The Skimmer Trawl

IN NORTH CAROLINA ESTUARIES

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Acknowledgments

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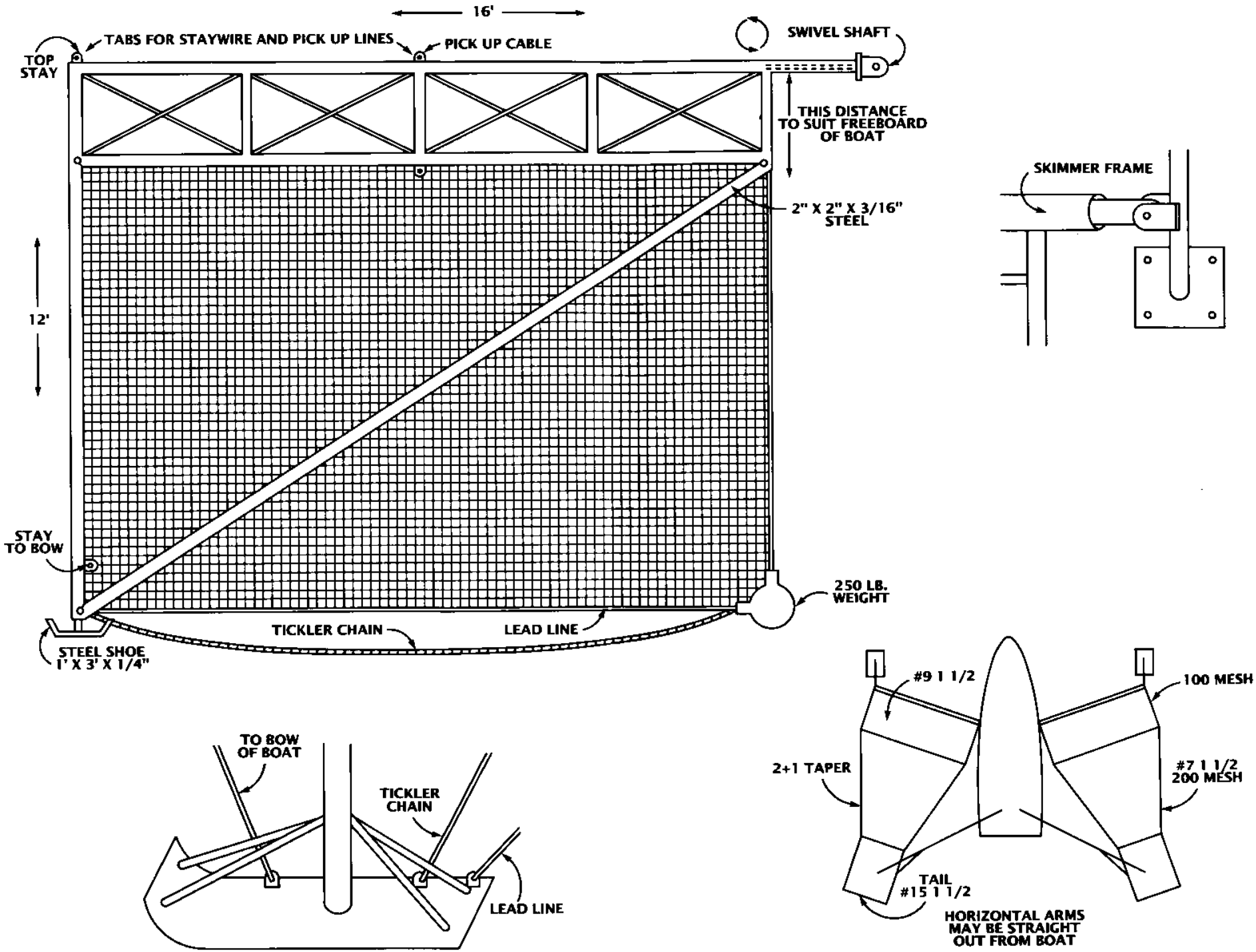
16'
TABS FOR STAYWIRE AND PICK UP LINES
PICK UP CABLE
SWIVEL SHAFT
TOP STAY
THIS DISTANCE TO SUIT FREEBOARD OF BOAT
2" X 2" X 3/16" STEEL
12'
SKIMMER FRAME
STAY TO BOW
250 LB. WEIGHT
TICKLER CHAIN
LEAD LINE
STEEL SHOE 1' X 3' X 1/4"
TO BOW OF BOAT
TICKLER CHAIN
LEAD LINE
#9 1 1/2
100 MESH
2+1 TAPER
#7 1 1/2 200 MESH
TAIL #15 1 1/2
HORIZONTAL ARMS MAY BE STRAIGHT OUT FROM BOAT

THE TROUBLE WITH BYCATCH

The commercial shrimp fishery is the most valuable fishery in the Southeast. More than 266 million pounds of shrimp — valued at $478 million — were harvested in the Gulf and South Atlantic regions in 1991. Shrimp fishermen typically use the traditional otter trawl, a highly unselective type of gear that catches a variety of other finfish and shellfish species. These other species, known as bycatch, are the incidental and usually unwanted (unmarketable) mix of species caught when trawling for a targeted catch.

Bycatch of the shrimp fishery has become an important issue to commercial fishermen and sportfishermen, environmentalists and fishery managers. It has been reported that between 4 and 6 pounds of juvenile finfish are discarded for every pound of shrimp caught. Bycatch studies have reported that 2.8 to 18 pounds of finfish — often unmarketable because of the size and/or species — are caught for each pound of shrimp.

In North Carolina, about 85 percent of shrimping takes place in inshore waters, bays and estuaries, which are also prime habitats for juvenile fish. After a typical 90-minute tow using an otter trawl, the bycatch survival rate is poor. Young fish are vulnerable because of net entanglement, time spent in towing and hauling back the gear, and time out of the water while shrimp are culled and gear reset.

Sea turtles are another component of bycatch. During the past few years, shrimpers have been required to comply with various regulations governing the take of sea turtles in trawl nets. Such requirements as reduced tow times and turtle excluder devices (TEDs) have reduced turtle mortality. But this reduction of turtle mortality sometimes occurs at the expense of the shrimper in regard to shrimp retention and gear cost and manageability.

