A Shrimp Separator Trawl for the Southeast Fisheries

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The demersal trawl fisheries for shrimp and industrial finfish in the northern Gulf of Mexico overlap considerably and the increasing harvest and discard of groundfish by the shrimp fleet is of major concern to fishery managers. This situation has become more critical in recent years because the high value of shrimp has provided economic incentive for shrimping in high finfish density areas, justifying the increased labor cost associated with sorting out the shrimp. These high density finfish areas are the principal fishing grounds for the industrial groundfish fishery, based primarily on the harvest of sciaenids for petfood and human consumption.

Shrimp trawl catches range from 4 to 12 pounds of trash per pound of shrimp caught, of which up to 70% are sciaenids as well as other species usable to the groundfish industries. These groundfish are considered "trash" by the shrimp fleet and discarded overboard with total mortality to the fish. This destruction of trash fish is a serious concern to the groundfish industry whose total production is approximately 100 million pounds annually. Since annual Gulf shrimp catches have averaged over 200 million pounds for the past 5 years, over one billion pounds of groundfish may be destroyed each year by the shrimp fleet.

This discard problem is of particular importance in nearshore and estuarine nursery areas where very large numbers of juvenile sciaenids are captured and killed by shrimping during certain times of the year. These estuarine nursery areas have relatively restricted spatial boundaries but seasonably support high density shrimp and fish populations, particularly emigrant juvenile shrimp and pre-recruit groundfish. A high level of fishing pressure by the "mosquito fleet" usually occurs in these areas at a time when juvenile groundfish are still present in large concentrations, and results in an extremely high fish mortality.

Other problems associated with the discard also exist. Occasionally, high discard rates on fishing grounds have led to reports of large accumulations of dead and rotting material on the bottom in areas of high shrimp fleet concentrations, which make the groundfish fishing fleet catches unusable for human consumption or petfood. Further, large trash fish discards have occasionally created problems of dead fish washing up on public recreational areas.

The groundfish fishery in the Gulf of Mexico can be expected to grow in scope as the demand, both domestic and export, for fish protein expands and new products and processes for utilizing these resources are developed. Further expansion of the groundfish industry will result in increasing interaction with the shrimping industry on the fishing grounds and a corresponding increase in associated problems. It is, therefore, essential that improved technology be introduced into the shrimp fleet to reduce the destruction of groundfish resources.

PREVIOUS DEVELOPMENTS

Shrimp trawls designed to separate shrimp from fish have been constructed and fished with varying degrees of success in Europe and the Pacific Northwest. French researchers in 1963 evaluated a shrimp trawl designed to separate shrimp from flatfish. This net was divided with a large mesh horizontal webbing panel into an upper and lower section, each with its own codend. Dutch experiments with a sorting trawl resulted in a design modification which incorporated a funnel-like separator and produced higher catch rates than the French trawl.

Behavioral research and fishing trials were initiated in 1968 at the Northwest Fisheries Center in Seattle, Washington, to develop a method for reducing trash in catches of Pacific Northwest pandalid shrimp. Large catches of these very small shrimp, up to several thousand pounds, are commonly produced in a tow. A normal tow in this area is usually composed of 80 to 90% shrimp and the remainder fish and discards. Since the price for Northwest pink shrimp is generally around 5¢ per pound, a boat must produce large amounts of shrimp to be profitable. Therefore, very little time can be spent sorting trash from shrimp. If the trash component of a catch becomes too large, the whole catch is dumped and the fishing vessel moves to a new area.

The Pacific Northwest shrimp separator trawl, which finally evolved, was a modified Gulf of Mexico type shrimp trawl. The net was constructed with a high vertical opening because the pandalid shrimp are often some distance off the bottom. The vertical separator panel on the Seattle net was attached across the net mouth with trash chutes in the center top and the center bottom of the net—one opening upward and the other downward—for fish escapement. Shrimp catches with this net were nearly free of unwanted trash fish.

