estuaries inshore of the barrier islands; these areas are prime nursery habitats for juvenile fish (Hines et al. 1993). Consequently, shrimp harvest by trawling in inshore waters often includes catches of juvenile fishes in substantial numbers.

The bycatch of juvenile fishes and other ecologically important species in commercial fisheries has become an important issue to commercial and sport fishermen, environmentalists and fishery managers (Murray et al. 1992). Bycatch is defined as the incidental, usually unwanted, mix of species caught when trawling for another species (Rulifson et al. 1992). Bycatch varies daily, seasonally and by location.

Results from the Cooperative Research Program addressing finfish bycatch in the Gulf of Mexico and South Atlantic shrimp fisheries show a finfish to shrimp weight ratio of 2.3:1 and a total number of organism ratio of 1.6:1 (NMFS, 1995). Additionally, the capture of sea turtles as bycatch during shrimp trawling is also an important bycatch issue.

In North Carolina, reduction of bycatch in the shrimp trawl fishery has been a priority of the Marine Fisheries Commission since 1992, when the Director of the North Carolina Division of Marine Fisheries established mandatory bycatch reduction device (BRD) requirements for shrimp trawls, the first rule of its type in U. S. coastal states. More recently, more comprehensive BRD requirements have been established in order to comply with the Amendment 3 provisions of the Atlantic States Marine Fisheries Commission's Weakfish Fishery Management Plan (Lockhart, et al., in press). This plan requires steps be taken by its member states to reduce bycatch by 50% by the 1996 shrimp season.

To address the bycatch issue, researchers from the NC Sea Grant College Program imported skimmer trawl technology from Louisiana in 1991 in the belief that the design inherently reduces finfish catches while shrimp losses remain minimal. The initial designs were tested in North Carolina coastal waters during the summer of 1991. The skimmer trawl proved to be an effective bycatch reducer while still retaining shrimp catch, and by the fall of 1991, commercial fishermen were converting to the skimmer design after observing increased catches of white shrimp (*Penaeus setiferus*) with minimal bycatch (Coale et al. 1994).

Skimmer trawls have advantages over traditional otter trawls because fishermen can continue to shrimp while the tailbag is being retrieved, thereby allowing a more frequent retrieval rate which reduces culling time for the fishermen and reduces bycatch mortality. Coale et al. (1994) used standard height (12 ft.) skimmer nets, which resulted in a reduction of finfish bycatch per pound of white shrimp by a ratio of 1.4:1 compared to 12.5:1 of a standard otter trawl. The effectiveness of full-sized skimmer nets on reducing bycatch while harvesting brown shrimp (*P. aztecus*) was inconclusive (total season average of 7.6:1 skimmer versus 8.4:1 otter). In Carteret County, North Carolina the number of skimmer trawls has increased from zero at the beginning of the 1991 season, to between 70 and 80 boats expected for the summer 1996 shrimping season (Paul Biermann, Beaufort, NC, personal communication). A few fishermen use skimmer trawls for all three commercial shrimp species -- white, brown and pink (*P. duorarum*) -- while most use skimmer trawls only for white shrimp because they tend to remain active higher in the water column than pinks and browns, which tend to remain closer to the bottom (Winkham and Minkler 1975). In order to compensate for white shrimp behavior, commercial shrimpers using otter trawls often attach floats to the headrope to keep the headrope higher in the water column.

The objective of the study described herein was to determine if modifying skimmer trawl nets by decreasing the vertical height of the net would further reduce bycatch rates while maintaining shrimp catch. Analyses compared high profile skimmer net catches to catches of low profile nets with regard to: (1) the amount of bycatch, (2) the amount of shrimp, (3) the composition of bycatch, and (4) increased fuel efficiency due to reduced drag of the smaller experimental net. Results should indicate if low profile skimmer trawl nets are practical for commercial applications.

## Site Description

Skimmer trawl nets were tested in inshore waters near Beaufort, North Carolina. One site was the Newport River (approximate location $34^{o}45'$N, $76^{o}42'$W), and in the North River ($34^{o}44'$N, $76^{o}36'$W) during May-June 1995 (Figure 1). The fishing locations were chosen by the industry partner and were consistent with the fishing patterns of the local inshore fleet. Twenty-seven (27) tows were taken after dusk in the North River and 15 in the Newport River. Recorded water depths were 0.58-1.83 m in the Newport River and 0.5-1.33 m in the North River. Both sites are primary nursery areas for juvenile finfish. Bottom topography is generally denoted by a gradual increase or decrease in depth. Bottom substrate consists primarily of sandy mud with limited submerged aquatic vegetation.

## Methods

The vessel for the study was the 28 ft *Shark's Tooth* docked in Beaufort, North Carolina. The vessel was a fiberglass hull construction powered by a 165-HP Volvo AQAD40B diesel engine with 2.5:1 transmission, a Volvo-Penta duoprop outdrive with a 18-in diameter three bladed propeller (nine in pitch), and a 15-in diameter four bladed propeller (nine in pitch). Vessel speed while towing was approximately 2.5 knots.