Various commercial fishermen's organizations throughout the Southeast have been involved in the controversy over TEDs and bycatch. But most have been reactive in the approaches to the issues.

However, a new and proactive response has emerged. Many fishermen are realizing that modifying standard gear with finfish excluder devices or TEDs is not a panacea for the bycatch problem. Alternative gear and techniques are gaining ground in the endeavor to further reduce bycatch in the shrimping industry.

KIMMING ECHNOLOGY: AR HEEL HRIMPERS AKE A CUE

In 1989, a *National Fisherman* article about a Louisiana shrimp trawl — the skimmer — caught the eye of Clinton Willis and Craig Schreck, two fishermen in the Carteret County Waterman's Association. The skimmer, a cross between a butterfly net and

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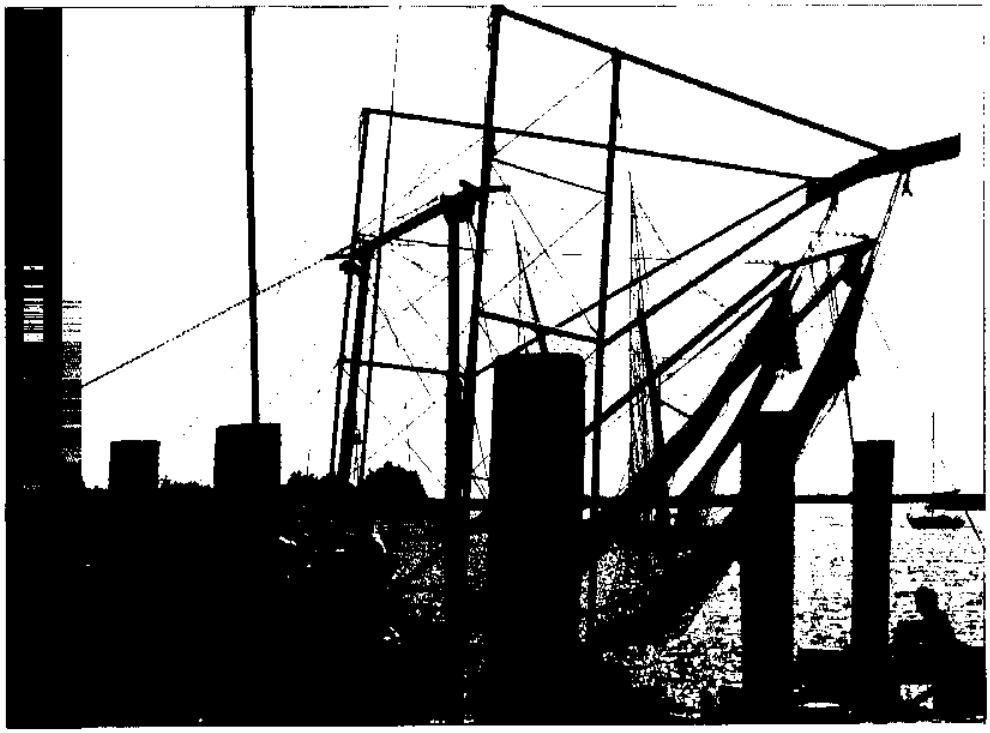
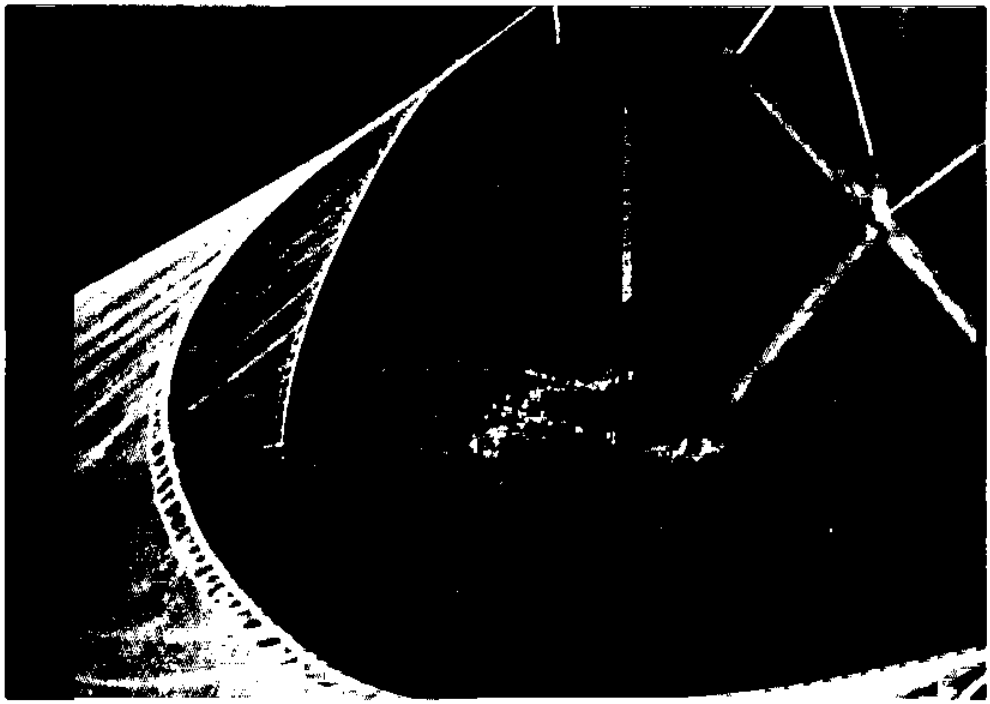


a Vietnamese "chopstick" rig, is pushed in pairs — one net on each side of the boat — rather than towed behind like an otter trawl.

The two Tar Heel watermen approached Sea Grant agent Bob Hines about building or obtaining the gear to try in North Carolina. Their interest at the time was dual. Since each net lies alongside the boat, and the tailbag can be conveniently retrieved with a pickup line while the net is still fishing, it appeared easy to dump and required no loss of fishing time. These fishermen reasoned that shrimpers would be willing to dump the catch about every 30 minutes. Any turtle caught in the net should easily survive a 30-minute tow, eliminating the need for a TED.

Second, they believed that finfish bycatch would be less with skimmers than in a trawl rig sized for a given boat, since the effective spread for finfish over the bottom is less. With the otter trawl, fish are herded toward the tailbag from the outer edge of the trawl doors and inward toward the body of the trawl, whereas shrimp are merely scattered. In the skimmer trawl, however, the entire net is effective for shrimp retention.



