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A Trawl Design: Employing Electricity to Selectively Capture Shrimp

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ABSTRACT—A shrimp trawl designed to selectively capture shrimp and eliminate the incidental capture of bottomfish and other marine organisms is described. The purpose of this trawl is to conserve the fish presently lost during shrimp trawling. Normal shrimp trawl bycatch is eliminated by completely closing the entrance to the net with a webbing panel. Shrimp pass into the trawl through the bottom of the net which is constructed of large mesh webbing. Effective control and separation of shrimp and fish utilizes the behavioral difference of the animals when exposed to an electrical field. Shrimp are forced up through the bottom mesh of the net by the electrical field located under the net, while the fish are frightened away from the path of the net by the electricity.

INTRODUCTION

The catch per unit effort in the Gulf of Mexico industrial bottomfish fishery has steadily declined since 1975. The vast abundance of these fish in the northern Gulf of Mexico may be nearing an end. Juhl et al. (1976) reported a marked drop in the availability of bottomfish on traditional fishery grounds and hypothesized that the decline may be due to heavy fishing by shrimp vessels, which discard a large tonnage of the demersal finfish.

The latest National Marine Fisheries Service (NMFS) figures indicate that the magnitude of shrimp effort and the corresponding discard of fish is considerable. Total production of groundfish for 1976 by the commercial fisheries was 45,350 t. In 1975 the estimated discard rate by the U.S. shrimp fleet was 330,000 t (S. Drummond, Southeast Fisheries Center, Pascagoula Laboratory, Pascagoula, Miss., pers. commun.). The NMFS shrimp fleet discard survey data for 1975 shows that 15,400 t of Atlantic croaker, *Micropogon undulatus*, spot, *Leiostomus xanthurus*, and sand seatrout, *Cynoscion arenarius*, were discarded in the inshore waters (0-10 m) off Louisiana, Mississippi, and Alabama. Data collected by the Mississippi Gulf Coast Research Laboratory indicates that large numbers of juvenile Atlantic croaker, Gulf menhaden (*Brevoortia patronus*), spot, and sand seatrout present in the Mississippi Sound were greatly reduced because of intensive trawling when the shrimp season opened in June 1976.

It is apparent that the discarding of fish by the shrimp fleets causes greater than normal fish mortality, and can be a major factor contributing to the decline in the Gulf groundfish stocks. These discards will certainly contribute to a further reduction in fish stock abundance and may be particularly significant when juvenile fishes are discarded on the inshore nursery grounds.

One solution to eliminate the fishing pressure on demersal finfish by shrimp trawlers is to develop trawling gear that captures only shrimp while avoiding fish. As a conservation measure, the NMFS Harvesting Technology Group at Pascagoula, Miss,. has undertaken the development of selective shrimp trawling gear to reduce the finfish harvest by the shrimp fleets in the southeastern United States.

WEBBING PANEL TYPE SEPARATOR TRAWLS

The initial effort to develop a simple and economical trawl, which would be similar to a conventional shrimp trawl, was to attempt separation using webbing panels inside the trawl to sort shrimp from fish (Seidel, 1975; Watson and McVea, 1977). Webbing panels were strategically placed in conventional shrimp trawls to use water flow through the net to force shrimp through the panels into the trawl bag. Fish were led along the panel into an escape chute, which allowed them to escape the trawl unharmed (Fig. 1). The panel separator trawl is a simple approach to the discard problem and, if successful, could easily be adopted by the shrimp industry.

The Harvesting Technology Group has been developing and evaluating webbing panel type separator trawls in the Gulf of Mexico since 1975. The development work has resulted in a separator trawl that functions relatively well under most conditions in the offshore shrimp fishery (10-30 fathoms). Comparative trawling tests between the separator and standard shrimp trawls indicate that an average 60-80 percent of the finfish captured in a standard trawl can be eliminated by a separator trawl.