The skimmer trawl rigging used in the study (Figure 2) was based upon a Louisiana design (Coale et al. 1994) but modified for a North Carolina shrimp boat. The skimmer frame was constructed of tubular 1.5-in round Schedule 80 aluminum. The aluminum shoe, located on the outward end of the frame, was 3 ft long by 2 ft wide. Nets were attached to the frames by rope at each corner of the frame for the control net, except for the lower inboard corner. Here the net was attached to a 165 lb. steel sled. The upper outboard corner of the experimental net was connected to the frame by measuring upward 3 ft from the bottom of the frame. The lower inboard corner also was attached to the sled. This configuration allowed the frame to skim along the bottom as the shoe followed bottom topography. Frames were raised and lowered by the same winch system that retrieved the tailbag. Details of construction and operation of skimmer trawls were previously published (Coale 1993; Hines et al. 1993).

Both the high profile skimmer net (12-ft sides) and experimental net (3-ft sides) were of two seam design, constructed of green polyethylene with a stretched mesh size in the trawl body of 1 3/4 in or 1 1/2 in, and 1 1/2 in mesh size in the cod end (Figure 3). The headrope length in the low profile net measured 19 ft 0 in, and 16 ft 0 in, in the high profile net. Different headrope lengths were a function of the construction a "kick out" at the bottom of the frames that caused differences in attachment points, but the mouth of the nets when towing varied only by height. The high profile net was the industry standard at the time of skimmer trawl introduction into North Carolina, and served as the control net for our study. The length of the tickler chain varied during the study, a common procedure on skimmer trawls to increase shrimp catch rates during the season. The tickler chain length was changed in both nets at the same time with the assumption that the catch rates between the two nets would remain similar. Tickler chain lengths initially were 27 ft 4 in beginning May 30, then changed to 26 ft 8 in on June 4, 27 ft 8 in on June 6, 25 ft 8 in on June 11 (changed attachment point to front of the inboard sled weight), and finally 25 ft 10 in on June 21. The diameter of the tickler chain link for both nets was 3/16 in. Loop chain links attached to the footrope were 3/16 in diameter, with eight loops per net and 16 links per loop. After June 18, the number of loops per net was decreased to four. Lazy lines were attached to the top of the tailbag by an elephant ear for winch assisted retrieval. Neither net included a turtle excluder device (TED) because tow times were scheduled for 55 minutes per tow, thus exempting the skimmer trawl from the TED requirement (U.S. Office of the Federal Register 57:84 (1992): 18446-18461). During the study, data were gathered from 42 of 50 tows. Catches from the remaining eight tows were not analyzed because of low catch or gear fouling.

Sampling was conducted following Southeast Area Monitoring and Assessment Program (SEAMAP) protocol for evaluation of bycatch reduction devices. Towing positions (port or starboard) for the control net (12 ft vertical height) and experimental net (3 ft vertical height) were alternated daily (with one exception due to a cracked frame) to eliminate possible bias in catch due to position. The skimmer trawl tailbag was emptied approximately every 55 minutes. Tow times, water depth, and boat position (lat. and long.) were recorded from the initial set time of the trawl, to the time at which trawl retrieval was initiated. The entire catch was weighed (nearest 0.25 kg) immediately after retrieval. As per SEAMAP protocol, the catch was subsampled and separated by targeted shrimp species (brown and pink shrimp), crustaceans (predominantly blue crabs and mantis shrimp), invertebrates (jellyfish, oysters, clams, and squid), debris (mud, wood, plants, aluminum cans, etc.), and fish species. Subsampling required mixing the catch of each net, separating the catch into four approximately equal portions, and randomly removing 3-6 kg (one large snowshovel) of the catch from one section of one portion. The remainder of this portion, and the other three portions, were recombined, shrimp were culled, and the bycatch was discarded overboard. This subsampling procedure resulted in smaller subsamples than required by the SEAMAP protocol, but was necessary due to large numbers of juvenile finfish in the catch. Shrimp were identified by species, counted, and weighed (discarded shrimp were considered unmarketable). However, for selected commercially and recreationally valuable fish species (weakfish *Cynoscion regalis*, summer flounder *Paralichthys dentatus*, southern flounder *Paralichthys lethostigma*, and Atlantic menhaden *Brevoortia tyrannus* ), all individuals were removed from the total catch; because few individuals of these species were present in total catches, the "subsample weights" and "subsample numbers" were extrapolated. This protocol was used for Tows 17-50. For all other fish species, each individual in the subsample was identified, counted and weighed. Sea turtles captured by the nets were identified, measured (carapace length and width), tagged, and released in an undisturbed area.

In order to document whether the low profile skimmer net offered fuel economy advantages over the traditional skimmer net, fuel consumption was compared on July 5 and 6 in the Newport River. A Flowscan fuel flow meter was used to monitor the amount of fuel burned. The skimmer vessel was rigged alternately on each of two successive nights with the two different size skimmer nets to minimize environmental variables. Weather conditions remained stable for both nights as the nets were pushed for three tows each night for approximately one hour from 2016 hr. to 2312 hr. on July 5 (low profile net), and from 2015 hr. to 2318 hr. on July 7 (high profile net).

Data were entered into the mainframe computer at East Carolina University and analyzed using SAS statistical software (SAS Institute 1990). Comparisons between the high profile and low profile skimmer nets included: (1) total shrimp weight by net type; (2) total shrimp weight of brown and pink shrimp; (3) proportion of shrimp biomass of the total catch; (4) relative abundance of biomass by species; and (5) relative abundance in numbers by species of finfish bycatch.