The separator trawl for the Northwest shrimp fishery has been fairly effective, primarily due to the large size differential between the small shrimp and large fish, and because of the low ratio of fish to shrimp in most catches. Shrimp catches with the separator trawl are lower than standard comparison nets, but it was felt that a fisherman could compensate for the decrease in shrimp catch by making longer drags and fishing more hours in higher finfish density areas since the need for sorting could be essentially eliminated. In addition, catches of smelt, which are small in size, were difficult to reduce.

Preliminary evaluation of the Northwest gear in the Southeast Region met with limited success because the problem in our area is quite different. In the Gulf fishery, the fish and trash components of a shrimp catch are often as high as 90% of the catch. In addition, Gulf shrimp are much larger than Pacific Northwest shrimp and are often as large, or larger than, many of the fish encountered during trawling. This factor increases the complexity in using mesh panels to separate shrimp from the small fish in the catch.

Development of an acceptable shrimp separator trawl has also been attempted by a few individuals associated with the shrimp industry in the Southeast Region, primarily trawl manufacturers. These individuals either lacked the financial resources, facilities, or time required to support such a gear development project. A project is presently being conducted by the Marine Extension Service of the University of Georgia in Brunswick to develop a separator trawl for removing jellyfish from a net. In general, though, few state agencies or universities are involved in research and development of applied fishing technology, since most lack the experience or facilities necessary to effectively develop and demonstrate a relatively sophisticated fishing system such as a shrimp separator trawl. The National Marine Fisheries Service (NMFS), however, is committed to the development of the nation's fishery resources including the development of harvesting systems required to encourage industrial utilization of these resources. For this reason, NMFS is undertaking the development of a shrimp separator trawl system to help reduce labor costs to the shrimp fleet and foster conservation of a valuable groundfish resource.

GULF OF MEXICO SHRIMP SEPARATOR TRAWL

The objective of this project is to develop a system which will accomplish selective capture of shrimp and provide in situ elimination, without injury, of trash and shellfish from the catch. Based on present economic factors, we have established a tentative minimum design criteria of 90% shrimp/trash separation while maintaining a 90% shrimp catch.

Each of the early separator trawl designs had a serious flaw. Horizontal separator panels tested by the French, Dutch, and initial net designs of the Seattle Laboratory, did not work well wherever tried in the U.S. The natural behavior of most shrimp is to instinctively swim downward to the bottom rather than upward as required for separation by horizontal panels. The Pacific Northwest vertical separator panel was attached directly from headrope to footrope and completely closed the mouth of the net. Unfortunately, a vertical panel moving through water perpendicular to the towing direction will become increasingly clogged with grass, trash, and gilled fish and while it is a fairly efficient separator for short tows or early in a drag, it becomes progressively less efficient on longer drags.

The Southeast Fisheries Center briefly evaluated the effectiveness of existing shrimp separator trawl designs for separating pink, brown, and white shrimp from trash fish and invertebrates in the late 1960's. These trials met with limited success due to the large size of Gulf of Mexico shrimp and the diversity of fish size. The Pacific Northwest vertical separator trawl was tested using large mesh separator panels. However, shrimp catch was reduced 30 to 40% when reasonable separation of trash was achieved. A horizontal type separator panel was designed and tested, but the best result which could be obtained was a 70% shrimp capture when a 75% reduction of trash was achieved. At that time, restructuring of Southeast Fisheries Center program priorities made it necessary to suspend research before development of a separator trawl could be completed. The present project to develop an effective commercial shrimp separator trawl for the Southeast Region was reinitiated in July 1974.

The shrimp separator trawl now being developed by the Harvesting Technology Task at Pascagoula uses a modification of the vertical separator panel. The design of this net is based upon observations of shrimp and fish behavior accomplished during previous projects, and an analysis of the shrimp-fish problem. It appears to offer excellent potential for satisfying the needs of a shrimp separator trawl in this region.