Overall, the skimmer promised definite advantages. Shrimpers could utilize shorter tow times and still get an ample catch. Because of the more frequent dumping of the catch, the bycatch would be more likely to be released alive. Also, the quality of the shrimp would be better. The rig can be pushed 5 to 8 percent faster than an otter trawl, thus covering more area per time fished. And finally, fuel expenses could be lower because the drag of heavy trawl doors would be eliminated.

In June of 1990, Hines, along with Willis and John Weeks, a marine vocations instructor at East Carteret High School, traveled to Buras, La., to test the waters with Gulf shrimpers. They witnessed the skimmer effectively catching brown and white shrimp. Judging from the variety of local boats using the gear, they were convinced it could be used on inshore Tar Heel shrimp boats with little or no modification.

With assistance from the Gulf and South Atlantic Fisheries Development Foundation, Weeks' class built a small skimmer rig (6 feet by 12 feet) for use aboard their 23-foot skiff in the fall of 1990. They fished it briefly with encouraging results.

To pursue the concept further, Sea Grant obtained a grant from the National Marine Fisheries Service to test the skimmer trawl in North Carolina waters. The plan was to conduct fishing trials with the gear alongside a comparably sized double-rigged trawler from the inshore fleet and to compare shrimp catch and quantity as well as bycatch composition and mortality.

Specifically, the goals of the project were to reduce the kill of finfish bycatch by 50 percent and to eliminate all turtle mortality in inshore waters using the skimmer trawl. The objectives of the skimmer project were:

- to test the skimmer trawl in several areas and at various depths in the Pamlico Sound region in North Carolina;
- to develop guidelines to construct the skimmer trawl and convert traditional inshore shrimp trawlers to the method;
- to document the total

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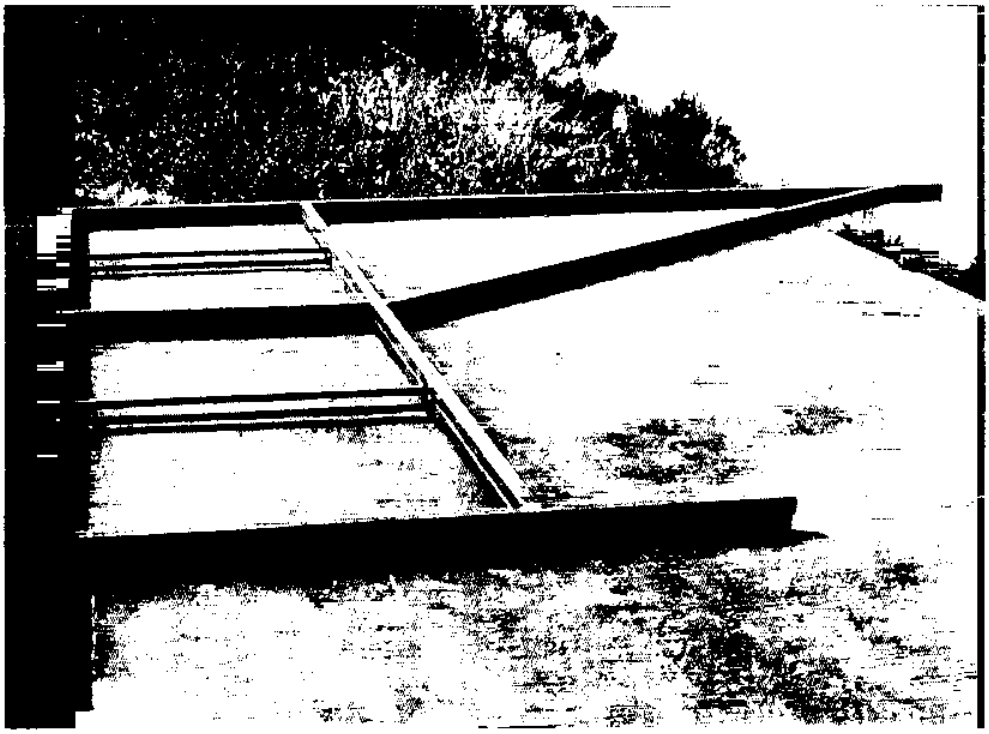
amount of finfish bycatch and its survival; and

- to document the incidental capture of sea turtles and their survival.

Experiments with the skimmer rigging and nets began in the summer of 1991 aboard the 41-foot *Frankie & Al*, a typical North Carolina wooden-hulled shrimp boat owned and operated by Paul Biermann of Beaufort. Biermann, an experienced local fisherman, did most of the fabrication and installation. A 37-foot wooden shrimp boat belonging to Willis was used as the control for the experiment. Willis' *Capt. Will* was outfitted with two 35-foot otter trawls with two sleds and two 7-foot-by-34-inch aluminum trawl doors.

OMPARING HRIMP ATCH: KIMMER VS. TTER

The skimmer trawl proved very effective for catching white shrimp in Carteret County's North



River. White shrimp was the largest contributor — more than 23 percent — to the total biomass collected by the skimmer trawl. The skimmer gear was less effective on brown shrimp, the largest contributor to the otter trawl biomass. Brown shrimp comprised only 6.1 percent of the skimmer biomass compared to 16.8 percent collected by the otter trawl.

In mid-July, Biermann and Hines returned to Louisiana to have a modified set of skimmer nets made. By the time the new nets were installed and fine-tuned, brown shrimp in The Straits area had moved to the deeper water of the channel (15 to 16 feet).

During trips in late July, the otter trawl sampled in the channel and exhibited the highest rate of shrimp caught per minute. At the same time, the skimmer gear, with a maximum effective depth of 12 feet, could not sample the bottom of the channel; it remained in the adjacent shallow areas and had a lower shrimp catch rate. When both vessels were sampling in waters 8 to 10 feet deep or less, brown shrimp catches were similar between the two gears. The skimmer trawl exhibited its highest rate of shrimp caught per minute while sampling for white shrimp in the North River.

RENDS IN YCATCH: HE NUMBERS RUNCH

The NMFS-funded Sea Grant project focused on the development and assessment of the skimmer trawl in the inshore shrimp fishery in North Carolina. But Sea Grant also wished to document the amount of finfish bycatch and its survivability and the incidental capture of sea turtles while using the skimmer trawl.