## Results

### *Project Considerations*

During the study, three factors may have affected study results: towing direction during sampling, steering difficulties caused by the drag differential between the high profile and low profile skimmer trawl nets, and water depth. In the study area, most of the shrimp fleet establishes either a clockwise or counterclockwise trawling pattern to minimize collisions and/or prevent gear entanglement. This may have affected the shrimp catch because the boat could not cross the designated line that separated legal shrimping areas from protected sites in both study areas. In general, boats attempt to position themselves as close as possible to the line so they can capture shrimp as they swim with the tides in the estuary. Therefore, it is reasonable to assume that the net positioned closer to the line may catch a higher ratio of shrimp (mainly on an outgoing tide). However, statistical comparisons between port and starboard nets indicated a nonsignificant (1.0%) difference. Consequently, any potential bias caused by net position and tow direction was minimal.

Steering difficulties were evident only in deeper portions of the Newport River study area. The deeper water substantially increased the amount of drag on the vertically-higher control net, which caused the boat to pull toward the control net side. As a consequence of the steering problem, occasionally the boat captain was unable to establish a trawling pattern next to the legal shrimping area line. For two nights, a sea anchor (4 ft x 4 ft) was attached to the outer frame of the experimental net by approximately 20 feet of rope in an effort to counteract the difference in drag. This procedure did decrease the drag differential but steering ability remained minimal (essentially straight) so the sea anchor was removed. Under commercial shrimping conditions, the skimmer frames occasionally are raised out of the water to facilitate tight turns.

Another factor that may have influenced study results was water depth during sampling. For example, if the water depth was < 1 m near the beginning of a tow, both nets were sampling the entire water column, but as the tow continued water depth increased, so that the experimental net was completely submerged. For scientific purposes it would be advantageous if water depth was constant, however, this study was conducted under commercial shrimping conditions and water depth fluctuation was not a controllable variable.

***Shrimp Catch Comparisons***

Total shrimp catch in the low profile net was lower than that in the control net, but was significantly lower only for brown shrimp. The total shrimp weight, including discards, caught during the study was 344.4 kg, but the experimental net caught only 138.6 kg for a 32.9% difference in total shrimp biomass (Table 1). For brown shrimp, catches in the low profile net totaled 78.3 kg compared to 128.5 kg in the control net, a significant ($p=0.001$) change in biomass of 39.1%. Pink shrimp catches in both nets were small and not significantly different (Table 1).

The proportion of shrimp biomass comprising the total catch for each net was similar between gear types (t-test, $p = 0.10$). Catches of all shrimp, including discards, in the low profile net comprised an average of 24.4% $\pm$ 0.09 of the total catch compared to control net catches, which averaged 28.2% $\pm$ 0.11.

*Finfish Bycatch*

In the sample, weight of finfish biomass to total catch biomass excluding debris was similar: 2.1:1 in the low profile net (47.5% finfish) and 2.2:1 (44.8%) in the high profile net. This difference is not due to increased finfish biomass but rather a decrease in shrimp in the low profile net. In Table 2, the total sample finfish weight (123.6 kg) was only 5% (3.2 kg) less in the low profile net. For economically important species, the low profile net captured a higher percentage of Atlantic menhaden (+66.0%) and spot (+19.4%), but neither change was statistically significant ($p = 0.08$ and 0.53, respectively). Atlantic croaker biomass was less by 17.9% in the low profile net, but this change was not statistically significant ($p=0.71$). Refer to Table 3 for overall species identification and percentage of total sample biomass.

Three finfish species were predominant by number in both the high and low profile nets (Table 4). The low profile net caught 30.6% more spot, 11.9% more Atlantic croaker, and 45.2% more striped and bay anchovies. The largest decrease in number occurred with Atlantic silversides (-97.3%), but the sample size was small in the low profile net.

*Catch Composition*

In the subsample, the percent shrimp composition of the total catch (including debris) was 29.2% shrimp mass in the low profile net and 31.4% in the high profile net., a difference of only 2.2%. This indicates that changes in catches involved all species and that the resulting catch composition was similar. This shrimp percentage of the sample is ±5% different from the previous comparison of the total shrimp catch, indicating the sampling technique was representative.

An observation that both nets were fishing equally include the percent of crustaceans (16.9% low profile net, 15.3% high profile net) and debris (9.3% low profile net., 12.4% high profile net) from the sample. These slight differences in bottom-oriented catch suggests that both nets were effectively skimming along the substrate.

*Fuel Economy*

There was no discernible difference in fuel economy between the two nets during the three trials of each net on successive nights. Equipped with experimental nets, the boat engine burned a total of 4.8 gallons (average 1.64 gallons/hour) during the three-hour test period. With the control nets mounted on the skimmer frames, fuel consumption was 4.9 gallons (average 1.61 gallons/hour).

*Sea Turtle Data*

While trawling in the North River, one Kemp's Ridley sea turtle (*Lepidochelys kempi*) was captured alive in the control net. The turtle was conscious and in good condition. Turtle size was 4.75 kg total weight with a curved carapace length of 31.5 cm and width of 32 cm. A metal tag (NMFS #151) was attached to the front left flipper. The turtle was held onboard to avoid recapture by other shrimp boats in the area, then released at approximately lat./long. 34°44'N, 76°36'W as the boat left the shrimping grounds.

