Bureau of Commercial Fisheries Exploratory Fishing and Gear Research Base, Pascagoula, Mississippi

July 1, 1967 to June 30, 1969

UNITED STATES DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES

Circular 351

Cover Photo.–RV *Oregon II*, a modern exploratory fishing research vessel assigned to Region 2.

UNITED STATES DEPARTMENT OF THE INTERIOR
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Bureau of Commercial Fisheries Exploratory Fishing and Gear Research Base, Pascagoula, Mississippi

July 1, 1967 to June 30, 1969

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Contribution No. 212, Bureau of Commercial Fisheries

Exploratory Fishing and Gear Research Base, Pascagoula, Mississippi 39567

CIRCULAR 351

Washington, D.C.
November 1970

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ABSTRACT

The research activities of the Base emphasize the development of new techniques for locating and assessing unutilized marine stocks and include studies in aerial photography, multispectral photography, marine bioluminescence, fish oil film, and sonar technology. Described are the outfitting of the new research vessel *Oregon II;* the continuation of conventional exploration for shrimp and fish in the Gulf of Mexico, Caribbean, and western Atlantic; the efforts to implement the development of the Florida calico scallop industry; and the activities of the Exploratory Data Center.

INTRODUCTION

The past 2 years at the BCF (Bureau of Commercial Fisheries) Exploratory Fishing and Gear Research Base in Pascagoula, Miss., have been years of both introspection and wide-ranging extrospection. That is, we have looked both within ourselves–at our methods, tools, and philosophy–and without–into the new world of big business, brain trusts, and rapidly advancing technology. Our problem, simply stated, was, and is, that traditional methods of fishery biology are not adequate to cope with assessment of tropical and subtropical marine stocks, particularly of those stocks that are not fished. Traditional methods of exploratory fishing are both inadequate for pelagic fishing assessment and cumbersome and slow for all assessment. Thus came our soul-searching period for the development of a new assessment system, details of which will be in this report.

The period has seen extensive reworking of programs to provide better integration and "wholeness." Our focus has shifted somewhat from exploratory fishing in the strict sense to fishery development in the widest sense. Our dedication remains: to serve the commercial fishing industry of the United States to the best of our ability.

Why have these problems arisen? Why couldn't we rely on time-proven methodology and techniques? Why "rock the boat?"

It is first important to understand the nature of the region served; a region stretching from Cape Hatteras, N. C., to mid-Brazil and encompassing the Gulf of Mexico and Caribbean Sea as well as the western Atlantic. This, as far as fisheries are concerned, is a young and growing region compared with more northerly regions. It is a region full of potential but lacking in concrete knowledge. *Because of this lack of knowledge and the pressing need to develop the potential rapidly,* new, more powerful, more concise, and more rapid assessment methods are needed.

As an example, we can cite the existence in the region of an estimated 6 million tons of pelagic schooling fishes–thread herring, *Opisthonema oglinum;* several species of anchovies; Spanish sardine, *Sardinella* *anchovia;* scaled sardine, *Harengula pensacolae;* round herring, *Etrumeus teres;* chub mackerel, *Scomber colias;* bumper, *Chloroscombrus chrysurus;* and scads, *Decapterus* and *Trachurus.* Less than 4,200 tons of these fishes are now being harvested per year.

Note we said above "an estimated 6 million tons." With the technology we now have we can only estimate. Perhaps "guesstimate" would be a better term. Now we feel we are moving towards the development of methods for firming up our figures. The following pages explain our progress.

Some remarkable events have occurred during the past 2 years in the midst of our drive toward a new technology. A few might be mentioned:

1. Activation of a laboratory for studying behavior as related to harvesting.
2. A move into "remote sensing" technology for fish location and assessment.
3. Delivery and operation of *Oregon II.*
4. Transfer of *Oregon* to Alaska.
5. Activation of a commercial fishery for calico scallops based on BCF findings.
6. Acquisition and activation of a Univac 9200[1] computer center.

DEVELOPMENT OF FISHING STRATEGY

In late 1967, as the catches of the menhaden industry began to decline seriously, we took a long, hard look at the whole problem of harvesting and, in a general sense, processing the host of small schooling pelagic fishes in the waters off the southeastern United States. It seemed to us that we were obligated to provide industry with knowledge of resources that could be substituted for the menhaden, show industry how these alternate resources could be caught, and devise ways of harvesting and processing that would alleviate the serious labor costs and problems now besetting industry.

Where were points of attack?

1. Menhaden gear, though admirably suited for catching menhaden, is not ideally suited to catching other pelagic species.
2. The large seines used by the menhaden industry "waste" labor.
3. The menhaden industry has large investments in shore physical properties (plants and vessels), that are used only a portion of the year, are expensive to operate and maintain, and again are sources of labor "waste."

Having thus established a few of the areas needing improvement, we made preliminary studies of each of these areas so we would have a basis for applying corrective measure. In essence, we came up with the following scheme involving:

1. Developing an automated barge to replace vessels (except meal-collecting vessels) and shore plants.
2. Attracting fish to the barge, rather than actively pursuing the fish.
3. Holding the fish alongside the barge.
4. Pumping the fish aboard the barge.
5. Processing automatically.

In the beginning, we had only hazy ideas on how we could produce such a system. Talks with equipment manufacturers, however, convinced us that there were no real problems in the development of automated processing equipment or pumps capable of bringing the fish aboard.

As a means of attracting the fish, we decided to concentrate on the use of *light;* to hold the fish, we decided to investigate *electric fields.*

Thus our system and strategy began to take shape, but we knew we had a long way to go. First, at the insistence of industry, we took to the field on a crash program designed to attract commercial quantities of suitable fish to lights available. We used the BCF research vessel *George M. Bowers.* Results were less than spectacular and confirmed our hypotheses that some rather basic work was needed in the laboratory as well as in the field.

We established a small staff to investigate how light and electricity affect various species of the pelagic schooling fishes.

A salt-water laboratory with recirculation system was constructed to permit the program staff to have controlled behavioral studies on how fish respond to harvesting gear. The laboratory was constructed within an existing one-story concrete block structure adjacent to the net storage shed at the Base's dock site on the Pascagoula River. Basic components of the recirculation system include a combination experimental poo

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[1]Trade names referred to in this publication do not imply endorsement of commercial products.

and water reservoir, sump, pump, filter boxes, and delivery system. Auxiliary components consist of a diatomaceous earth filter and a 500-gallon storage tank used to clean the water before it was introduced into the system.

Water for the recirculation system can be obtained either from a salt-water well or a high-salinity wedge in the 40-foot deep Pascagoula River channel. Iron precipitate in the well water and particulate material in the river salt water are removed by recirculation through the commercial swimming-pool diatomaceous earth filter.

The experimental pool dominates the center of the laboratory, is 18 feet in diameter by 4½ feet deep, and has a capacity of about 7,000 gallons. A moveable catwalk is located above the experimental pool. One wall of the laboratory has a rectangular experimental tank, 4 feet wide, 4 feet deep, and 15 feet long, and an instrumentation table. The northern portion of the laboratory has two water tables used for aquariums and small tanks. A 700-gallon portable fiberglass tank is often placed in the laboratory for holding live specimens.

Laboratory studies are currently underway to evaluate and determine the correct type and amount of light and electricity for attracting and leading fishes. These studies will provide the data from which it will be possible to field test commercial harvesting systems that use lights and electricity.

