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Promising Leads in Fishing Gear Development

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Abstract

Fishing gear research and development in the Gulf of Mexico is conducted by the Branch of Exploratory Fishing at its field station in Panama City, Florida. The current program is devoted almost entirely to research into the development of improved shrimp harvesting methods.

This program is being pursued in three phases: (1) shrimp trawl mechanics, (2) natural shrimp behavior, and (3) shrimp response to artificial stimuli. Preliminary data with respect to trawls indicate there are no major differences in the mechanical performance of the three basic designs presently in use.

The studies of the natural behavior of shrimp have been confined to pink shrimp *(Penaeus duorarum)* and to those aspects of behavior that involve escapement from conventional shrimp trawls. Data to date indicate that shrimp avoid trawls and predators primarily by the process of burrowing into the bottom. Burrowing behavior appears to be directly related to the level of light on the bottom, i.e., they burrow when the light reaches an as yet undetermined level and they emerge from the bottom when it falls below this level.

Phase 3, response of shrimp to artificial stimuli, has involved only the examination of the effect of low power electricity as regards its ability to evoke a strong enough "blocking" response to cause a burrowed shrimp to emerge from its burrow. Experiments to date indicate that power levels below 50 watts between electrodes can be effectively utilized in conjunction with trawls to harvest burrowed shrimp.

FISHING GEAR RESEARCH is conducted in the Southeastern United States by the Bureau of Commercial Fisheries Gear Research Unit in Panama City, Florida. The research vessel assigned to this work is the M/V GEORGE M. BOWERS.

Before discussing the status of our current projects it may be well to discuss first the concept of fishing gear research generally and the Bureau's role in particular. Definition of fishing gear research is as broad as an individual chooses to extend it. It may range from detailed animal behavior studies to the design and development of gear handling equipment including vessels. Some feel that a Gear Research Program in the Gulf of Mexico should include evaluation of the relative efficiency of the various standard shrimp trawl designs through extensive comparative fishing tests or the evaluation of the effectiveness of various types of modifications and accessory gear. Others feel that development of more efficient deck equipment or better animal location instrumentation is where the emphasis should be placed. Because of the wide range of possible projects it is apparent that funds and personnel are not available to pursue all aspects considered to be within the realm of gear research.

It was necessary to establish a working definition of gear research consistent with funding and a reasonable probability of achieving eventual development of more effective gear. In doing this the many activities regarded as gear research were considered. Comparative fishing utilizing standard gear was given a very low priority owing to the extremely high cost and to the assumption that if any significant efficiency differences existed in the various gear the commercial fishermen would already have discovered them. Similar reasons were used for rejecting the evaluation of trawl modifications and accessory gear as a significant project. In addition, in both of the above cases a strong argument against adoption as research projects is the absence of any means of determining why differences in performance may be occurring.

Projects directed toward improving deck equipment or vessel design were not considered except where they related directly to specific requirements within existing projects. Development of deck equipment can usually be accomplished by private industry without incurring the prohibitive costs of expensive vessel sea time.

A partial analysis of why progress has been so notably lacking in the development of fishing gear was made. Industry has kept pace with technological developments in such things as vessel design, gear handling equipment, fish location and navigation instruments, and shore side facilities for efficient handling, distribution, and marketing of their products, but progress with respect to the primary capturing gear has not occurred. Many reasons were brought out but the most evident was that practically nothing was known regarding the natural behavior of the animals sought or the mechanical performance of the fishing gear used.

For example, there was an almost complete absence of data regarding the burrowing habits of commercial shrimp. No one knows fully how shrimp behave, when they emerge from the bottom, what determines whether they stay on bottom or swim up into the water, or why any of these things occur. Also, fishermen do not know how their gear captures shrimp.

The absence of knowledge regarding these two factors, animal behavior and gear performance, makes it almost impossible to improve the efficiency of present gear. It appears that harvesting apparatus has developed about as far as possible without additional knowledge regarding the behavior of the animals and the performance of the gear. The reason for lack of knowledge is largely financial. It is extremely expensive to make observations and measurements of fishing gear and animals at sea. The development of instrumentation for these purposes is particularly costly. The present gear research program consequently is being directed into those areas where new information is required and where industry is reluctant to enter due to the extreme costs involved.