## Discussion

Before discussing bycatch reduction, the first consideration should be whether the shrimp loss difference between the high and low profile skimmer trawl nets is at a level acceptable to the commercial shrimping industry. Realistically, if the shrimp catch loss is too high, it would not be an economically viable alternative for commercial shrimpers. Examination of the data between the two net types indicates that shrimp loss was significant (-32.6%), with the exception of pink shrimp (-17.1%). A 30% loss of marketable shrimp over the course of the shrimping season translates to an economic loss in the thousands of dollars, and would not be considered an economically viable option.

At the same time, the low profile net did not reduce bycatch biomass significantly. This trend has been observed in other studies. Christian et al. (1993) tested a low profile otter trawl compared to a standard otter trawl and obtained results similar to this investigation. Watson et al. (1993) reported that the use of a low profile net to reduce bycatch may be limited. Results from this study does support their findings.

In the 1991 comparison between a skimmer and otter trawl, problems associated with gear development and shrimping in non-comparable areas (the otter trawl captain trawled for several nights in a channel where the skimmer was unable to effectively shrimp) made effectiveness comparisons inconclusive for pink and brown shrimp. When the skimmer gear was operating properly and the vessels were shrimping in comparable waters, the brown and pink shrimp catch was low, but the catch rates between the gears were similar.

In recent years, the inshore shrimping fleet typically uses an otter trawl during the early and mid-Summer periods for brown and pink shrimp and switches to skimmer gear in late Summer as white shrimp arrive. The shrimpers reason that brown and pink shrimp associate with the bottom and a high relief net is not necessary. Additionally, an otter trawl is a more versatile gear if they need to follow shrimp to deeper waters or channels. By contrast, white shrimp are known to associate higher in the water column and previous research and recent practice has demonstrated the skimmer's effectiveness for catching white shrimp. Since the high and low profile nets were fishing similarly, one needs to contemplate possible explanations as to why such a significant shrimp loss occurred in the low profile net. One possibility is that brown and pink shrimp were locating higher in the water column on an outgoing tide (Rulifson, 1980), thereby avoiding capture in the low profile net. The inshore fleet in the area typically shrimps on "the line" and harvests shrimp as they move from the nursery area, a closed area, into the rivers and sounds. Brown and pink shrimp may locate higher in the water column while moving on an outgoing tide, thus avoiding capture.

Another explanation may be the relative affect of drop back between the two nets. Although the drop back is similar between the two nets (~8 ft), it is possible that shrimp may jump before encountering the tickler chain and a percentage of the shrimp will randomly jump forward and over the 3 ft headrope in the low profile net. In the high profile net shrimp would still be captured. A related explanation is that the 3 ft height of the headrope was too short and that those shrimp jumping forward and over the net would have been retained by a higher headrope. Since the conception of this project, several area shrimpers have installed an otter trawl net by tying it into a skimmer frame. They used a 4 ft vertical headrope and have reported satisfactory catches. Nevertheless, results from this study suggest that the inshore fleet in the area should consider utilizing high profile skimmer nets during the brown and pink shrimp seasons.

More specifically, comparison of bycatch results for this study and a previous North Carolina skimmer trawl study can be made. In the Coale et al. (1994) study, bycatch from a standard otter trawl was compared to a standard high profile skimmer trawl. Even though the Coale study was conducted in June-August 1991, it was conducted in the same area (± 5 mi.) as the current study. Spot, pigfish, and lizardfishes comprised larger proportions of the catches in the standard shrimp trawl than observed in skimmer trawls (Table 5). Atlantic croaker, Atlantic cutlassfish, and sharks had a higher percentage biomass in the current study than in the Coale et al. (1994) study. This may be a result of changes in the estuarine finfish community over time. Anchovies were the only species captured by skimmer trawls with a higher biomass than otter trawls.

Results from fuel economy testing indicates there was no distinguishable difference in fuel consumption between the low and high profile nets. Possible reasons for this included: (1) the amount of fuel burned by the vessel was too low to distinguish differences caused by the extra mesh in the high profile trawl; and (2) the area where the fleet was shrimping (Newport River) was too shallow (< 6 ft.) to determine the full differences in drag between a 12 ft. and 3 ft. net. In general, the low amount of fuel consumed (1.6 gallons/hr.) was a positive result demonstrating the economic benefits for skimmer trawls.

The capture of an endangered Kemp's Ridley sea turtle (*Lepidochelys kempi*) illustrates the importance of shorter towing times that is not only possible, but practical with skimmer trawls. When skimmer trawls are retrieved at shorter intervals, the chance of survival for the turtle increases. Also, commercial shrimpers realize that reduced mortality of sea turtles is imperative to improve the public's perception of the shrimping industry.

Results from the study indicate it would not be practical to use low profile skimmer trawl nets on a constant basis. When the only considerations are to maximize the catch or fuel economy, then the experimental nets are not an efficacious choice. However, in certain circumstances it could be advantageous for commercial shrimpers to rig their boats with lower nets. These situations might include: (1) when high winds create aerodynamic drag and effect shrimping efficiency, (2) shrimping in small estuarine areas where tight turns are mandated, (3) in shallow waters making taller nets an additional cost, (4) in waters with large amounts of floating debris (submerged nets reduce clogging) and (5) when operating a vessel alone, shorter nets are less cumbersome to rig and store. Increases in the number of skimmer trawls operating in North Carolina's inshore shrimping grounds will probably continue as vessels convert from otter trawls to skimmer trawls.