For each night of testing, the skimmer trawl tailbag was emptied about every 30 minutes; the otter trawl was hauled back every 90 minutes. For the first tow of the evening, a 1-gallon subsample was removed from the catch with a plastic shovel and

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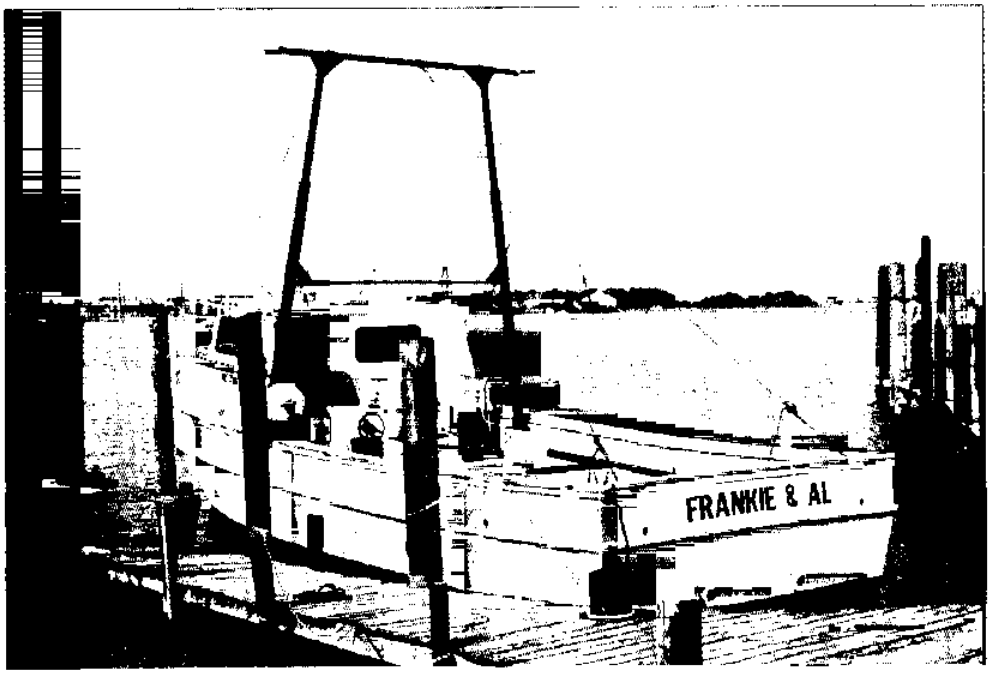

placed into an onboard 50-gallon tank with circulating water to determine survivability of the catch. A second 2.5-gallon subsample of the catch was removed from each tow in a similar manner and set aside for later examination.

All shrimp were culled from the total catch as quickly as possible, and total cull time was noted. Fish of marketable size and other large animals were counted and weighed separately. The total bycatch (less the shrimp and subsample) was then weighed; all shrimp from the total catch were weighed separately.

For each 2.5-gallon subsample, shrimp were counted and weighed by species. The remainder of the subsample was separated by species, counted and weighed. Miscellaneous materials such as sea grass, mantis shrimp, jellyfish and beer cans were weighed together. At least twice during the night, individuals of selected finfish species in the subsample were measured for total length.

To determine survivability of the bycatch, the organisms in the live tank from the 1-gallon subsample were removed after a minimum of two hours; the number of live and dead specimens were listed by

species. Data were entered into the mainframe computer at East Carolina University and analyzed using SAS (Statistical Analysis System) software.

In general, the skimmer trawl caught less bycatch per minute than the otter trawl, although this trend was not readily apparent while collecting the data. Once gear problems were solved, the skimmer trawl had the smallest bycatch rate (kilograms per minute) and fish-to-shrimp ratio during the white shrimp season.

After shrimp, the two largest contributors to biomass in the catch were spot and crab species *(See Chart 2).* Spot biomass ranked second and crabs third in otter trawl catches; this ranking was reversed in the skimmer. Miscellaneous animals, plants and trash ranked fourth for both gears. Pinfish biomass ranked sixth in the otter trawl and fifth in the skimmer. Other commercial species of interest were Atlantic croaker, which ranked ninth in the otter trawl and 14th in the skimmer trawl, and Atlantic menhaden, which ranked 13th in the otter trawl and seventh in the skimmer.

During the study, only one sea turtle was caught. The loggerhead turtle was snared by the skimmer trawl; neither the skimmer nor the otter trawl was equipped with a turtle excluder device. The turtle was held onboard and released in good condition outside the shrimp fleet fishing area to reduce the risk of immediate recapture. The more frequent tailbag retrieval associated with the skimmer should increase the survival rate of sea turtles.

Skimmer trawl bycatch was much more likely to survive than otter trawl bycatch. The lower mortality of skimmer bycatch may have been attributable to frequent retrieval of the tailbag or to the gear itself (net configuration, twine size, etc.) or to both. And because of the more frequent retrievals, the bycatch spent less time on the culling table because there were fewer fish to cull.

Of the 20 different species tested in both live wells, 15 species showed increased survival in the