The laboratory electrical studies are aimed at determining the combination of pulse rate, voltage, and pulse width that is best suited to lead each of the coastal pelagic species. Fish stimulated with the proper type and amount of pulsating current can be controlled and forced to swim to the positive electrode; whereas, improper electrical stimulation does not permit control and does not induce forced swimming to the anode. No one combination of electrical characteristics will be satisfactory for leading all of the coastal pelagic species. Optimum electrical combinations probably will vary according to the species and size of the individual fish. Hence, a series of laboratory studies are currently underway to determine the ideal combination of electricity for leading each of the coastal pelagic species. The technique used to obtain the proper combination of electricity is to place individual fish into an insulated 16.4-foot long tank (fig. 1). Preselected electrical stimuli (i.e., pulse rate, voltage, and pulse width) are applied to each individual. We record the various fish responses and the time it takes each fish to swim from the cathode to the anode. These responses and reaction times are later compared with the responses and reaction times of fish subjected to

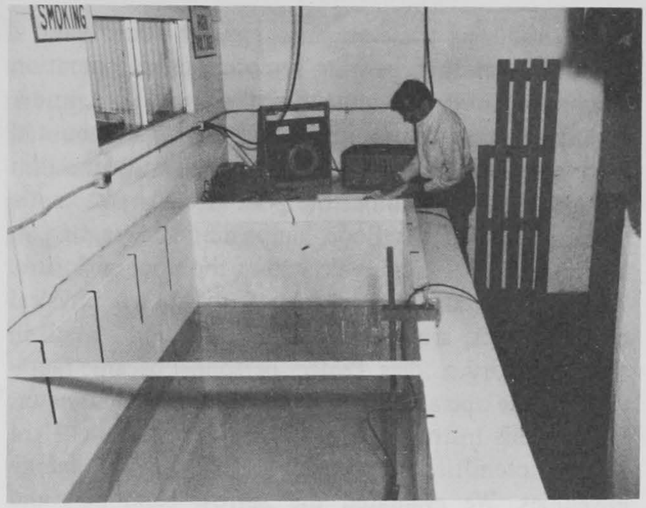

Figure 1.–Tank and equipment for electric-stimulation fish studies.

other electrical combinations. We designate as optimum the electrical characteristics that provide the best and most desired fish responses.

To provide a wide range of pulse rates and voltages for the laboratory studies, Bureau of Commercial Fisheries and General Electric engineers modified the BCF-developed electric shrimp pulse generator. This generator uses a modified pulse generator to provide a capacitor discharge type pulse to the insulated tank. The pulse generator converts alternating current to direct current and rectifies it into a capacitor discharge type pulse. A variable transformer controls the voltage output, and pulse rate is altered by means of a variable resistor.

The laboratory studies have provided information on the electrical combinations that are best suited for leading eight species. Additional work will be continued to determine the electrical characteristics best suited for other coastal pelagic species. The electrical characteristics will be evaluated in the field during the forthcoming year.

Through a combination of field and laboratory studies, we are investigating the light attraction phenomenon and its suitability for commercially harvesting the coastal pelagic fishes in the Gulf of Mexico. Initially, light attraction in the field is for capturing live specimens and for generating hypotheses to be tested in the laboratory. Results from laboratory experiments will guide the development of prototype light attraction systems and techniques that will be field tested to determine their commercial feasibility.

Light attraction of selected coastal pelagic species was studied in the experimental pool. We used 35-mm. motor driven, wide-angle (fisheye) lens to record fish behavior during these experiments. We constructed a control panel that permits remote camera operation and built an experimental light source, also under command from the remote panel, that was mounted over the pool. A light-tight black, polyethylene film curtain was hung around the pool area. An automatic timer controlled the flood lamps used for creating an artificial diurnal light cycle within the pool enclosure.

Experimental light sources, with known physical characteristics, are being used as attraction stimuli in the laboratory studies. Project personnel became familiar with the operation of the Base's spectro-radiometer. We use this instrument to balance experimental light source intensities to provide equal spectral energy envelopes. We evaluated the narrow band pass and density filters and selected the combinations that provide equal energy at selected intervals from the visible spectrum.

Preliminary laboratory light-attraction trials on bay anchovy, *Anchoa mitchilli,* were used to establish experimental procedures and data handling techniques. We began the experimental studies with the testing of the response of dusky anchovy, *Anchoa lyolepis,* and Spanish sardine to white light. We are now analyzing the film from these studies.

The light-attracted community appears to be a complex that may include both photopositive species and opportunistic predators. Some planktonic organisms, which are photopositive, may attract many of the suspected predators. To further our understanding of the light attraction phenomenon in the sea, we have begun a study of the photic responses of selected zooplankton. We have tested the responses of zoea, megalops, and early crab stages of the blue crab, *Callinectes sapidus,* and the adults of one species of copepod.

A light net used with surface quartz-iodide and underwater mercury vapor light is currently being used for collecting live specimens for laboratory study and will be used in the future to evaluate light attraction techniques. A 16.4-foot diameter lift net, designed, constructed, and installed aboard the *George M. Bowers,* uses an improved lifting arrangement. The mounting frame used to permit positioning an underwater light and echo sounder transducer above the lift net was designed and constructed. Figure 2 is an echo tracing, from a hull-mounted transducer, of fish being attracted to a 1,000-watt quartz-iodide lamp deployed above the surface in 10 to 12 fathoms of water. Lift net samples contained dusky anchovies; round herring; Spanish sardines; rough scad, *Trachurus lathami;* chub mackerel; and squid. Larger fish were seen but not captured.

We have completed the instrumentation phase of this project and have begun a study of light attraction of pelagic fishes both in the laboratory and in the field.

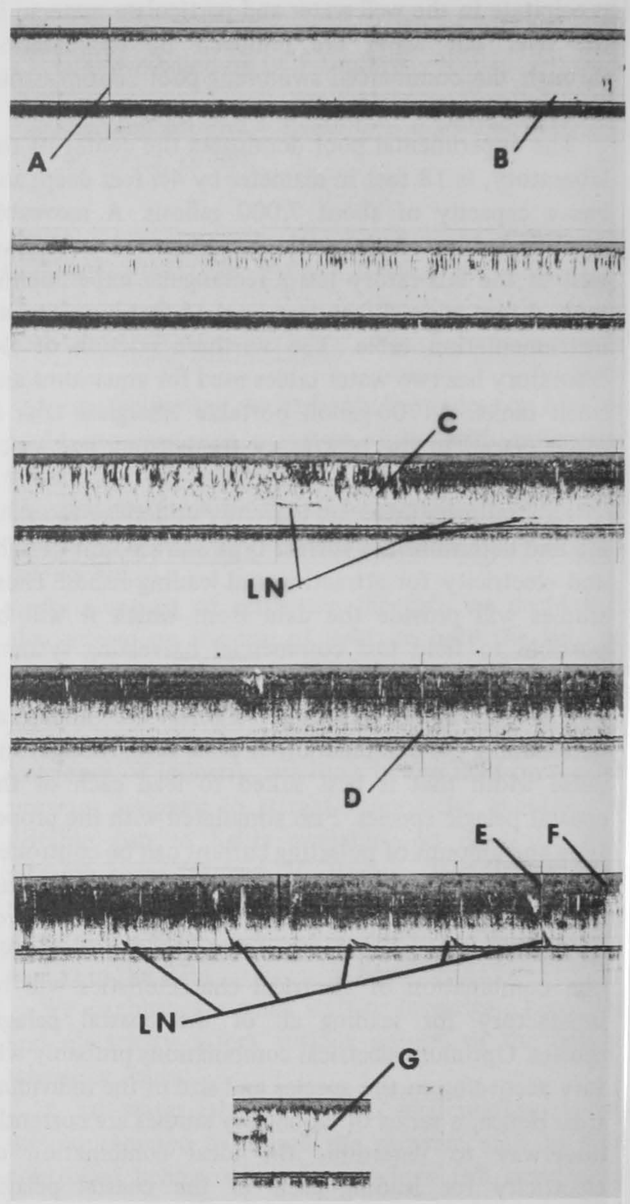

Figure 2.—Echo trace made June 2, 1969, during nightlighting studies aboard the *George M. Bowers* in 12 fathoms of water off Mississippi. (A) 1900 hours, light turned on; (B) 1945 hours, sky dark; (C) 2200 hours; (D) 2300 hours; (E) 2400 hours; (F) 0015 hours, light turned off; (G) 0030 hours, end of observation; (LN) lift net.