A major problem with the webbing panel type separator trawl, however, is the loss of shrimp. No matter what the specific design, some portion of shrimp entering the trawl mouth will pass out the escape exit along with the finfish. Shrimp loss can vary greatly depending on conditions encountered. On the majority of offshore fishing grounds

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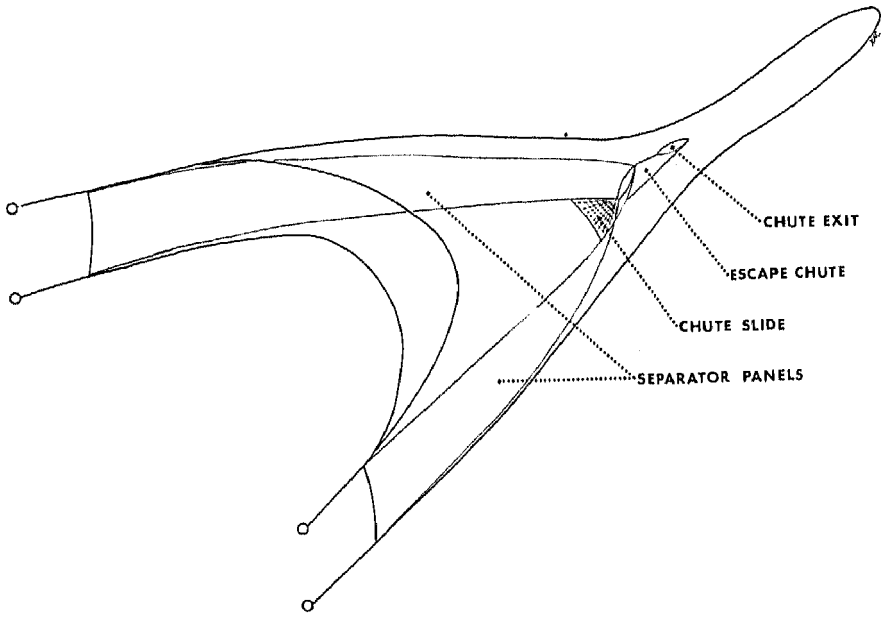

Figure 1.—Webbing panel type shrimp separator trawl design.

where most of the fish are larger and not heavily concentrated, the separator trawl shrimp catch can average as little as 10 percent less than the standard shrimp trawl. When heavy concentrations of fish are encountered (500-1,000 pounds/hour) or when the fish are small in size, the shrimp loss may reach 50-60 percent. The smaller fish also tend to gill in the separator panel and block the panel, thereby reducing the amount of shrimp that can pass through to the bag. Large concentrations of fish also cause more shrimp to be carried out the fish exit without contacting the separator panels. One other factor affecting the efficiency of the shrimp separator trawl is the towing time. As it increases, so does the rate of shrimp loss because accumulating fish clog the separator panels.

Limitations of the panel type separator trawl make general acceptance of the trawl by the commercial shrimp fleet doubtful. Results indicate good potential for limited application on many offshore shrimp grounds, but it is not likely to be universally accepted. The greatest potential destruction of groundfish stocks by shrimp trawlers occurs in the inshore shrimp fishery where fish concentrations are more dense and the fish sizes generally smaller. Under these conditions, where a shrimp separator trawl is most needed, the conventional webbing panel type separator trawl is the least efficient and would be unacceptable by shrimp fishermen. There is, therefore, an urgent need for a more effective approach to the fish discard problem, particularly by the inshore shrimp fishery, even though the solution may be more complicated and somewhat more expensive to use.

RECENT ADVANCES IN ELECTRICAL FISHING TECHNOLOGY

The Harvesting Technology Group has been involved in applying electrical fishing techniques since the mid-1960's. This work resulted in the development of an electric shrimp trawl system (Seidel, 1969). Although not widely accepted at present by the fishing industry, the electric shrimp trawl system is an effective harvesting device and can increase shrimp production day or night. Recent advances by the Harvesting Technology Group with the electric shrimp trawl system have greatly improved its capability. Improvements to the electrical pulser system, and particularly the electrode array design, have significantly improved performance. Recent behavioral studies of shrimp reactions to the electrical stimulus and field experiments with the trawl established the first known, accurately defined catch efficiency for any trawl (Watson, 1976). Further studies of fish behavior to electrical fields made possible the control of fishes by electrotaxis (Klima, 1972; Seidel and Klima, 1974). This expertise and technology, which has been established within the Harvesting Technology Group, can be utilized to develop a shrimp separator trawl system which potentially could eliminate the capture of all fish on any shrimp ground, and would certainly offer a solution to the difficult problem of separating fish and shrimp on the inshore grounds. A general concept of the trawl design follows.