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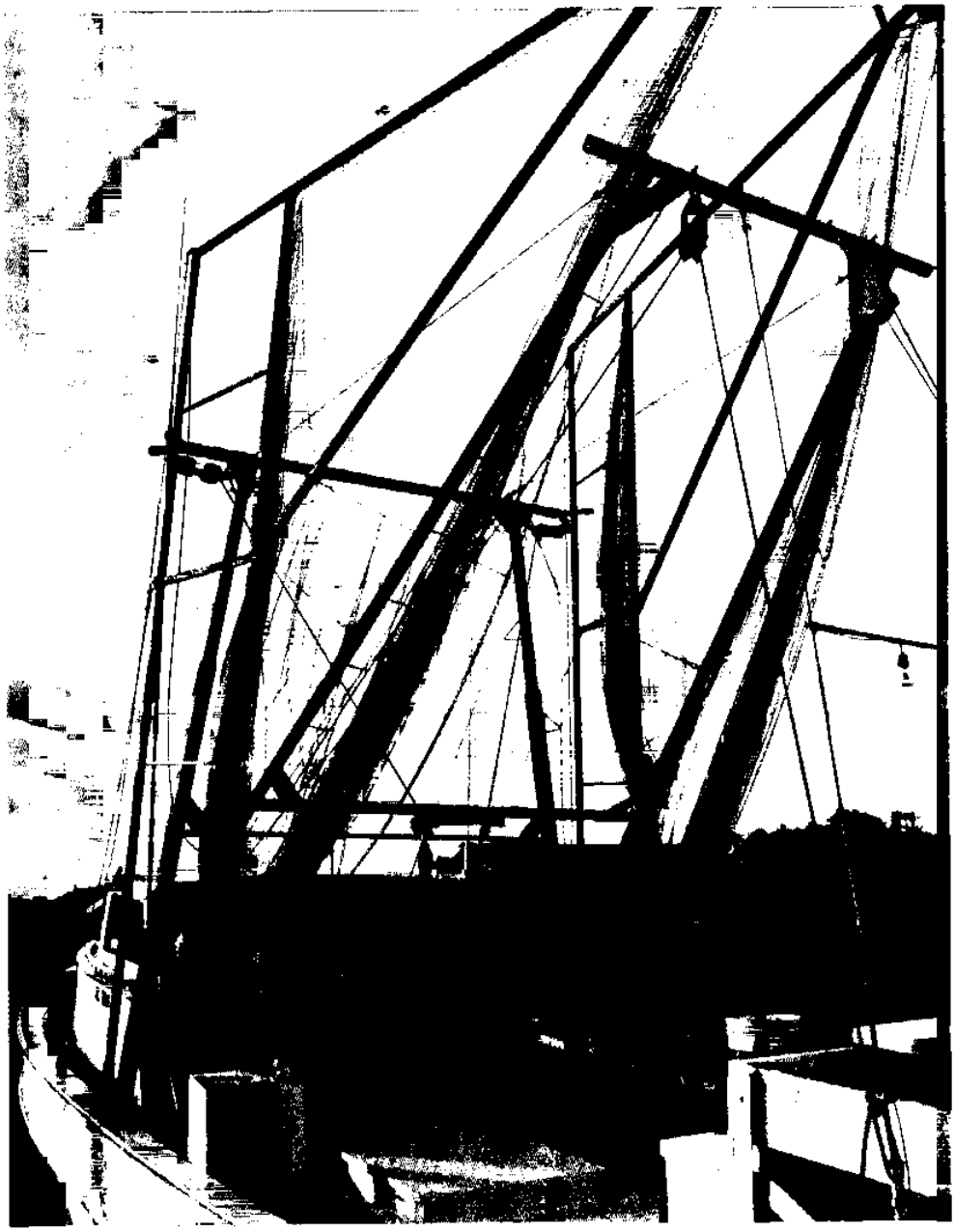
skimmer trawl *(See Chart 3)*. Atlantic croaker, spot and Atlantic menhaden showed considerably higher survival rates in the skimmer trawl compared to the otter trawl. Survival results for weakfish and bluefish in the skimmer trawl were inconclusive because of the very low numbers caught during all tests throughout the study. Spanish mackerel are fast-swimming fish, but their small scales



probably make them more susceptible to net damage in any trawl, as illustrated by high mortality in both gear types. But because of the small number of Spanish mackerel caught, these conclusions should be viewed with caution. Hardy crab species showed high survival rates in either gear. All three commercial shrimp species showed increased survivability in the skimmer trawl, which implies less damage and therefore higher quality of these target species.

ETTING IN EAR: HOW O BUILD ND ADAPT HE SKIMMER ESIGN

The skimmer rig consists of two rigid frames — one mounted to each side of the boat — to which the nets are attached. The gear is pushed rather than pulled across the bottom.

The inboard end of each frame is hinged to the base of the boat's A-frame so that it can be raised and lowered. The frame itself can be built in various configurations. However, all consist basically of a horizontal arm (when lowered) that dictates the width of net and a vertical arm on the outboard end that dictates the depth of net to be used. The bottom of the vertical arm is fitted with a "shoe" that slides over the bottom.

The frames used in the Sea Grant tests were constructed of 2-by-2-by-3/16-inch steel square tubing and effectively measured 16 feet wide (horizontal) by 12 feet deep (vertical). These dimensions dictate the net size. The overall dimensions of the frame are larger but each must be built to fit a given boat, taking into consideration freeboard; the distance from the boat's A-frame to the edge of the gunwale; beam; and the capacity of winches used to set and haul the gear.

Since they were built of steel, the frames were very heavy; they could be built

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Lighter twine in the webbing could help alleviate this problem.

Skimmer nets are made with hanging ropes in each upper and lower corner. The upper two are tied to the inboard and outboard ends of the horizontal frame. The lower outboard line is tied to the shoe, and the inboard line is tied to a 200-pound to 300-pound weight. This weight is tethered to the bow of the boat as low to the water as possible. This keeps the bottom of the net spread open.

The net can be made to fish "harder" or "softer" by adjusting the relative lengths of the hanging lines. For example, it can be made to fish harder by lengthening the two top lines or softer by shortening them. Fishing of new rigs should start with the lines set evenly and then adjusted by trial and error.

A tickler chain is run from the shoe to the weight, just as it would be run between the doors of a trawl. The length should be 24 inches shorter than the leadline. During the trial, it was tied at the same points as the net ties on the shoe and on the weight. The loop chain was hung to the bottom line of the net. Four pieces of 3/16-inch chain were hung in the belly of the net, and two pieces of 1/4-inch chain were hung in each wing of the net. Each loop of chain was 16 links long.

ISHING THE KIMMER

The skimmer gear differs from trawl gear in fishing and handling characteristics. Because of the weight and cumbersome size of the rigid frames, it is initially more difficult to set and retrieve. But this becomes easier as one gets the feel of the gear. Since the time of this project, fishermen in Marshallberg have developed another frame arrangement made of aluminum pipe, which they say is lighter and much easier to set and retrieve.

In the Sea Grant trials, the frames were hinged to rotate at the base of the horizontal arm in an up-and-down direction. This allowed them to be raised

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or lowered. Also, they were made with a swivel in the base of the horizontal arm so they could be turned forward or aft. When raised, the frames were swung aft and lashed to the A-frame for stowage when not fishing. The frames could also be swung forward for stowage, depending on the layout of the boat and the position of the frame mounts relative to the boat's pilothouse.