NEW TECHNIQUES FOR LOCATING AND ASSESSING UNUTILIZED STOCKS

We have become increasingly uncomfortable in recent years because we are unable to apply the many aspects of a rapidly advancing nonfishery technology to the rapid location and accurate assessment of the many stocks of fishes in our region that are not fished or under-utilized.

Traditional methods of fishery biology such as use of landing statistics and tagging are of no value in the study of a stock of fish that is not being used. There are no statistics; the tagged fish would not be recovered. What sort of approach *can* be used?

To discuss this logically we must divide our attention to three groupings of resources: (A) the surface and near-surface pelagic fishes, (B) the so-called mid-water fishes, and (C) the bottom-dwelling fishes and shellfishes.

LOCATION AND ASSESSMENT OF SURFACE-DWELLING PELAGIC FISHES

Near complete frustration has marked the mood of Base biologists for nearly 20 years as they watched the *Oregon* steam mile after mile through schools of such fishes as thread herring, Spanish and scaled sardines, razor bellies, and others. They have seen the depth recorder of the *Oregon* detect miles of near-surface to bottom schools that samples showed to be round herring. The frustration resulted from an absolute inability to quantify–i.e., assess–these stocks. None of the traditional methods of assessment would work, and our imaginations and our budgets were too limited to develop adequate assessment methods. Thus our reports were replete with terms such as "tremendous numbers," "immense schools," "heavy tracings," and similar subjective and nonquantitative wording.

Research with remote sensors capable of rapidly assessing latent and underutilized stocks is now underway at the BCF Exploratory Fishing and Gear Research Base, Pascagoula, Miss. The overall program goal is to develop a rapid fishery intelligence system for assessing and mapping fish stocks. We are testing spectrometers, image intensifiers, and lasers that may be used to survey wide areas of the oceans by day and night. An effective multisensor system is one that would identify those characteristics of pelagic school-fish that permit direct detection, identification, and quantification of the schools from remote platforms. The state-of-the-art in remote sensing can then be used in an aerial system to assess fishery resources. Sensing-surveying methods and data dissemination techniques, in turn, will be developed to provide a practical means of assessing the fishery stocks over large oceanic areas.

To realize those goals, we directed our research effort during the past 2 years to the following four study areas:

1. Studies of spectral reflectance.
2. Aerial photographic studies.
   a. multispectral
   b. Apollo 7
3. Studies of fish oil films.
4. Low-level light/bioluminescence studies.

Studies of Spectral Reflectance

A pilot program to assess the feasibility of fish identification by remote sensing was conducted by this Base and TRW Systems, Inc. under a BCF contract. The study consisted of spectral reflectance measurements on 18 species of live pelagic fish indigenous to the Gulf of Mexico. Also measured was the spectral reflectance of sea water. Recommendations were made for airborne instrumentation that could be used to obtain spectral reflectance measurements of fish schools. Reflectance curves for bluefish, *Pomatomus saltatrix;* largescale menhaden, *Brevoortia patronus;* ladyfish, *Elops saurus;* black mullet, *Mugil cephalus;* round scad, *Decapterus punctatus;* Spanish sardine; and chub mackeral produced curves significantly different from one another. Spectral reflectivity of bluefish has maximum values at 400 to 450 millimicrons with moderate reflectance (fig. 3). High reflectance values of ladyfish peaked at 500 to 550 millimicrons. Largescale menhaden possessed moderate reflectance at 700 millimicrons (fig. 4). Spectral reflectivity of black mullet

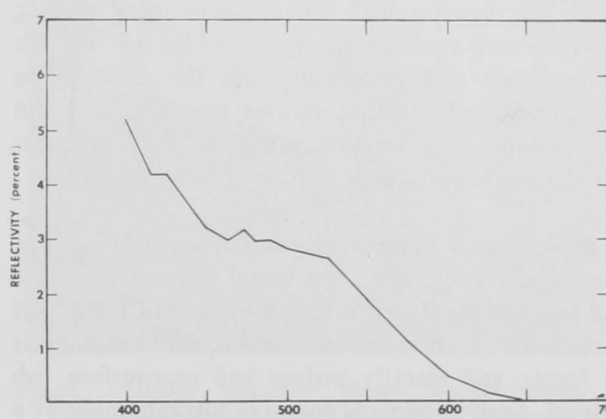

Figure 3.–Spectral reflectivity of bluefish, *Pomatomus saltatrix.*

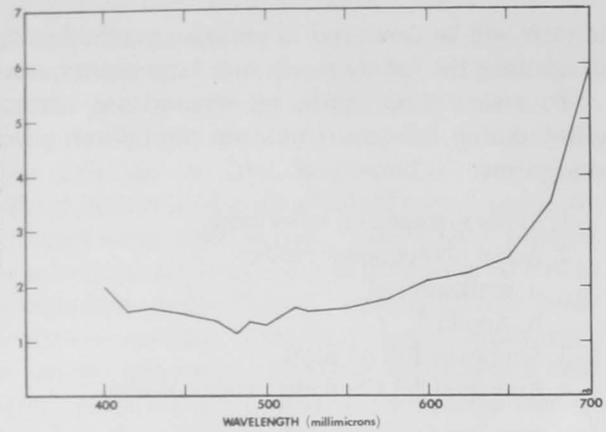

Figure 4.–Spectral reflectivity of largescale menhaden, *Brevoortia patronus.*

shows overall low reflectance with no maximum values. Round scad confined in a net in the ocean showed high reflectance with a maximum value at about 660 millimicrons. Similarly the spectral reflectivity of a natural school composed of round scad, Spanish sardine, and chub mackeral showed high reflectance and a maximum value at 675 millimicrons and was significantly different from the reflectance curve of clear ocean water associated with the natural school (figs. 5 and 6). The results of this initial research proved that a strong potential exists for application of remote spectrophotometry in fishery assessment and survey work.

Early Photographic Efforts.–Considerable air time was spent in fiscal year 1968 photographing fish schools vertically with 9-inch aerial cameras using a variety of black-and-white, color, and color infrared films. Fish schools thus photographed could be measured for surface area. We attempted to correlate the aerial photography with simultaneous sonar pinging and follow-up commercial capture of the schools. We accomplished this successfully, but the difficulty in coordinating all three operations simultaneously did not permit us to collect sufficient data to allow correlations of surface area, color, and fish density.