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Figure 1.--Map of the North and Newport River study areas in N.C.

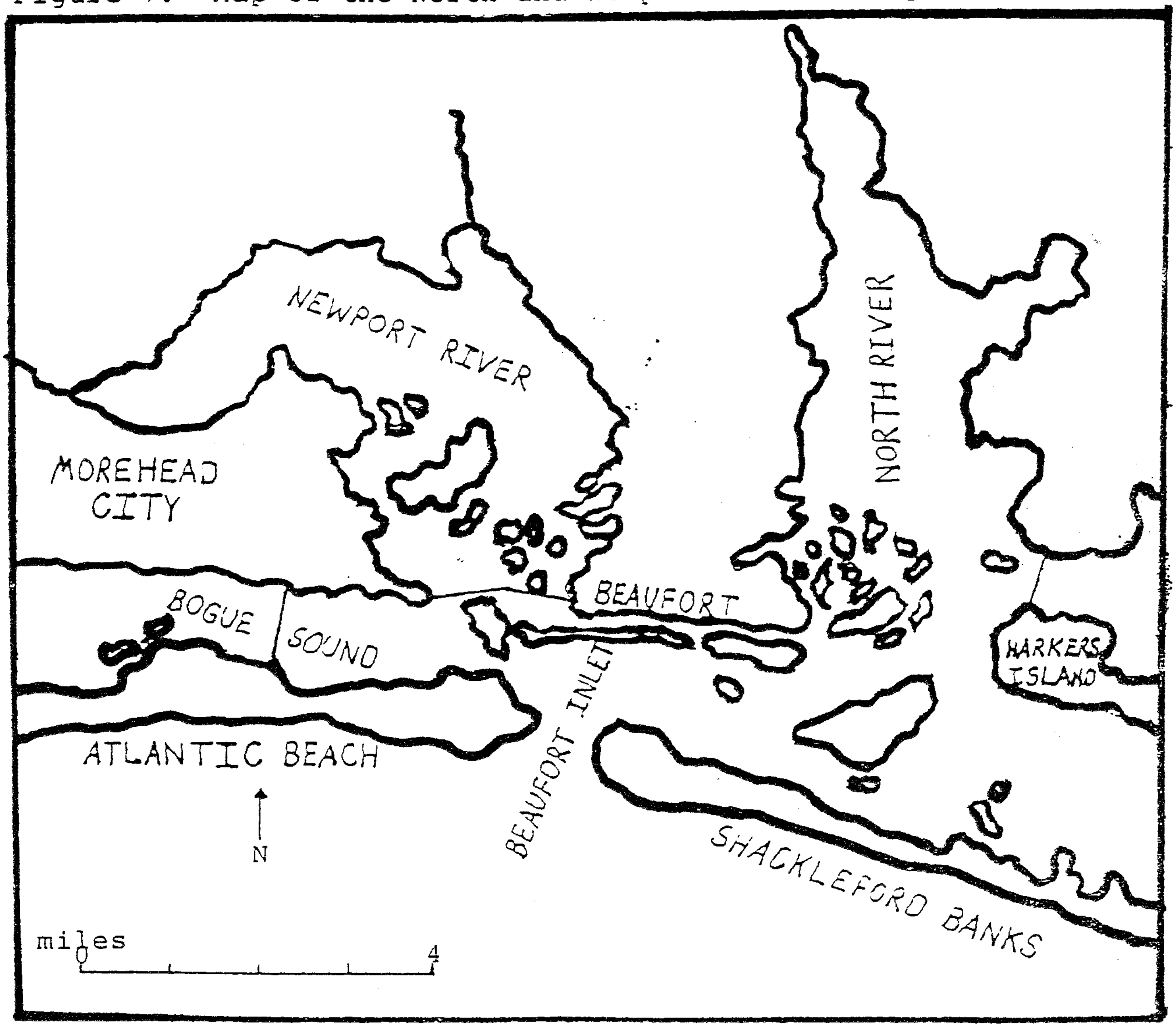


Figure 2.--Diagram of a typical North Carolina skimmer trawl. From Coale et al.(1993).