It is relatively easy to set the gear after one gains some experience. First, the frames are unlashed and swiveled outward and the stay wires hooked to the bow. (Since the frames in the Sea Grant trials swiveled aft, the two stays had to be removable from the bow fitting, allowing the frames to move aft.) Next, the frames are lowered from the vertical position until the shoe is just above the water. While the boat is under way at low speed, the nets are streamed out and the frames lowered to touch the bottom. Then the weights are lowered over the side to touch bottom.

Fishing speed will depend to some degree on the power plant and gearing of the boat. The skimmers are more difficult to push than one might think, but they are generally easier to push than an appropriately sized trawl rig. In trials, they were fished at about 2.5 knots, which was faster than most of the surrounding trawl boats.

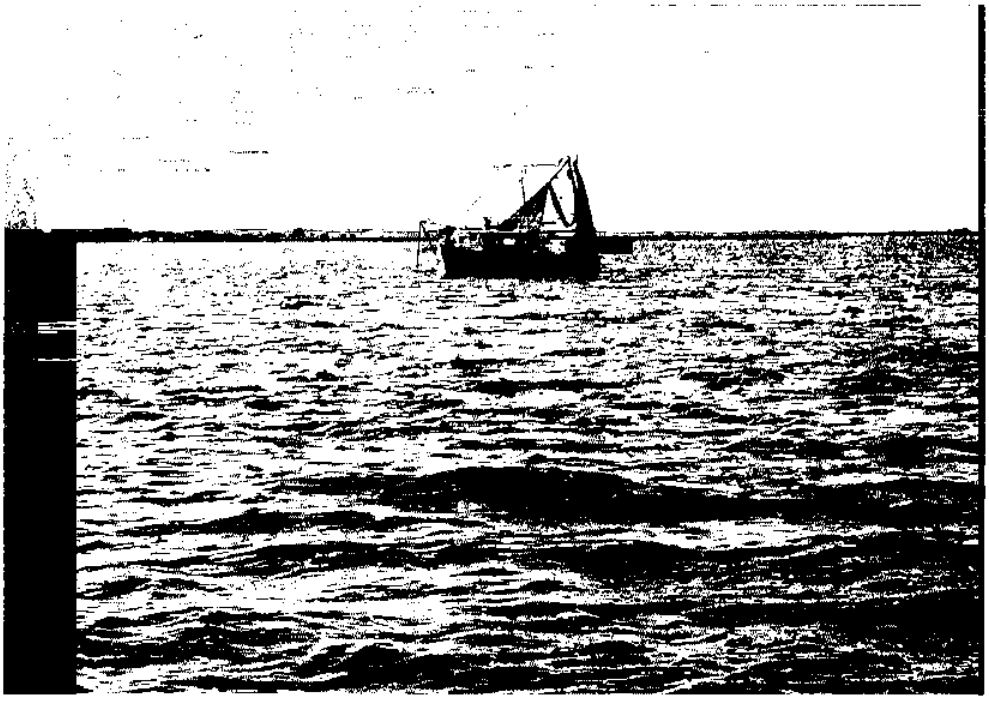
The tailbags can be picked up and dumped as often as desired. In the test runs, bags were dumped every 30 minutes, which made culling easier. One of the advantages of the skimmer is that one need not stop fishing when picking up the tailbags for dumping; the mouth of the net remains in the water and continues to fish.

When fishing is finished, the gear is retrieved in reverse order from setting.

SUMMARY

The skimmer gear offers many advantages over conventional trawl gear, including the following *(Also see Chart 1).*

- The tailbag fishes



near the stern of the boat, which allows frequent haul-backs and no loss of fishing time because the mouth of the net is still fishing.

- Because it is not dragging the heavy otter doors of conventional trawls, the skimmer can travel faster and allows more bottom to be covered per unit of time.
- Shorter tow time and more frequent dumping keeps shrimp and bycatch in better condition.
- The gear caught less bycatch than otter trawl gear in the Sea Grant tests.
- After culling, bycatch is returned overboard behind the mouth of the net so that the same bycatch is not caught repeatedly. Also, the more frequent haul-backs mean there's less catch to cull, reducing the time that bycatch is on the culling table.
- The gear is extremely effective on white shrimp. In the Sea Grant tests, the skimmer outfished conventional trawls as much as 5-to-1 on this species. The authors offer one theory in regard to the skimmer's superiority on white shrimp. These shrimp have a tendency to swim higher in the water column, so they can swim above or jump out of

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conventional shrimp nets. But since the top of the skimmer net extends above the surface of the water, it is able to contain white shrimp.

Following are some disadvantages of the skimmer gear.

- Seaweed tends to clog the net, requiring special attention during fishing. During testing, the operators had to stop the vessel, pick up the frames and roll the grass out of the front of the net. However, poly webbing, rather than the dipped nylon used in the test, might alleviate this problem.
- The gear is heavy and cumbersome to set and to pick up. However, construction of aluminum frames rather than steel would remedy this problem.
- The gear cannot reach bottom in water deeper than the frames allow.
- The skimmer does not fish well over greatly irregular bottoms, such as along steep channel edges.
- Greater care is required when turning or stopping to avoid getting the net caught in the boat's wheel.

The skimmer gear did not prove as effective on brown shrimp. But unusual circumstances during testing may have skewed the data. The gear was not fished to maximum efficiency early on; it took several days to learn how to properly fish it. Also, high rainfall forced brown shrimp into water too deep in which to operate the skimmer.

By the time proper nets were installed and tuned, the available brown shrimp in the area were being caught in deeper water channels (15 to 16 feet), and the skimmer simply could not reach them on the bottom. The skimmer performs better on brown shrimp in water 10 feet or less.

The skimmer proved so effective on white shrimp during Sea Grant's trial that four or five Carteret County fishermen immediately built skimmers and began using them in the white shrimp fishery in North River. These fishermen needed several days to become accustomed to the gear and tune it properly, but the payoff was worth it; they caught more shrimp

with less effort than the remaining traditional trawlers. In fact, one of the first local boats to install skimmers caught the lion's share — more than 1,000 pounds — in Jarretts Bay the night it opened for trawling.