SELECTIVE ELECTRIC SHRIMP TRAWL

A diagrammatic view of a selective shrimp trawl using electricity is shown in Figure 2. The most prominent and unusual feature of this concept is that the mouth of the trawl is completely closed with a webbing panel, and 6-8 feet of setback is provided to give the mouth panel a pronounced slope (Fig. 3). The fish barrier closing the mouth of the trawl is made of webbing and allows water to flow through the trawl, but prevents fish from entering the net. A large (12- to 18-inch) mesh bottom panel is placed in the net and the trawl is adjusted to fish 12-24 inches from the bottom. The electrode array is attached to the footrope of the trawl and trails back under the net to create an electrical field under the net. The electrodes are constructed of 1-inch diameter rope covered with conducting material to provide a large diameter electrode and thus increase the electrical current flow into the water. A capacitor discharge electrical pulsar, similar to that described by Seidel (1969) and Watson (1976), is used to create the electrical field, which controls the behavior of the shrimp. Shrimp are forced to jump up through the large mesh bottom panel, while fish stimulated by the field are

herded ahead of the trawl (Fig. 3). Other fish are simply directed away from the trawl by the closed mouth. This approach is unique and differs from other separator trawl designs in that the fish never enter the trawl; therefore, they do not have to be separated from the shrimp catch. The application of electricity to sort shrimp from fish is possible because of the differences in behavioral reactions of fish and shrimp to an electrical field.

Klima (1968) studied the reaction of penaeid shrimp to electrical fields. He found that the optimum voltage level and pulse rate needed to induce a "jumping" reaction (Watson, 1976) in shrimp was 3.0 V (measured across 10 cm distance parallel to the electric field) at a pulse rate of 4-5 pulses per second. To induce electrotaxis in fish, pulse rates of 15-50 per second at voltage levels of 1.5-3.0 V across 10 cm are required (Klima, 1972; Seidel and Klima, 1974). The slower pulse rates required to control the shrimp do not induce electrotaxis in fish, but produce a fright response instead. In addition, the reaction direction of shrimp to the electric field is vertical while the fright reaction of fish is horizontal or 90° different from the shrimp's movement. These factors, together with optimizing the electric field, will effectively select shrimp for capture and at the same time drive fish away from the electrified area under the trawl.

The electrical separator trawl concept is technically feasible and represents a very effective approach to solving the shrimp fleet discard problem. The use of an electrical field provides direct control of the shrimp and fish rather than relying on their passive behavior as with panel type separator trawls. The technology and expertise exist to accomplish the development and introduction of this selective shrimp trawl into the shrimp fishing industry, and would greatly enhance the capability for the effective conservation and management of our shrimp and fish resources.

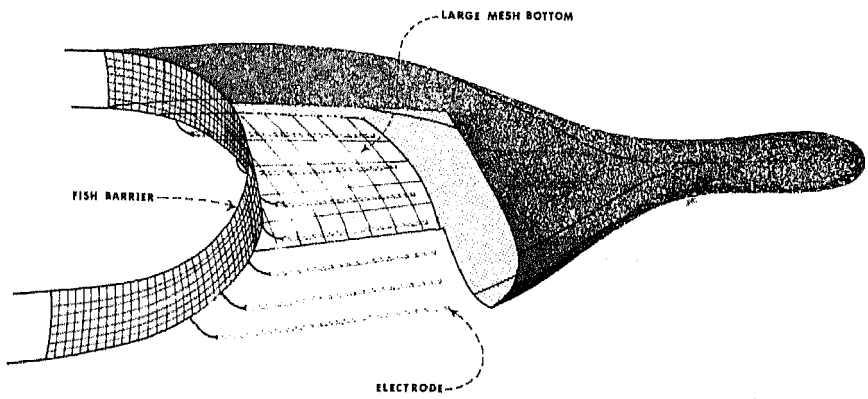

Figure 2.—Selective electric shrimp trawl design showing placement of large mesh bottom entrance, fish barrier, and electrodes.

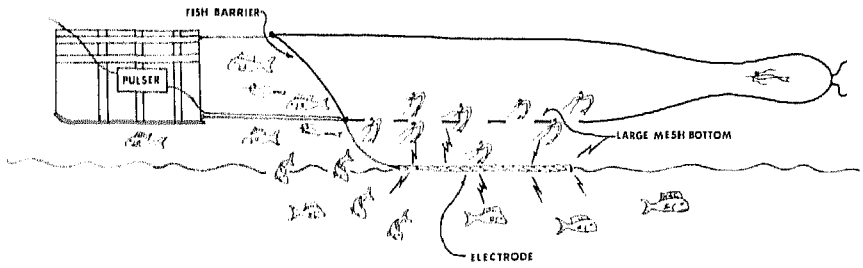

Figure 3.—Selective electric trawl diagram depicting method of shrimp separation employing an electrical field.

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