Multispectral Photographic Analyses.–During June and August 1968, the Long Island University Science and Engineering Research Group under a BCF contract studied the feasibility of using multispectral techniques to locate and identify surface and near-surface fish schools. Analysis of aerial color photographs made by a four-lens, multispectral camera with Ektachrome film demonstrated that such a sensor system can optically discriminate colors of artificial underwater targets. Analysis of the photographic imagery included false color processing and additive color rendition using a color viewer. Special narrow-band camera filters provided increased contrast between target and background. False color separation chromatically separated the background from the targets.

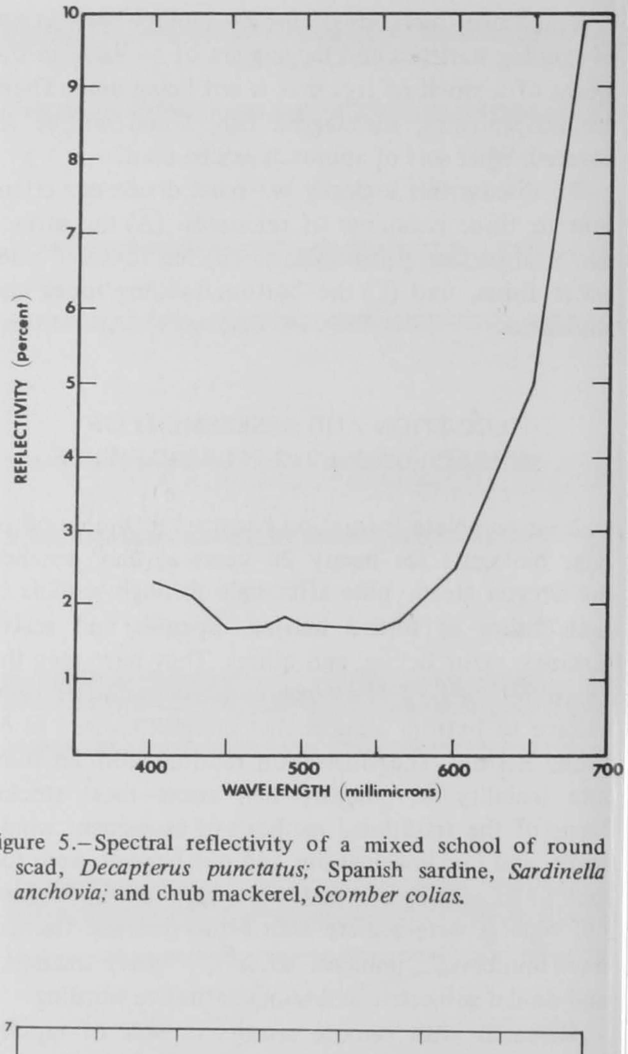

Figure 5.–Spectral reflectivity of a mixed school of round scad, *Decapterus punctatus;* Spanish sardine, *Sardinella anchovia;* and chub mackerel, *Scomber colias.*

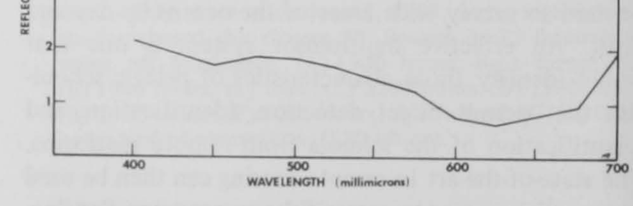

Figure 6.–Spectral reflectivity of ocean water contiguous with mixed school of fish in figure 5.

Aerial Photography in Support of Apollo 7.—Personnel from the U.S. Coast Guard Air Station, Miami, Fla.; the Naval Oceanographic Office Spacecraft Oceanography Project, Washington, D.C.; BCF Biological Laboratory, Galveston, Tex.; and BCF Exploratory Fishing and Gear Research Base, Pascagoula, Miss., cooperated in a joint research effort to provide "ground truth" observations for Apollo 7 photographic experiments in the Gulf of Mexico. The aims were to locate, photograph, and identify concentrations of surface fish off Campeche Bank; locate the boundary of the Yucatan Current from airborne measurements of sea surface temperatures; release Rhodamine-B dye and menhaden fish oil; and obtain simultaneous photographic imagery of dye, oil, and fish schools from aircraft and spacecraft. Oceanographic and ground truth data were collected from the *Oregon II*. In addition, the Base furnished a two-lens camera system with special films, filters, and lenses; and infrared radiation thermometer and recorder. The results included detection of upwelling in the form of a temperature change of 2° F. recorded over a distance of 1 mile. BCF photographs demonstrated that the special SO-121 color film can detect Rhodamine-B dye and fish oil films at altitudes over 10,000 feet.

Studies of Fish Oil Films

Surface schooling pelagic fish such as menhaden, mullet, Spanish mackerel, and thread herring are known to secrete oils that form a thin film on the sea surface. Studies by the BCF Technological Laboratory at Pascagoula, Miss., on the absorption spectra of black mullet and largescale menhaden, showed characteristic differences in the absorption spectra of oils from different parts of the body and differences between species.

Because preliminary tests suggest that measurements of the characteristics of oil films may be a way to identify species, the U.S. Naval Oceanographic Office's Spacecraft Oceanography project awarded a contract to Baird-Atomic, Inc. to make an in-depth study of fish oil films. The aims of this work were to 1) analyze the spectral properties of marine fish oil films and 2) develop design criteria for an airborne/spaceborne sensing system. The BCF Fishery Intelligence System Program at Pascagoula will provide fish oil samples and monitor the contract.

Low-Level Light/Bioluminescence Studies

Stimulated by reports of fish schools "firing" at night and the development of tactical night vision devices for the military in Viet Nam, we decided to explore the feasibility of spotting fish schools at night. During the year we tested a Plumbicon television image–intensifier system from Coast Guard helicopters, fixed-wing aircraft, an oceanographic platform, and surface vessels (fig. 7). The image intensifiers were loaned by the U.S. Army's Night Vision Laboratory, Ft. Belvoir, Va. The devices amplify the bioluminescence associated with fish schools 40,000 to 70,000 times. The Plumbicon television coupled to the image intensifier provides a highly sensitive system combining the advantages of easy operation, high speed of response, and relatively good resolution. Observations using the portable (Starlight scope) image intensifier were made at Port St. Joe, Fla., where bioluminescence associated with Spanish mackerel schools was recorded on video tape (fig. 8). The data were collected aboard a commercial haul seiner during dark-of-the-moon. The haul seine was clearly outlined in the water when luminescent organisms were stimulated by the mesh. Spanish mackerel, weighing three-quarters of a pound and "firing" inside the seine, have been seen leaving bioluminescent trails as they charged the net. Biological luminescence was also recorded on tape while the