For several years the Harvesting group at Pascagoula has worked to develop an electric shrimp trawl for both resource assessment and commercial applications. For resource assessment, a mathematical model was developed to predict the efficiency or catch rate of the electric shrimp trawl. During field studies to establish the actual catch efficiency of the trawl and verify the model, some very important by-product information was obtained which has been used in the experimental design of our separator trawl. Divers found that after shrimp entered a net, almost all were carried into the wings of the net and pressed against the webbing. Closer observation revealed that essentially all of the water flowing into the trawl net is spilled out through the wings (Fig. 1).

Shrimp are relatively weak swimmers and the force of the water current is strong enough to carry them to the wings and hold them firmly against the webbing. After "kicking" away once or twice, the shrimp relax and remain pressed against the webbing; then, with an infrequent kick they tumble along the wing and gradually fall back into the codend. Very little water flow is found in the codend and bag, and shrimp movement in this area of the net is relatively unrestricted.

These observations indicated that a vertical panel positioned along the net wings could take advantage of the water flow pattern and high flow rate to help force separation of shrimp. The strong water pressure along the wings would press the shrimp to the separator panel, forcing them through the proper size meshes. Our divers have also observed that many fish swim freely in a net along the wing and other webbing panels. We decided that by tapering the separator panels in a "V" along the wings to the back of the net, fish could be led to an escape chute (Fig. 2). A vertical separator panel in this position would use the water flow pattern to separate shrimp and still lead many of the fish out of the net.

ALL RESULTS TO DATE

An empirical approach was used to establish the initial design, location, taper, size, and other configurations of the V-shaped separator panel along the wings of a standard 40-ft. semiballoon trawl. First we built a 16-ft. trawl, installed a vertical separator panel, and used divers to adjust and change the location and shape of the separator panel and trash chute until it was correctly positioned in the net. A small net was first used because it can easily be observed in tow from a small boat which requires a minimum amount of logistic support. After establishing the basic panel and trash chute design, these components were scaled upward for installation on a 40-ft. net and again diver-evaluated to optimize the configuration.