POST SCRIPT

The skimmer project was very effective in spite of early problems with the gear. There was a great deal of interest in the project within the fishing community because it was conceived by local watermen. A test project with a small rig at East Carteret High School also spurred interest early on.

With less bycatch snared than with otter trawls, the skimmer has proved its worth. In areas of shallow water that sustain "runs" of white shrimp, the gear is a logical alternative to otter trawls and TEDs. With additional minor modifications, the gear can be made to reduce bycatch even more.

Since the time of the initial project, the project team has tested Florida Fish Excluders in skimmer nets. While these data have not been completely analyzed, they do seem to indicate that these excluders are effective in further reducing finfish bycatch.

Since the time of the project, fishermen in Marshallberg have developed a modified frame arrangement that uses a bit less material, is lighter in weight and can be set and retrieved by one man more easily than the frame of our original design. These new skimmer rigs, fitted with slightly wider nets, have been effective in catching pink shrimp in water shallow enough for the rigs to touch bottom.

As a testament to the effectiveness of this alternative gear, at least 17 boats were using skimmers in the Carteret County area as of October 1992. Tar Heel watermen have taken fisheries technology from the Bayou and made it their own. Doubtless, the gear will continue to evolve as our fishermen adapt it to conditions in North Carolina waters. ▪

CHART 1.
Relative advantages of a skimmer vs. a double-rigged otter trawl.

	Skimmer	Otter
1. Cost *(Assuming no existing rigging on either vessel)*		
a. A-Frame or mast	Same	Same
b. Outriggers or skimmer frame	Same	Same
c. Tackle (rope, blocks, eyes, etc.)	Same	Same
d. Winch	Same	Same
e. Nets	Same	Same
2. Fuel efficiency	Estimated 5 to 15 percent more efficient based on same engine speed (less drag resulted in greater vessel speed and ground coverage).	—
3. Ground coverage	Greater due to slightly increased vessel speed.	—
4. Deployment	More cumbersome.	Easier to deploy than the skimmer used in this study. However, recent modifications by industry have minimized the differences.
5. Haul-back	Easier because only tail-bag needs to be retrieved (2 to 3 minutes). Mouth of net still fishing.	All gear retrieved to empty tailbag (10 to 15 minutes).
6. Effective fishing time	Greater because of extra speed of the vessel and therefore greater area covered per unit of time. No time lost due to haul-back.	Less ground coverage and loss of time due to haul-back.
7. Maximum depth limitation	Limited by the height of the vertical arm of the frame (12 feet in this study).	No depth limitation for North Carolina shrimp grounds.

	Skimmer	Otter
8. Shrimp catch rate		
Brown	Less in the study.*	More
Pink	Less in the study.*	More
White	Up to four and one-half times greater per unit of time.	Much less.
9. Bycatch	Approximately 12 percent less bycatch per unit of time for the entire study and 30 percent less for comparable time during the white shrimp season.	More bycatch caught per unit of time.
10. Bycatch to shrimp ratio	During the white shrimp season, there was an eightfold decrease in the fish-to-shrimp ratio. Approximately 1 pound of fish caught per pound of shrimp caught.	Fish-to-shrimp ratio higher. Averaged 8 pounds of fish per pound of shrimp.
11. Mortality	12 of 16 finfish species showed increased survival. In addition, all three shrimp species showed higher survival, indicating a higher quality product.	Reduced bycatch survival. Smaller proportion of shrimp survived.
12. Cull time	Cull time was less, given the more frequent haul-backs.	Fewer numbers of culls, but cull time greater given fewer haul-backs.
13. Miscellaneous		
a. Fouling	More seagrass and seaweed caught because top of net fishes above water surface.	Caught less seagrass and seaweed because it was not fishing at the surface.
b. Recapture of bycatch	Eliminated. Bycatch returned to the water behind the mouth of the net.	Bycatch can be recaptured because discard is forward of net mouth.

* *However, gear not fine-tuned.*

CHART 2.
Relative abundance (percentage of total biomass and percentage of total number) of organisms caught in the North Carolina shrimp fishery by otter trawl and skimmer trawl in The Straits of Marshallberg and the North River in 1991.

	OTTER TRAWL		SKIMMER TRAWL	
COMMON NAME *SCIENTIFIC NAME*	% Biomass	% Number	% Biomass	% Number
sergeant major *Abudefduf saxatilis*	0.0	0.0	<0.1	<0.1
wahoo *Acanthocybium solandri*	0.0	0.0	<0.1	<0.1
anchovy species *Anchoa* species	0.6	0.4	1.1	2.2
gray triggerfish *Balistes capriscus*	0.0	0.0	<0.1	<0.1
silver perch *Bairdiella chrysoura*	0.3	0.2	1.1	0.8
Atlantic menhaden *Brevoortia tyrannus*	1.6	0.7	6.0	2.3
loggerhead turtle *Caretta caretta*	0.0	0.0	0.0*	0.0*
blue runner *Caranx crysos*	<0.1	<0.1	0.2	0.1
crevalle jack *Caranx hippos*	0.0	0.0	<0.1	<0.1
blue crab species *Callinectes* species	16.6	4.5	12.1	3.4
black sea bass *Centropristis striata*	<0.1	<0.1	0.0	0.0
Atlantic bumper *Chloroscombrus chrysurus*	0.1	0.1	0.2	0.2
Atlantic spadefish *Chaetodipterus faber*	0.2	0.1	0.4	0.2
bay whiff *Citharichthys spilopterus*	1.3	2.1	0.3	0.3
conger eel *Conger oceanicus*	<0.1	<0.1	0.0*	0.0*
spotted seatrout *Cynoscion nebulosus*	0.0	0.0	<0.1	<0.1