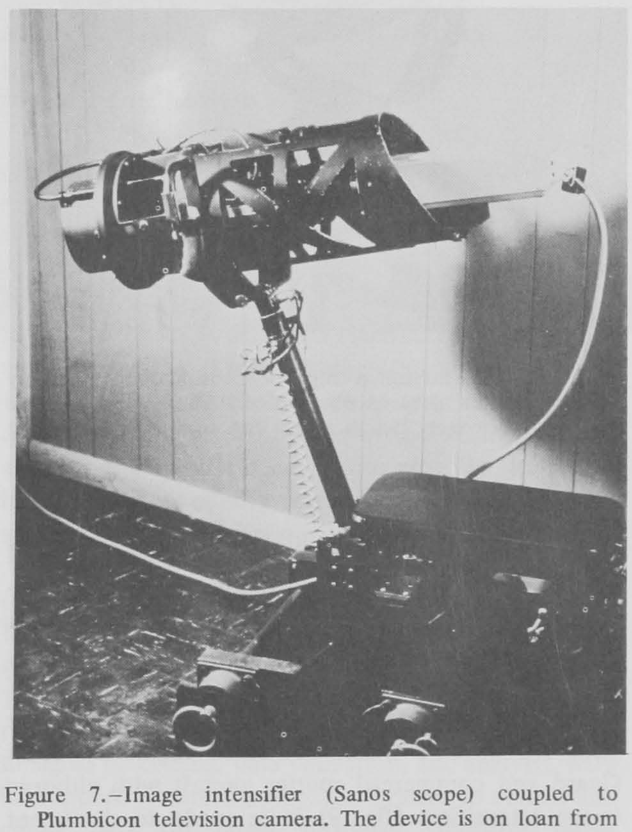

Figure 7.—Image intensifier (Sanos scope) coupled to Plumbicon television camera. The device is on loan from the U.S. Army's Advanced Research Project Agency, Night Vision Laboratory, Ft. Belvoir, Va.

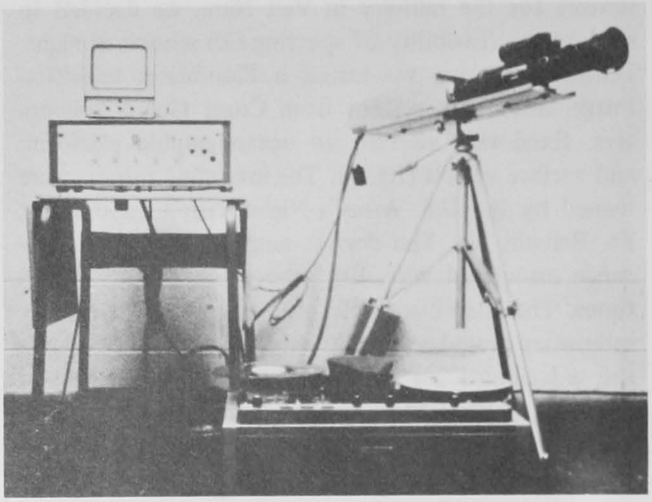

Figure 8.–Image intensifier (Starlight scope) coupled to Plumbicon television system.

Figure 9.–Image intensifier (night observation device) specially designed for airborne observations. The device amplifies bioluminescence 75,000 times that seen with the naked eye.

sensor system was on the U.S. Naval Ship Research and Development Center's oceanographic platform at Panama City, Fla. One of our small boats towed an anchor 6 feet below the surface to stimulate luminescence. Two separate trails of light were visible on the TV monitor; one from the anchor and another from the outboard motor's wake. Combined flights by Coast Guard and commercial spotter aircraft with airborne image intensifiers (fig. 9) were made to document bioluminescence associated with thread herring schools. Crescent and half-moon shapes, and snakelike undulations were observed and sensor imagery was recorded at night from altitudes of 500 to 5,000 feet (fig. 10). Observers estimated that some schools were 500 feet in diameter. During morning twilight observers aboard the spotter craft at 2,000 feet saw intense bioluminescence when the helicopter repeatedly passed over a school at 500 feet; this firing apparently was due to acoustical reverberation that stimulated escape responses.

The aerial observations and sensor imagery indicate that biological luminescence is a source of illumination that provides a means for rapid surveys of surface and near-surface fish stocks during the night. The major factors believed to be responsible for the production of stimulated bioluminescence associated with schoolfish are the density of luminescent dinoflagellates, and the speed, depth, and density of the school.

Contract research by the University of South Alabama involved exploratory studies of the causative organisms of bioluminescence in near-shore waters of the northern Gulf of Mexico. Specific aims were to determine the species composition of complexes responsible for stimualted bioluminescence associated with fish schools at night, and to measure the relative and absolute abundance of these complexes. Unfortunately, attempts to determine which plankters were luminescent were unsuccessful. Mechanical stimulation failed to elicit the luminescent response in the organisms collected. *Peridinium* (36 percent) and *Ceratium* (47 percent) were the two most abundant genera of dinoflagellates collected off the U.S. Naval Ship Research and Development Center's platform. Data show-

Figure 10.–School of Atlantic thread herring, *Opisthonema oglinum,* detected at night from an altitude of 3,500 feet. The bioluminescent image is caused by school's movement through the water. This television screen photograph shows the faint glow amplified 55,000 times by the image intensifier.

ing vertical distribution of all dinoflagellates down to 16 feet indicated that they are most numerous at the surface (42-87 cells per gallon) and less abundant at lower depths.

Use of Oceanographic Platform for Remote Sensing Methodology

Many problems associated with making feasibility tests of remote sensors can be isolated and solved more readily through experimental programs from a stationary platform where sufficient "ground truth" data are available. Such data must include not only measurements of the phenomena of interest but also of the environmental parameters which, in many cases, may alter or completely mask the optical signature of the target.

The U.S. Naval Ship Research and Development Center recently approved our request to conduct experiments from its offshore platform, Stage II (fig. 11). Preliminary tests have shown that it is ideally suited for studies dealing with the detection and identification of fish schools. The platform is equipped with a system for automated data acquisition and environmental monitoring. The data recorded include wind speed and direction, air temperature, water temperature at 10 levels, wave height, and current speed and direction at 2 levels. The platform is 1.6 miles off Panama City, Fla., in 64 feet of water. Conditions in this area are representative of coastal oceanic waters.

Installation of Schoolfish Impoundment

We anticipate that schooling fish in pure and mixed schools will be confined in an impoundment adjacent

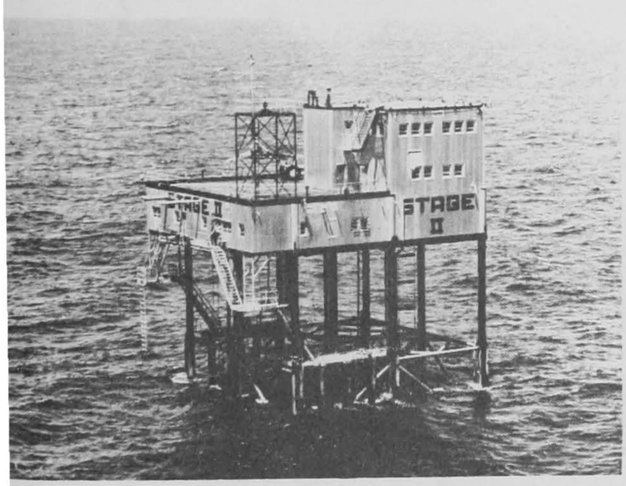

Figure 11.–U.S. Naval Ship Research and Development Center's oceanographic platform at Panama City, Fla. (U.S. Navy Photograph)

to Stage II for observing the behavior of schools and identifying the spectral characteristics associated with each school. Construction and test installation of the net began near the end of the year. Materials included two panels 120 feet long and two panels 60 feet long; all panels were 60 feet deep. The netting consisted of 1-inch stretched mesh, No. 6 twine with sponge corks for flotation, and screw-type anchors. Initial tests of 3 days duration using the 120-foot panel were unsuccessful because the current clogged the net with algae. Another test lasting for 5 days using the 60-foot panel with additional flotation and anchors was also unsuccessful for the same reason. Further tests are planned.