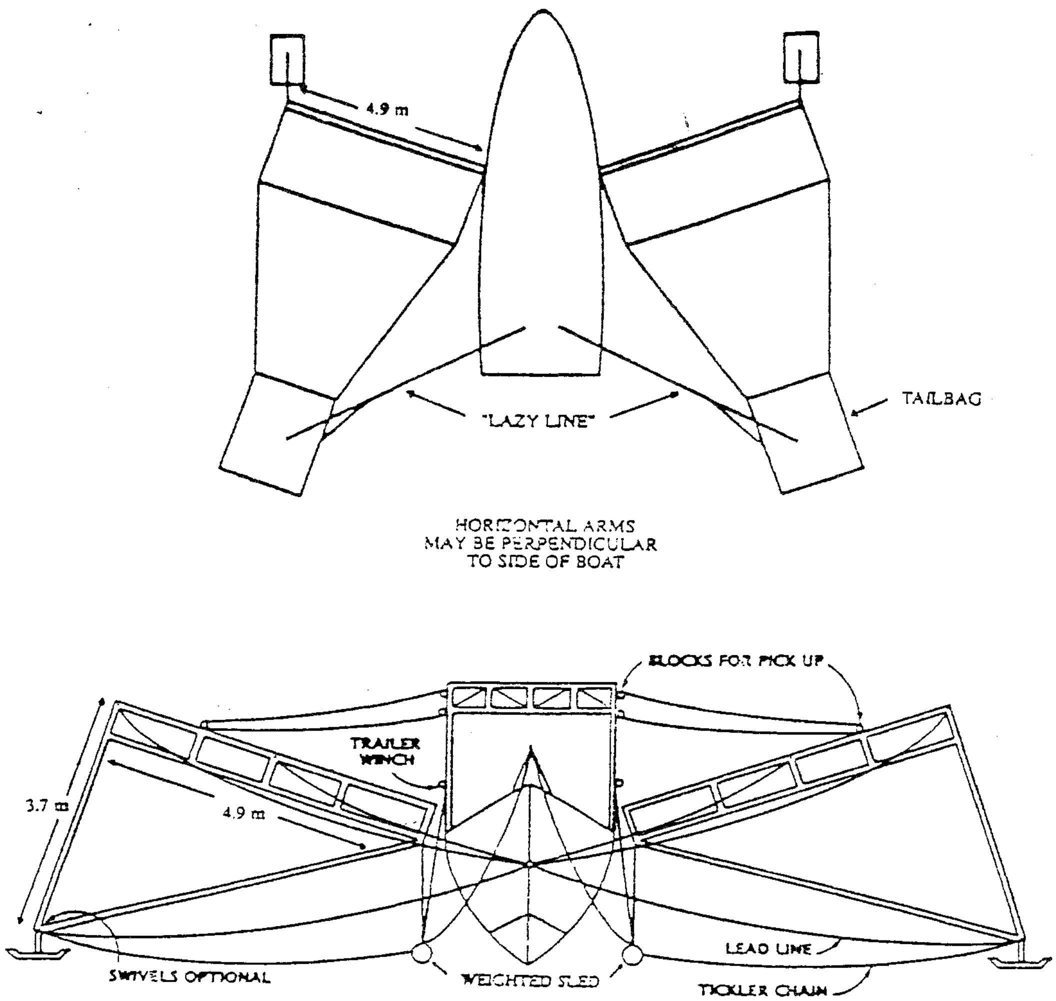
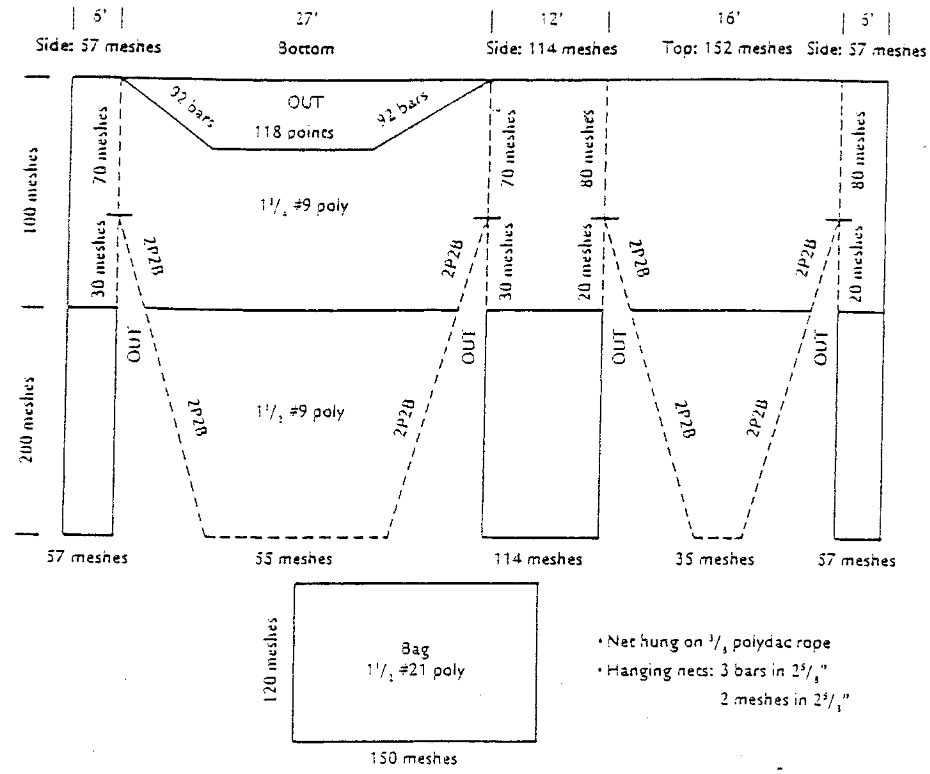


Figure 3.--Schematic of high profile and low profile skimmer nets.