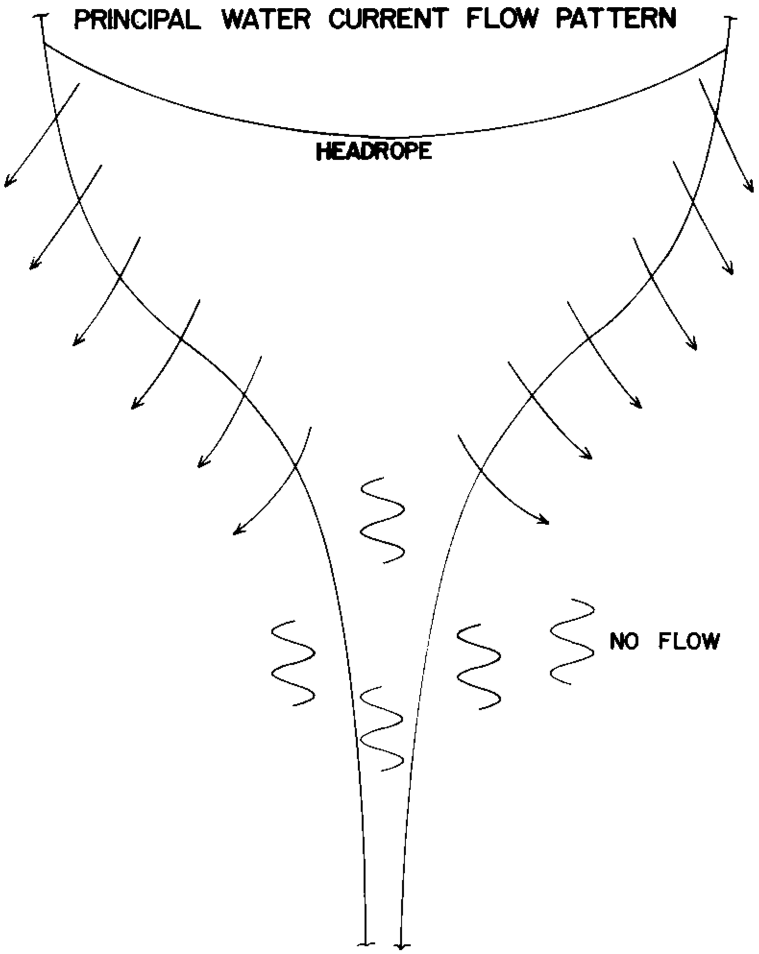

Fig. 1. General water flow pattern through a net.

The 40-ft. modified net was then used to establish the validity of the V-shaped wing separator panel and establish baseline catch data for use in measuring future progress. During these experiments, two secondary fish separation techniques shown in Figure 2 were also evaluated to establish their potential for improving separation, particularly of small fish. Separation of small fish from shrimp will be the most critical problem in development of an effective separator trawl for the Southeast fisheries. It is not at all uncommon, particularly when harvesting large shrimp, for fish as small or smaller than the shrimp (Fig. 3) to comprise 30 to 40% by weight of the total catch. Because many of these small

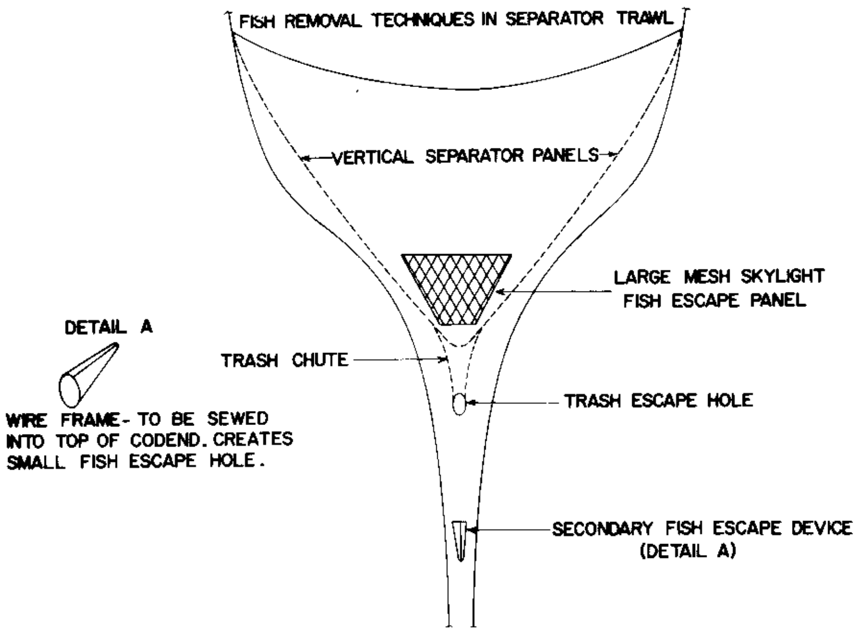

Fig. 2. Location of the vertical separator panel, codend fish escape device, and "skylight" panel in separator net.

fish will pass through a separator panel with the large shrimp, it will be necessary to develop secondary techniques to remove them either before or after they have passed through the separator panel.

The first fish escape technique evaluated was a small wire frame shown in Figure 2. This device, sewn into the top of the codend, creates a small hole through which fish which were small enough to pass through the separator panel can escape. The operating principal of this device is that while many fish will freely swim forward and upward to escape, shrimp will not.

The second fish removal technique evaluated was a large mesh "skylight" panel also shown in Figure 2. This modification is a wedge-shaped panel of large mesh webbing sewn into the top of the net directly in front of the throat and entrance of the trash chute. Our divers have observed that certain species of fish attempt to escape the net through the top panel. The "skylight" is intended to allow these species to escape through the upper panel before they pass through the shrimp separator panel or go out through the trash escape chute. Since shrimp tend to swim downward, this technique should not significantly increase their escapement rate.