LOCATION AND ASSESSMENT OF MIDWATER FISHES BY SONAR

Between the surface and the bottom of the sea is a host of fish comprising several species suitable for either human food or meal manufacture. The quantities of these fishes are difficult to assess–perhaps even more difficult than surface fishes–and so far have not been taken commercially in warm waters.

Some of our activity was directed toward development of a practical sonar system for assessing the pelagic resources off southeastern United States. The experience gained with standard horizontal and vertical sonars resulted in the collection of target incidence/target strength data in a manner suitable for computer processing and analysis.

Most of the coastal pelagic fishes, both utilized and unutilized, in our regional waters inhabit shallow-water areas of the Continental Shelf–many in waters less than 10 fathoms deep. The use of sonars in the shallow waters presents some unique problems, especially with horizontal scanning sonars. These problems are due largely to the reverberations received from the seabed and the surface. These reverberations mask the fish traces and make sonar assessment systems and techniques developed in other areas of the world unacceptable for the specific needs of our area. We, therefore, have elected to modify relatively inexpensive off-the-shelf equipment to meet our assessment needs.

We are in the age of the electronic "black box." The modification we are making to the 100 kHZ Ross Recorder fits this description. The development of this system is a cooperative project with NASA's Mississippi Test Facility group, Bay St. Louis, Miss. Its space and rocket activities have given this group vast experience in signal processing, data collection, and analysis. With its support we are developing a system to collect and count data on target incidence, measure target strengths, record the data on analog tape, and convert to digital data for processing and analysis by computers (fig. 12). These data supported by corroborative sampling will provide us with a system to measure concentrations of fish schools on the Continental Shelf. Field activities in the Gulf have been limited to a series of short cruises of the *George M. Bowers* to obtain acoustical signal data. From these data we have built and tested a "first-step" modification. Preliminary evaluation of signal data received from "fish and no-fish" targets is encouraging. Computer programing of the data collected is now underway.

A series of bimonthly survey cruises begun in January 1968 off the east coast of the United States was completed with three cruises in fiscal year 1969. This survey based at Brunswick, Ga., is designed to provide information needed for a better evaluation of the stocks of midwater and surface pelagic schoolfish in coastal waters of the southeastern States.

Continuous high-resolution, vertical echo tracings were obtained on 26 standard transects in the 5- to 20-fathom depth range between Cape Hatteras, N. C., and Jupiter Inlet, Fla., during July, September, and November.

Data on target configuration and pertinent oceanographic information collected on each transect were tabulated and transferred to automatic data processing for computer analysis. We are now evaluating a summary analysis of the percentage of space occupied by fish throughout the water column.

Preliminary examination of the data reveals that commercial concentrations of fish appear to have definite patterns in their north-south, seasonal, diurnal, and inshore-offshore movements. We will use the results of this survey technique to establish guidelines for exploratory and experimental fishing.

This series will be expanded to include use of more sophisticated instrumentation being developed at Pascagoula.

"BLACK BOX" CONCEPT

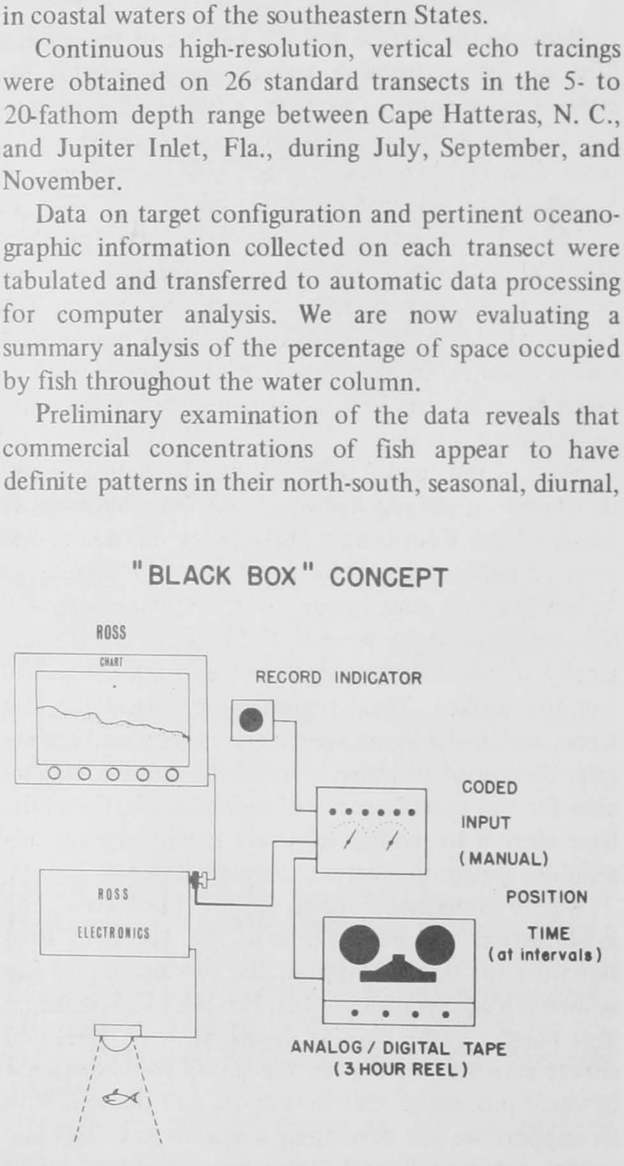

Figure 12.–Conceptual design of a fish stock assessment system.

LOCATION AND ASSESSMENT OF BOTTOM-DWELLING RESOURCES

Dragging trawls and dredges over the bottom is a slow way of assessing stocks of bottom-dwelling animals. It is also expensive in terms of vessel hours, and it is difficult to determine the true relation between catch and abundance. Therefore, the "new technology" has been extended to a bottom survey technique and its appropriate instrumentation.

Several years ago BCF discovered extensive scallop beds a few miles off Cape Kennedy on the east coast of Florida. To assess the availability of this resource and possibly to predict the location and patterns of occurrence of the scallops, BCF conceived and developed a remote-controlled photographic sea sled. In February 1969 the BCF Exploratory Fishing and Gear Research Base, Pascagoula, and the General Electric Company, Bay St. Louis, Miss., cooperated in designing and constructing the vehicle.

Designated RUFAS (remote underwater fishery assessment system) the sled is designed to operate at a depth of 300 feet at a towing speed of up to 5 knots (fig. 13). Diving vanes, controllable by cable from the

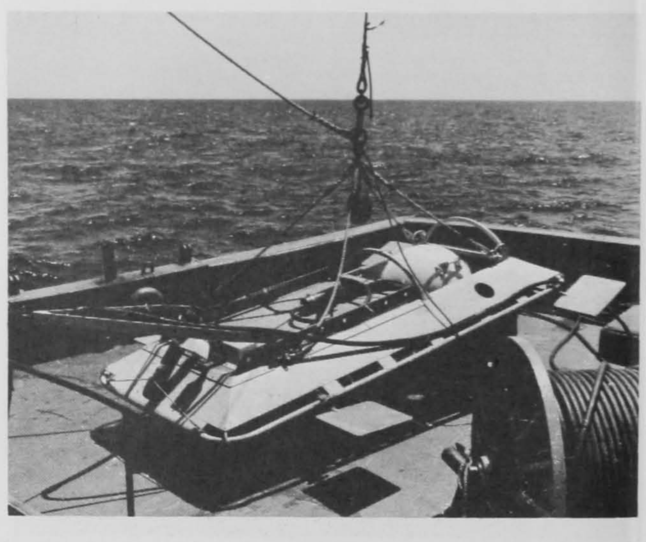

Figure 13.–A remote-controlled photographic/TV sea sled designed by BCF and General Electric Company to assess ocean bottom resources.

tow vessel, enable the vehicle to dive, climb, or hold its position above the bottom. Underwater lights, 16-mm. camera, vertical sounder for bottom reference, and an underwater TV camera connected to a video tape recorder provide the system with visual records for detailed analysis. With this equipment the sled is capable of performing a wide variety of underwater research tasks.