## High Profile Skimmer Net




## Low Profile Skimmer Net

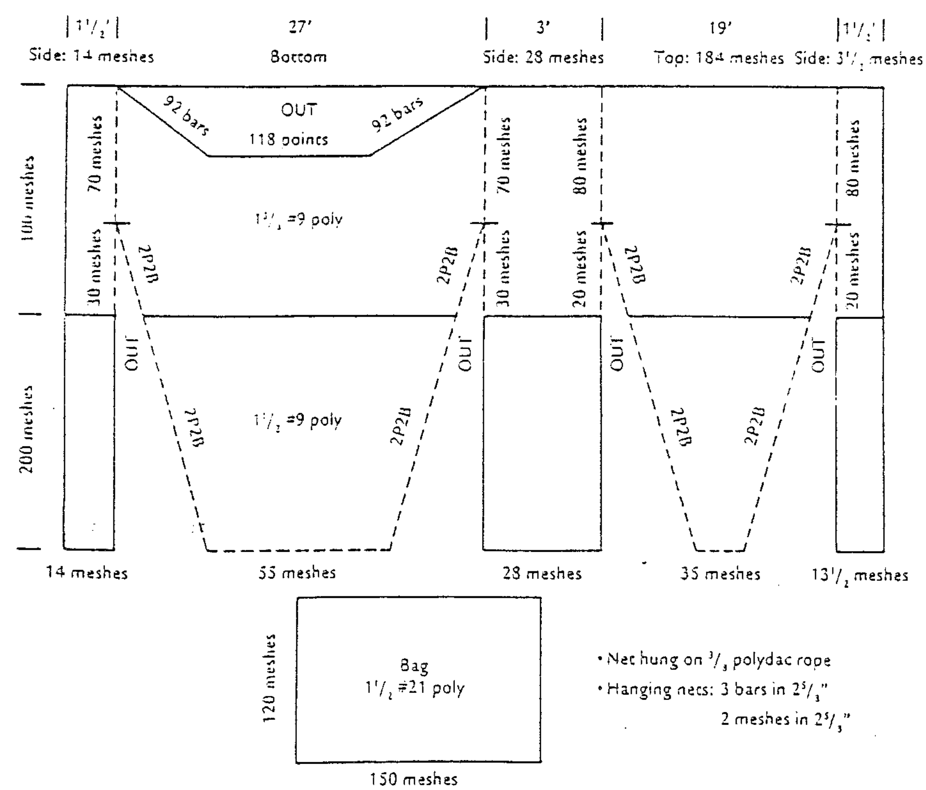


Table 1.--Shrimp catch comparisons of high and low profile skimmer nets in the Newport and North Rivers, in 1995 using the F-test.

| Category | No. of tows | Total shrimp wt. | Shrimp biomass (kg) Low profile | High profile | Difference (kg) | % change | P value |
|---|---|---|---|---|---|---|---|
| All shrimp, including discards | 42 | 344.4 | 138.6 | 205.8 | 67.2 | -32.6 | 0.0001 |
| Brown shrimp | 36 | 206.8 | 78.3 | 128.5 | 50.2 | -39.1 | 0.0001 |
| Pink shrimp | 36 | 26.7 | 12.1 | 14.6 | 2.5 | -17.1 | 0.1934 |

Table 2.--Finfish biomass by weight of commercially and recreationally valuable finfish from low and high profile skimmer trawl nets in the North and Newport Rivers, North Carolina, in 1995.

| Species | Total wt. | Finfish biomass in sample (kg)<br>Low profile | High profile | Difference | % Change |
|---|---|---|---|---|---|
| All finfish | 123.6 | 60.2 | 63.4 | 3.2 | -5.0 |
| Atlantic menhaden | 2.4 | 1.8 | 0.6 | 1.2 | +66.6 |
| Weakfish | 1.0 | 0.3 | 0.7 | 0.4 | -57.1 |
| Spot | 29.8 | 16.5 | 13.3 | 3.2 | +19.4 |
| Southern flounder | 0.8 | 0.3 | 0.5 | 0.2 | -40.0 |
| Summer flounder | 0.3 | 0.2 | 0.1 | 0.1 | +50.0 |
| Bluefish | 0.8 | 0.4 | 0.4 | 0.0 | 0.0 |
| Atlantic croaker | 24.4 | 11.0 | 13.4 | 2.4 | -17.9 |

Table 3.--Relative abundance (%) of biomass by species from low and high profile skimmer trawl nets in the North and Newport Rivers, North Carolina, in 1995.

| | | Percent of biomass | |
|---|---|---|---|
| Common name | Scientific name | Low profile net | High profile net |
| Brown shrimp | *Penaeus aztecus* | 21.3 | 25.4 |
| Crustaceans | - | 18.6 | 17.4 |
| Spot | *Leiostomus xanthurus* | 13.0 | 9.4 |
| Atlantic croaker | *Micropogonias undulatus* | 8.7 | 8.3 |
| Discarded shrimp | - | 7.0 | 5.2 |
| Pink shrimp | *Penaeus duorarum* | 5.3 | 5.1 |
| Atlantic cutlassfish | *Trichiurus lepturus* | 5.0 | 7.4 |
| Striped and bay anchovy | *Anchoa hepsetus, A. mitchilli* | 4.0 | 2.1 |
| Atlantic stingray | *Dasyatis sabina* | 2.9 | 1.1 |
| Sharks | - | 2.6 | 2.8 |
| Cownose ray | *Rhinoptera bonasus* | 1.8 | < 1 |
| Pinfish | *Lagodon rhomboides* | 1.6 | 3.2 |
| Atlantic menhaden | *Brevoortia tyrannus* | 1.3 | < 1 |
| Alewife | *Alosa pseudoharengus* | < 1 | < 1 |
| American eel | *Anguilla rostrata* | < 1 | < 1 |
| Silver perch | *Bairdiella chrysoura* | < 1 | < 1 |
| Crevalle jack | *Caranx hippos* | < 1 | < 1 |
| Horse-eye jack | *Caranx latus* | < 1 | < 1 |
| Black sea bass | *Centropristis striata* | < 1 | < 1 |
| Spadefish | *Chaetodipterus faber* | < 1 | < 1 |
| Striped burrfish | *Chilomycterus schoepfi* | < 1 | < 1 |
| Bay whiff | *Citharichthys spilopterus* | < 1 | < 1 |
| Spotted seatrout | *Cynoscion nebulosus* | < 1 | < 1 |
| Silver seatrout | *Cynoscion nothus* | < 1 | < 1 |
| Weakfish | *Cynoscion regalis* | < 1 | < 1 |
| Bluntnose stingray | *Dasyatis sayi* | < 1 | < 1 |
| Threadfin shad | *Dorosoma petenense* | < 1 | < 1 |
| Ballyhoo | *Hemiramphus brasiliensis* | < 1 | < 1 |
| Southern kingfish | *Menticirrhus americanus* | < 1 | < 1 |
| Atlantic silverside | *Menidia menidia* | < 1 | < 1 |
| Planehead filefish | *Monacanthus hispidus* | < 1 | < 1 |
| Striped mullet | *Mugil cephalus* | < 1 | < 1 |
| Summer flounder | *Paralichthys dentatus* | < 1 | < 1 |