The results of 1-hr. comparative tows between a standard 40-ft. semiballoon shrimp trawl and the shrimp separator trawl are shown in Table I. Separator panels of 3½-, 3-, and 2½-in. mesh webbing were evaluated in terms of smallest

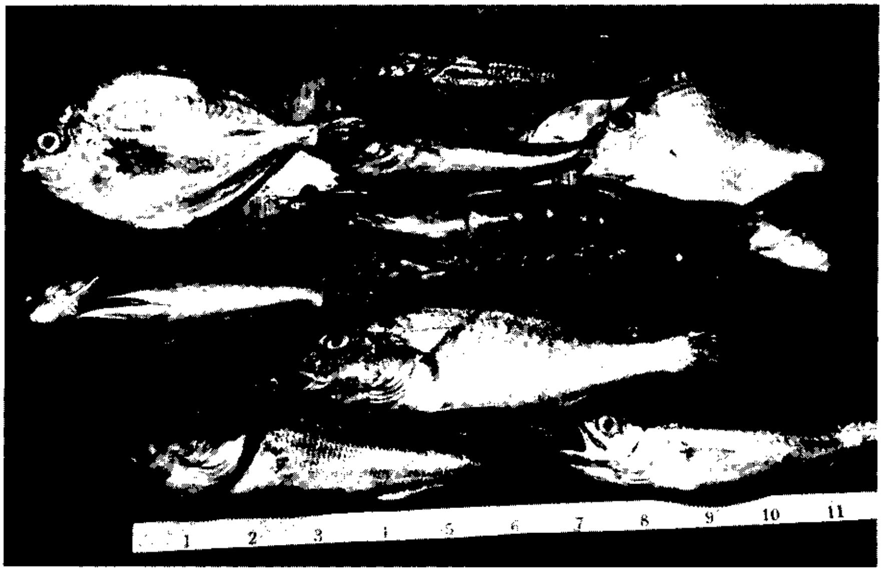

Fig. 3. Size comparison of shrimp to fish which comprised up to 40% of trawl catch during preliminary testing.

effective mesh. The fish escape device and "skylight" panel to improve fish removal were also tested. Results shown in Table I were obtained on catches of large brown shrimp, *Penaeus aztecus*, ranging from 14 to 16 count per pound, with a total length of 120 to 200 mm.

Conclusions based on the results shown in Table I are as follows:
(1) Vertical separator panels along trawl wings can be developed so as not to reduce the shrimp catch more than 10%. (2) It should be possible, through various separator trawl techniques, to approach a 90% reduction in the fish and trash catch for the Gulf of Mexico. (3) A 3½-in. square mesh panel caused less than a 10% shrimp loss and a 2½-in. panel is too small for 15-count shrimp. (4) A fish escape device in the codend reduces the fish catch an additional 10% but also reduces the shrimp catch 10%—other locations should be tested. (5) A "skylight" panel removed approximately 50% of remaining fish while only causing an additional 7% shrimp loss—further study and development should be devoted to this technique. (6) Square mesh panels are an effective approach—further development studies with rectangular meshes should be pursued.

No final conclusions on effectiveness should be drawn from the results, because installation and adjustment of the separator panel and fish separation techniques were made continuously throughout the above tests. All tows with the 3½-in. panel and five tows with the 3-in. panel were made with an initial trash escape chute design. Shrimp loss in this configuration for both panels was less than 10%. Because of fish gilling and clogging, the trash chute was redesigned

Table I. Comparison of separator trawl with standard trawl.