Construction of the system has been essentially completed. Delayed delivery of the 1,000-foot, 30-conductor instrumentation cable caused the project to fall behind schedule. On June 11 and 12, 1969, the vehicle was tested using a 175-foot temporary control cable. With this short cable, vertical penetration could be accomplished from the surface to a depth of 70 feet while stable control of sled was maintained. At the proper setting of the vane, the sled maintained zero degree of roll and 0 to 3 degrees of pitch through the 70-foot vertical range at vessel speeds of 2-½ to 3 knots. We encountered some on-surface instability at slow speeds, but minor modifications to the vehicle should overcome the problem. To date, the limited field trials of RUFAS have produced excellent results.

Present data indicate that the scallop beds lie in a north-south direction (fig. 14); therefore, 13 east-west transects, extending from 15 to 30 fathoms, have been set up to traverse the north-south lines.

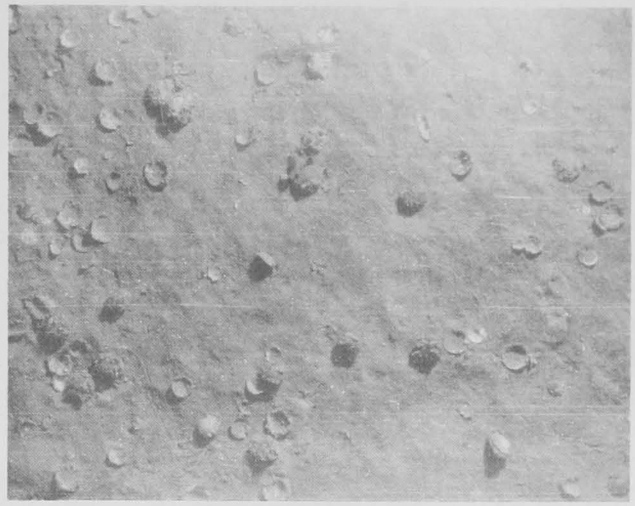

Figure 14.–Scallops photographed from the research submarine *Aluminaut* in 15 fathoms off the east coast of Florida.

TRADITIONAL EXPLORATIONS AND RESEARCH

Meanwhile, as research into new methods of assessment proceeds, our vessels have been busily engaged in the more traditional means of assessment in the Gulf of Mexico and Caribbean Sea as well as along the east coast of the United States.

Two significant events in this 2-year period were the delivery of the new *Oregon II* in August 1967 and the transfer of *Oregon* to the Exploratory Fishing and Gear Research Base at Juneau, Alaska, in February 1969.

DELIVERY AND OUTFITTING OF *OREGON II*

The exploratory fishing vessel *Oregon II* was delivered to the Bureau by the builder on August 10, 1967. Owing to budgetary limitations, the gear handling systems and refrigerated cargo spaces were not included in the original contract specifications. Supplementary funds were, however, made available late in 1967, and bids were solicited for the procurement and installation of this vital equipment.

The special design of much of the equipment required as much as 6 months for manufacture and delivery and necessitated operation of the vessel on a limited basis until the equipment was available.

Winches

What is perhaps the largest and most powerful trawl winch system ever built for the U.S. fisheries has been installed aboard *Oregon II* (fig. 15). The Marine

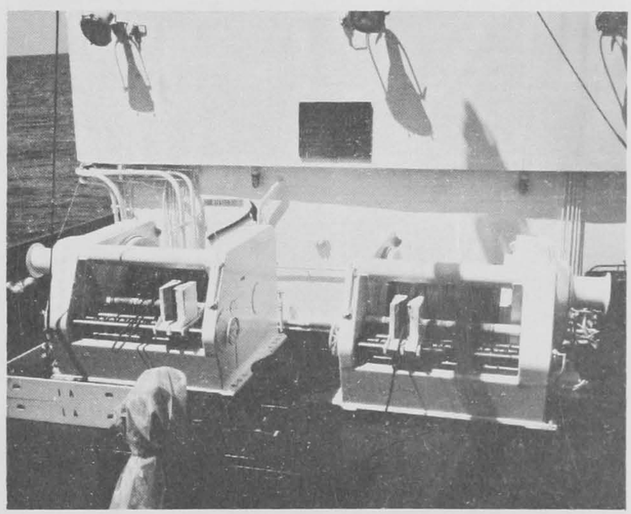

Figure 15.–Forward trawl winches on *Oregon II*. Each drum has a capacity of about 1,400 fathoms of 1-inch diameter cable and can pull the trawl at 200 feet per minute at mean layer at 20,000-pound line pull. Operation is remote from consoles located in the pilothouse or the main deck.

Construction and Design Company of Seattle, Wash., designed and built the system; the Bender Welding and Machine Company of Mobile, Ala., installed it.

The complete ship set, which is powered and controlled throughout by fluid transmission, includes two single-drum, 10-ton trawl winches, each drum of which holds 6,000 feet of 1-inch diameter cable; a 10-ton, double-drum combination trawl and seine winch, each drum of which holds 9,000 feet of ½-inch diameter cable; three topping winches and a boom swinger winch, which controls the movement of the two 3-ton cargo booms; two quarter-rope and lazyline winches; and three 3-ton (single wire) cargo winches. A constant tension "Netsonde" winch with capacity for 6,000 feet of coaxial cable is also installed to handle the transducer cable to the overboard gear (fig. 16).

Control of the winches is incorporated into master consoles and locally at the winches. Precise control during operation is accomplished by disc-type clutches and brakes and by sophisticated hydraulic circuitry. Each single-drum trawl winch delivers 136 line horsepower (23,000 pounds at 195 feet per minute). The combination seine and trawl winch delivers 120 line horsepower (20,000 pounds at 200 feet per minute). Power for these winches comes from the main propulsion engines through integrated hydraulic circuits. Integrated footage out and line tension devices monitor accurately the trawl action.

The auxiliary gear handling winches are powered by separate electro-hydraulic systems so designed as to provide positive and precise control and optimum use of input power. The entire system has been designed for ease of operation and dependability and for minimum needs of manpower.