COMMON NAME *SCIENTIFIC NAME*	OTTER TRAWL % Biomass	 % Number	SKIMMER TRAWL % Biomass	 % Number
weakfish *Cynoscion regalis*	0.9	0.5	0.6	0.3
southern stingray *Dasyatis americana*	0.2	<0.1	0.2	<0.1
stingray species *Dasyatis* species	0.1	<0.1	0.1	<0.1
bluntnose stingray *Dasyatis say*	0.4	<0.1	0.0*	0.0*
porcupinefish species *Diodon* species	<0.1	<0.1	<0.1	<0.1
ladyfish *Elops saurus*	0.0*	0.0*	0.2	<0.1
silver jenny *Eucinostomus gula*	0.6	1.1	0.6	0.8
seagrass/ seaweed	0.0*	—	0.4	—
ballyhoo *Hemiramphus brasiliensis*	0.0	0.0	<0.1	<0.1
silverstripe halfbeak *Hyporhamphus unifasciatus*	0.0	0.0	<0.1	<0.1
pinfish *Lagodon rhomboides*	6.4	6.5	8.2	5.8
spot *Leiostomus xanthurus*	16.8	20.0	10.3	10.1
tripletail *Lobotes surinamensis*	<0.1	<0.1	<0.1	<0.1
brief and long-finned squids *Lolliguncula* and *Loligo* sp.	0.0*	0.0*	0.2	0.1
southern kingfish *Menticirrhus americanus*	<0.1	<0.1	<0.1	<0.1
northern kingfish *Menticirrhus saxatilis*	0.0	0.0	<0.1	<0.1
silverside species *Menidia* species	0.0*	0.0*	0.2	0.3
miscellaneous (grass, trash, mantis shrimp, etc.)	6.9	—	9.7	—
Atlantic croaker *Micropogonias undulatus*	2.6	1.5	0.9	0.5

Continued

COMMON NAME *SCIENTIFIC NAME*	OTTER TRAWL % Biomass	 % Number	SKIMMER TRAWL % Biomass	 % Number
filefish species *Monocanthus* species	0.4	0.3	0.2	0.2
smooth dogfish *Mustelus canis*	1.2	<0.1	0.8	<0.1
striped mullet *Mugil cephalus*	0.2	0.1	0.9	0.7
Atlantic thread herring *Opisthonema oglinum*	1.6	2.9	5.5	18.3
oyster toadfish *Opsanus tau*	0.1	<0.1	0.0	0.0
pigfish *Orthopristis chrysoptera*	4.1	3.7	1.7	1.2
gulf flounder *Paralichthys albigutta*	0.2	0.2	<0.1	<0.1
summer flounder *Paralichthys dentatus*	0.8	0.4	<0.1	<0.1
southern flounder *Paralichthys lethostigma*	0.2	0.1	0.2	<0.1
red porgy *Pagrus pagrus*	0.0	0.0	<0.1	<0.1
harvestfish *Peprilus alepidotus*	<0.1	<0.1	<0.1	<0.1
brown shrimp *Penaeus aztecus*	16.8	25.9	6.1	7.9
pink shrimp *Penaeus duorarum*	6.6	17.7	2.6	8.4
white shrimp *Penaeus setiferus*	5.1	7.6	23.3	33.1
butterfish *Peprilus triacanthus*	0.0	0.0	<0.1	<0.1
bluefish *Pomatomus saltatrix*	0.3	0.2	0.9	0.4
sea robin species *Prionotus* species	1.0	0.9	0.2	<0.1
cobia *Rachycentron canadum*	1.8	<0.1	<0.1	<0.1
king mackerel *Scomberomorus cavalla*	0.0	0.0	<0.1	<0.1

COMMON NAME *SCIENTIFIC NAME*	OTTER TRAWL % Biomass	 % Number	SKIMMER TRAWL % Biomass	 % Number
Spanish mackerel *Scomberomorus maculatus*	1.1	0.7	2.5	1.4
lookdown *Selene vomer*	0.5	0.2	0.4	0.2
sennet species *Sphyraena* species	<0.1	<0.1	<0.1	<0.1
tonguefish species *Symphurus* species	0.2	0.2	<0.1	<0.1
pipefish species *Syngnathus* species	0.0	0.0	<0.1	<0.1
puffer species *Sphoeroides* species	0.1	<0.1	<0.1	<0.1
Atlantic needlefish *Strongylura marina*	0.0	0.0	<0.1	<0.1
lizardfish species *Synodus* species	2.0	0.8	0.7	0.4
Florida pompano *Trachinotus carolinus*	0.0	0.0	0.1	<0.1
Atlantic cutlassfish *Trichiurus lepturus*	0.0*	0.0*	0.5	<0.1
hogchoker *Trinectes maculatus*	<0.1	<0.1	<0.1	<0.1
agujon *Tylosurus acus*	0.1	<0.1	<0.1	<0.1

*Species caught in the gear but not present in the subsamples, so weight and number of individuals could not be estimated.

Total biomass = 1,957.82 kg (otter); 2,346.30 kg (skimmer)
Total number of organisms = 111,056 (otter); 138,296 (skimmer)

CHART 3.
Comparison of average survival rates for selected finfish and shellfish species collected by otter trawl (control) and skimmer trawl in The Straits of Marshallberg and the North River in 1991. n = number of tests. Survival rates assume a tow time of 90 minutes for the otter trawl, 30 minutes between retrievals for the skimmer trawl tailbag, and immediate culling of the catch after placement of the catch in the culling tray.

	OTTER TRAWL		SKIMMER TRAWL		
SPECIES	*n*	*%alive*	*n*	*%alive*	*Relative change in survival (%)*[1]
blue crab species	12	94.28	12	92.33	-1.95
pinfish	13	76.23	18	87.24	+11.01
pigfish	10	68.11	11	90.91	+22.80
pink shrimp	4	64.43	4	89.39	+24.96
Atlantic croaker	6	63.03	11	86.36	+23.33
brown shrimp	5	60.67	6	64.52	+3.85
weakfish	2	58.33	3	42.86	-15.47
Atlantic spadefish	3	50.00	3	100.00	+50.00
white shrimp	2	34.27	6	56.02	+21.75
spot	14	33.79	21	70.28	+36.49
bluefish	3	33.33	3	25.00	-8.33
silver perch	3	33.33	6	36.67	+3.34
Atlantic menhaden	7	30.10	14	49.60	+19.50
sea robin species	5	26.67	5	60.00	+33.33
silver jenny	6	20.83	5	46.31	+25.48
Atlantic thread herring	9	17.11	20	8.30	-8.81
lizardfish species	5	10.00	8	6.25	-3.75
bay whiff	9	0.00	3	8.33	+8.33
Spanish mackerel	8	0.00	12	7.64	+7.64
anchovy species	4	0.00	13	0.96	+0.96

[1] *Positive change means better survival in skimmer trawl.*