Type Gear	No. Tows (1 hr ea)	Shrimp Catch (lb/hr)	Shrimp Loss (%)	Fish Catch (lb/hr)	Fish Reduction (%)
Separator with 3½-in. panel	14	15.9	9.1	94.0	37.0
Standard net		17.5		149.3	
Separator with 3½-in. panel and fish escape device in codend	7	21.2	21.2	130.3	46.9
Standard net		26.9		245.2	
Separator with 3-in. panel	16	15.6	21.2	68.9	55.2
Standard net		19.8		153.7	
Separator with 3-in. panel and fish escape device in codend	10	16.3	31.5	66.9	64.9
Standard net		23.8		190.5	
Separator with 3-in. panel and "skylight" panel	6	14.3	28.5	52.8	77.9
Standard net		20.0		238.9	
Separator with 2½-in. panel	14	8.8	63.5	35.9	83.5
Standard net		24.1		217.5	

and enlarged for better trash flow, but the shrimp loss with the 3-in. panel subsequently increased to over 20% for the next 11 tows. This demonstrated that more design study will be necessary on configuration and flow patterns of the trash chute. Overall, however, individual results were very encouraging and demonstrated that the V-shaped vertical wing panel separator design should eventually be effective in separating shrimp. This design, in conjunction with secondary fish escape methods and improved panel characteristics, has excellent potential for achieving the 90% shrimp/fish separation and 90% shrimp catch design criteria.

ON-GOING DEVELOPMENT

Results from the preliminary tests are being used to design laboratory and model tests to establish optimum design characteristics for our future prototype separator trawl. We feel that the validity of the wing-vertical panel approach has been established and are now undertaking a series of laboratory shrimp response and net design studies to optimize the vertical V-panel, secondary fish escape techniques, and other proposed methods to achieve maximum shrimp/fish separation ratios without loss of shrimp. The results of these studies will then be used to design the first prototype commercial shrimp separator trawl.

Shrimp response behavior to webbing panels will be evaluated in a small flume test tank where shrimp can be subjected to a range of water flow rates under different webbing panel conditions. Separation panels can be developed to selectively pass shrimp or restrict fish, but these may require mesh shapes and/or materials other than those presently used in net construction. For instance, a change in mesh shape may be effective. Webbing hung on 0.707 spacings (perfect diamond) presents the largest opening dimensions to fish and shrimp passage (Fig. 4). To keep fish and shrimp from passing through a diamond-shaped mesh, a mesh smaller than the animal must be used. The objective of a separator panel, however, is to *pass* shrimp and *prevent* passage of fish. As shown in Figure 4, the mesh dimension that restricts most fish is the vertical height of the opening. Shrimp, on the other hand, approach a mesh horizontally due to their normal swimming attitude. This has been observed to be particularly true when they are forced to the wing panels by the high water current flow. Therefore, to pass shrimp, the most important webbing dimension is the horizontal opening.

The two different conditions of passing shrimp and restricting fish cannot be accomplished effectively with a diamond-shaped mesh. From Figure 4, it can be seen that a square mesh decreased the vertical opening presented to most fish and still retains good horizontal opening for passing shrimp. However, a rectangular mesh should be even more effective as a separator than either a dia-