The program is currently concerned almost entirely with research directed toward the development of improved shrimp harvesting methods because of the importance of this fishery in the southeastern United States. There are three program phases: (1) shrimp trawl mechanics, (2) natural shrimp behavior, and (3) shrimp response to artificial stimuli. In conjunction with these three phases an instrumentation section has been established to provide the necessary tools for performing the work effectively.

The mechanics phase of the program was initiated with a sub-project to evaluate the gross performance of commercial shrimp trawls. Scuba divers were utilized for making direct observations and movies of the gear in operation. The objective of the work was to establish generally how the gear performed under various operating conditions and whether there were potential improvements in performance that would become obvious by observation. This aspect of the mechanics phase was terminated early this year with the release of a movie describing the operation of the three basic Gulf of Mexico shrimp trawl designs and their performance under various operational conditions.

Work on the mechanics phase is now directed toward acquiring quantitative data on how the trawls perform mechanically. Data to be acquired include horizontal and vertical distances, angles between gear components, loads or strains on various sections, and the effect of bottom contact with various components. Measurements will be made under various operational conditions such as towing speed, scope ratio, door size, and bottom type. Knowledge of these factors will afford a means of comparing the mechanical performance of present trawling gear quantitatively and will also give direction to development of more efficient equipment.

For example, there are no data available with respect to the distribution of towing strains on the gear. It is not known what percentage of the total towing strain of a trawling assembly is attributable to the doors, to the trawl, or to any component section of the trawl; it is not known what thrust is developed by the doors in spreading the trawl; and further, it is not known to what extent contact between the door and bottom increases the shearing or lifting force of the door.

Quantitative knowledge of these factors will afford a rational basis for comparing trawl performance, provide a basis for more precise evaluation of catches, particularly in exploratory fishing operations, and show where emphasis of future development work can be placed with the greatest probability of success. An example of the importance of basic knowledge of the type being collected is found in trawl door studies. The shearing or lifting force of trawl doors (operating on the bottom) is little understood. Much research time and money has gone into development of more efficient doors based on theories and principles of aerodynamics used in the development of airplane wing designs — which serve a function similar to trawl doors in providing a lifting force thru the flow of a liquid around a surface. However, in the fishing industry, contact between the trawl doors and a solid surface is essential; in the case of airplane wings it is not. Possibly the absence of data on the effect of bottom contact in generating a mechanical lifting force has resulted in much effort being expended in developing hydrodynamically superior but operationally inferior trawl doors. It is possible that future effort should be expended in attempting to increase the shearing force between the door and the bottom. Questions like these need to be answered through mechanical studies of gear if future efforts are to be directed to areas where the possibility of successful application is greatest.

Instrumentation development includes possible commercial application of devices giving fishermen pertinent knowledge of how gear is performing. An example here is the on-bottom indicator, a device that may be an essential element in successful shrimp trawling in deep water. Commercial companies are reluctant to undertake development when the potential market is only a few units. Successful demonstrations of the need for this type of equipment throughout the fleet would point to a market potential of possibly thousands of units, reducing cost and increasing the number of organizations interested in production.

Currently under development for mechanical evaluation of trawls are a remote reading load cell system for measuring towing strains on various parts of the gear, a remote reading sonic distance measuring system, a multiple angle recorder for measuring and recording angles between gear components, a remote reading bottom speed indicator, and an on-bottom indicator utilizing a sonic telemetering system between the gear and vessel. In conjunction with the electrical telemetering systems, experiments with conductor equipped trawl cable are being conducted. Most of these units are operational or nearly so, and the work of applying them to evaluation of shrimp trawls is beginning.

Natural behavior patterns of shrimp being examined are burrowing and vertical migration habits. The principal method employed by shrimp to avoid trawls and predators is by burrowing into the bottom. This behavior is currently being studied with pink shrimp captured in St. Andrew Bay, Florida, and transported to observation cages located in clear water about one mile from the capture area. The shrimp are held in the cages for 24 hours and observed each 30 minutes throughout the period. Fresh shrimp are used for each daily experiment. Observations are obtained by divers utilizing Scuba gear.