(Table 3 -- Continued)

Table 3.--Relative abundance (%) of biomass by species from low and high profile skimmer trawl nets in the North and Newport Rivers, North Carolina, in 1995.

| | | Percent of biomass | |
|---|---|---|---|
| Common name | Scientific name | Low profile net | High profile net |
| Southern flounder | *Paralichthys lethostigma* | < 1 | < 1 |
| Four-spot flounder | *Paralichthys oblongus* | < 1 | < 1 |
| Harvestfish | *Peprilus alepidotus* | < 1 | < 1 |
| Butterfish | *Peprilus triacanthus* | < 1 | < 1 |
| Bluefish | *Pomatomus saltatrix* | < 1 | < 1 |
| Northern searobin | *Prionotus carolinus* | < 1 | < 1 |
| Striped searobin | *Prionotus evolans* | < 1 | < 1 |
| Northern puffer | *Sphoeroides maculatus* | < 1 | < 1 |
| Scup | *Stenotomus chrysops* | < 1 | < 1 |
| Blackcheek tonguefish | *Symphurus plagiusa* | < 1 | < 1 |
| Inshore lizardfish | *Synodus foetens* | < 1 | < 1 |
| Northern pipefish | *Syngnathus fuscus* | < 1 | < 1 |
| Hogchoker | *Trinectes maculatus* | < 1 | < 1 |

Table 4.--Relative abundance (%) in numbers, by species, in the finfish bycatch subsamples collected from the North and Newport Rivers, North Carolina, in 1995.

| | Low profile net | | High profile net | | |
|---|---|---|---|---|---|
| Species | Number | Catch (%) | Number | Catch (%) | % Change |
| All species[a] | 6899 | 100 | 5207 | 100 | +24.5 |
| Spot | 2958 | 42.9 | 2053 | 39.4 | +30.6 |
| Striped and bay anchovy | 1704 | 24.7 | 934 | 17.9 | +45.2 |
| Atlantic croaker | 1433 | 20.8 | 1263 | 24.2 | +11.9 |
| Pinfish | 209 | 3.0 | 224 | 4.3 | -6.7 |
| Atlantic cutlassfish | 163 | 2.4 | 220 | 4.2 | -25.9 |
| Atlantic menhaden | 53 | 0.8 | 29 | 0.6 | +45.3 |
| Pigfish | 53 | 0.8 | 51 | 1.0 | +3.7 |
| Striped searobin | 43 | 0.6 | 61 | 1.2 | -29.5 |
| Inshore lizardfish | 39 | 0.6 | 12 | 0.2 | +69.2 |
| Blackcheek tonguefish | 33 | 0.5 | 26 | 0.5 | +21.2 |
| Atlantic silverside | 2 | <0.1 | 75 | 1.4 | -97.3 |
| Silver perch | 8 | 0.1 | 41 | 0.8 | - 80.2 |

[a]Species not listed comprised less than 1% of finfish bycatch in both nets

Table 5.--Comparison of bycatch biomass of the most abundant species collected by Coale et al. (1994) in 1991 and this study (1995).

| | Percent of total biomass | | | |
|---|---|---|---|---|
| | Coale study | | Current study | |
| Species | Control otter trawl | High profile standard skimmer | High profile standard skimmer | Low profile skimmer |
| Spot | 16.8 | 10.33 | 8.2 | 11.8 |
| Crustaceans[a] | 16.5 | 12.1 | 15.3 | 16.9 |
| Pinfish | 6.4 | 8.1 | 2.8 | 1.5 |
| Pigfish | 4.1 | 1.7 | 1.8 | 1.3 |
| Atlantic croaker | 2.6 | 0.9 | 8.3 | 12.9 |
| Lizardfishes[a] | 2.0 | .0.7 | 0.1 | 0.2 |
| Atlantic menhaden | 1.5 | 6.0 | 0.4 | 1.2 |
| Sharks[a] | 1.2 | 0.8 | 2.4 | 2.3 |
| Anchovies[a] | 0.6 | 1.1 | 1.8 | 3.6 |
| Atlantic cutlassfish | 0.0 | 0.5 | 6.5 | 4.5 |

[a]Species composition may vary.