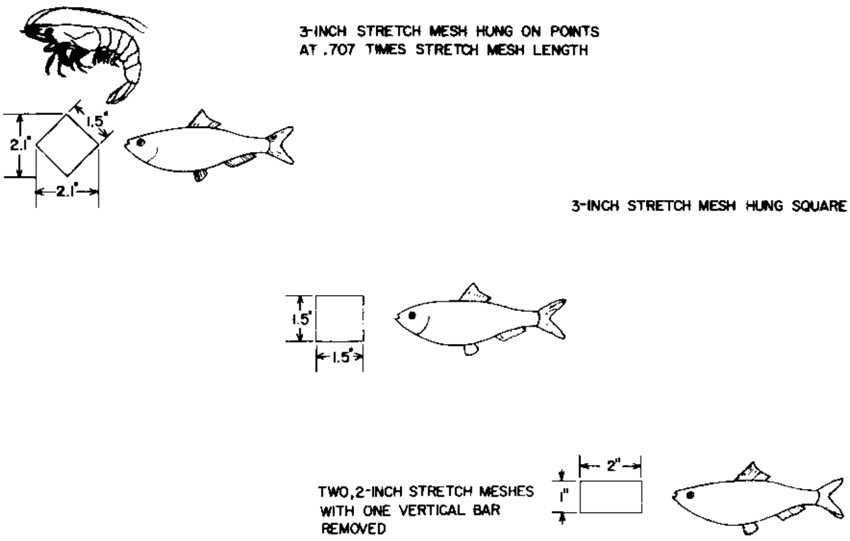

Fig. 4. Effects of mesh shape on separation. (A) Mesh hung on points presents maximum dimensions for fish and shrimp passage. (B) Same mesh hung square reduces vertical height for fish passage but also restricts shrimp; however, more effective than diamond for separation of shrimp. (C) A rectangular mesh achieves the best horizontal opening for passing shrimp and the best decrease in vertical height for restricting fish.

mond or a square mesh. The rectangular mesh contains both desired characteristics of a maximum horizontal opening for passing shrimp and a minimum vertical opening to prevent passage of fish.

Other characteristics of the separator panel which can probably be used to advantage that will be thoroughly evaluated are type of material, stiffness, and panel color.

A second experimental study will be directed toward optimizing design of the trawl net and configuration of the separator panel. The effectiveness of the V-shaped separator panel depends upon using the high water flow rates in the wings of the trawl to control and force separation of shrimp. We therefore need to thoroughly evaluate the water flow pattern in a net to optimally orient the separator panel where the water current flow is at a maximum to positively force shrimp through the separator panel. This will be accomplished on model nets in controlled flume test tanks and with divers. The small net or model studies will determine water flow patterns and velocities in different areas of the net, optimum location and configuration of the vertical separator panel, optimum trash escape chute design, and the effect of secondary fish escape techniques and other separation modifications which would affect water flow rate, pattern, and net performance.

The results of the two laboratory studies, together with the preliminary baseline evaluation results which we have obtained, will be combined to design and construct the first commercial prototype shrimp separator trawl for field evaluation. The prototype trawl will be diver evaluated to adjust trawl doors, footrope, headrope, separator panels, and secondary separation devices to ensure the net is correctly balanced for optimum fishing. Diver evaluation of fish and shrimp response will also be conducted whenever feasible or as the opportunity arises. Finally, comparative fishing trials will be conducted to evaluate and prove the commercial potential of the net. During fishing trials the effect of mesh size, shape, stiffness, panel visibility, secondary fish escape devices, large-mesh fish escape panels, and other secondary techniques will be established under various conditions of shrimp and fish size, species, and concentrations. Two comparisons which must be made during trawl evaluation are the weight of trash reduction achieved and the production rate of shrimp. Our design goals of a 90% reduction in trash without reducing the rate of shrimp production more than 10% seem realistic.

BENEFITS

The development of an effective shrimp separator trawl will directly benefit the shrimping industry through a reduction in labor cost and manpower requirements presently associated with the on-deck sorting of shrimp from other trash caught by a conventional trawl. Since it is the trash part of the catch that limits the length of each drag to 2 to 3 hours, it may be possible to compensate for any shrimp loss in the separator trawl by making fewer, longer drags and increasing the fishing time now lost between drags. The reduced trash load may also result in less damage to the shrimp catch from crushing and crabs, and could possibly permit the use of lighter webbing in net construction. A shrimp separator trawl will permit shrimp fleet operations in high density fish areas previously impractical for shrimping.

The groundfish fishery will substantially benefit from the shrimp fleet using separator trawls through conservation of sciaenids previously subject to high mortality as shrimp trash. The reduction in unavoidable killing of the fish portion of a shrimp catch presently occurring with standard conventional shrimp trawls would greatly increase the resource base of the groundfish fishery and substantially increase the production potential of the fishery.