Pink shrimp observed in this study remained burrowed during daylight hours and showed varying degrees of nocturnal activity. The animals emerged from the bottom approximately 30 to 60 minutes after sunset and remained out for 3½ to 10½ hours. The variation in nocturnal activity appears to be directly related to the light level on the bottom. During the full moon the animals were active for only 1½ to 2 hours after emergence before burrowing again, while during the dark of the moon they remained active until daybreak. During moon phases between the extremes, activity periods corresponded generally to the degree of moonlight available.

These observations will be continued, utilizing time lapse camera systems in conjunction with photometers in an effort to determine quantitatively the relationship between shrimp activity and light levels. Knowledge of this phenomenon could be of significant value to the industry at the present time, as well as of considerable importance in the development of new gear.

The field work to determine the degree of vertical movement of shrimp has not started. Sampling gear and instrumentation for this project is presently being acquired. The objective of this work is to determine if movements of shrimp during the night, under some conditions, are such that a significant percentage are avoiding trawls by swimming above them.

The study of shrimp response to artificial stimuli has involved only the examination of the effect of low power electricity to evoke a strong enough "blocking" or shocking response to cause a burrowed animal to emerge from the bottom. No attempt has been made to achieve either electronarcosis or electrotaxis. The primary objective of this work is to establish whether electricity can be effectively utilized in conjunction with trawls to harvest shrimp that are in the burrowed state, or to take shrimp which are presently located within bad bottom areas and consequently not accessible to trawling gear.

Presently, experiments are being conducted to determine factors necessary to develop electrode equipped trawls. These include power requirements between electrodes necessary for positive responses, the number of pulses required to bring the shrimp out of the burrow and up into the water, the effect of animal size and electrode orientation on the magnitude of response, the most effective pulse rate for obtaining rapid and strong contractions, the shape and magnitude of the electrical field associated with two electrodes in sea water and the effect of electrode material, length, and spacing on the field strength.

In obtaining data on these factors two distinct problems are evident: (1) the electrical requirements for evoking the desired reaction from the shrimp, and (2) the mechanical aspects of producing the required electrical stimulus in front of and under a moving trawl. In regard to the first item it has been learned that electricity on the order of 50 watts (10 volts at 5 amps) will cause burrowed shrimp to emerge rapidly from the bottom. As a result of these electrically induced muscular reactions shrimp can be caused to move out of the bottom and up into the water a distance of 6 to 24 inches. It has been found also that animals oriented at right angles to parallel electrodes respond much better than those parallel to the electrodes and that larger shrimp respond more strongly to a given field than smaller ones. Optimum pulse rates for obtaining strong responses is important information needed for design of the trawling gear since it has been found that approximately three strong contractions are required to move the shrimp into the desired position. At the present, a pulse rate of 4 per second appears maximum. More frequent pulses tend to produce rapid but small contractions since the animal does not have time between pulses to completely relax. These rapid responses are not of adequate strength to get the shrimp out of the bottom.

In acquiring information pertaining to the mechanical aspects of equipping a trawl with electrodes, the shape and strength of the electrical field between electrodes in sea water has been measured. We found the voltage field is approximately symmetrical in all three planes, the strength being approximately the same 6 inches into the bottom as it is 6 inches above. Also, it was noted that longer electrodes require greater input power to produce a field of given strength than shorter electrodes and that 3/32 inch diameter stainless steel cable serves as electrodes equally as well as ⅛ inch brass rod, a factor important to the handling characteristics of an electrode equipped trawl. The principal objective of these studies is to determine the optimum electrode material, length, and spacing which will produce the required electrical field in front of a moving trawl for a sufficient length of time. Much work remains to be done on the present aspects as well as on refinements, including investigation of various frequencies, pulse shapes, electrode arrays, and trawl modifications.

We hope that a prototype model of a commercial size trawl will be ready for field testing by next summer.

Another Look at the Royal Red Shrimp Resource

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Some 12 years have elapsed since the discovery that a new commercial species of shrimp *(Hymenopenaeus robustus)* was available in the upper slope zone in the Gulf of Mexico. Since then extensive effort has been devoted to an evalua-