Deck machinery and hardware are strategically located to permit operation of a variety of fishing gear

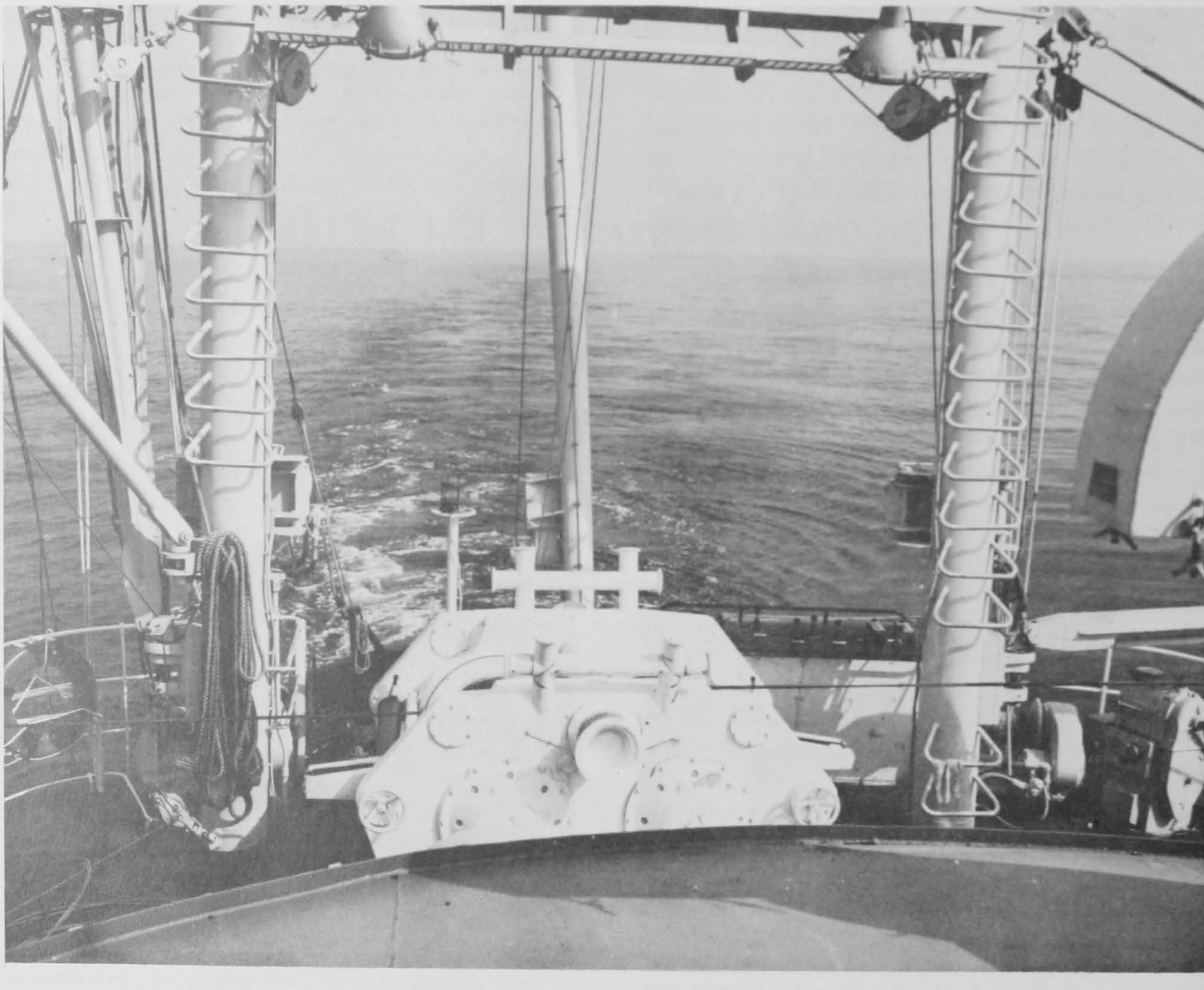

Figure 16.–Combination purse seine and trawl winch located on upper deck aft. Note operating console between king posts and lazyline and boom topping winches on aft side of king posts.

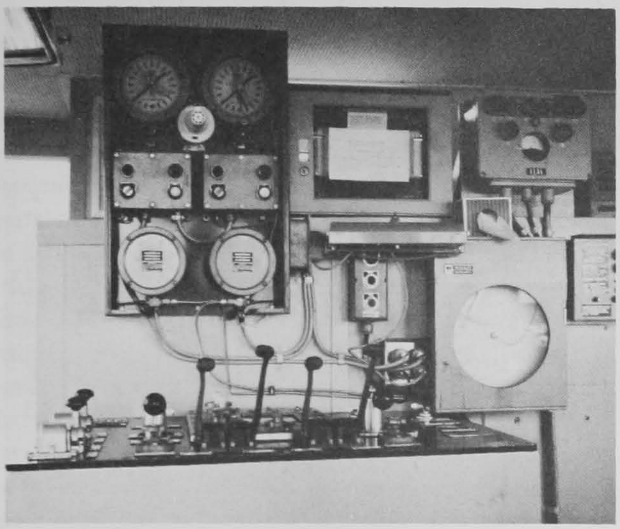

Figure 17.–Wheelhouse winch console aboard the *Oregon II.*

without modification to structure, machinery, or existing arrangement.

Refrigerated Spaces

The refrigeration equipment and facilities installed aboard *Oregon II* consist of five separate freezer spaces designed so that each may serve as a freezer or as a cold storage room. System design is such that the catch may be iced, immersion frozen, dry frozen, or maintained in chilled sea water.

A large walk-in 38° F. chill box provides storage space for perishable foods and selected specimens.

For safety and for installation economy, Freon was chosen over ammonia for the refrigerant because the rules and regulations of the U.S. Coast Guard and American Bureau of Shipping are significantly more stringent for ammonia systems.

Aft Freezer.–The aft -20° F. shelf freezer has a direct expansion Freon 502 system incorporating pipe-coil evaporators. This freezer doubles as a cold storage room for frozen comestibles and as a freezer and holding room for the fish catch. Arrangement of shelving permits easy substitution of fishery products as comestibles are consumed. Loading and unloading is by dumbwaiter located between the wet or processing laboratory and the freezer entrance.

The system is designed for either fully automatic or manual operation and can maintain compartment temperatures with an operating differential of ± 5° F.

This freezer, which is located under the wet or processing laboratory, can maintain a -20° F. temperature when loaded with shrimp or fish introduced at a temperature of 88° F. at the rate of 4,000 pounds in 24 hours. Storage capacity is about 7,000 pounds of shrimp or fish packed in 5-pound cartons.

Forward Freezers.–The four forward reefer spaces have a dual direct expansion Freon 12 system incorporating fan-coil and pipe-coil evaporators.

Two reefer spaces are designed exclusively for dry freezing and refrigerated storage, and the other two are designed as combination wet and dry freezer or refrigerated storage spaces. Back pressure regulators permit individual control of the temperature of each reefer space in the range of -10° F. to +38° F. to facilitate processing and technological studies.

The system is designed for either fully automatic or manual operation and can maintain compartment temperatures with an operating differential of ±5° F.

Manifolding of the refrigerant piping systems permits the two wet/dry reefer spaces to be cooled down by one compressor while the two dry reefer spaces are serviced by the remaining compressor. Capability is also provided for one compressor to service all four reefer spaces during holding condition.

The combination wet/dry reefer spaces can maintain the specified dry and wet bulb temperature when loaded in a prechilled space at the rate of 2,000 pounds per space in 24 hours.

Automatic defrost systems are provided.

The capacity of the four forward reefer spaces, which are located adjacent to the forward fish ponds, is about 50 tons.

Mechanical elevator platforms, serviced by the cargo boom, are used for loading and unloading these spaces.

Although in general they are not subject to the same operational demands as commercial fishing vessels, many research vessels, especially those used for exploratory fishing, must be similarly equipped if they are to fulfill their missions effectively. *Oregon II* has been equipped in accordance with this premise (fig. 18).

Conveyor System

A conveyor system for transporting the catch from the deck into the wet laboratory aboard the *Oregon II* was designed, and bids solicited and awarded during the 1969 fiscal year. Installation of the system will be completed early in fiscal year 1970.

EXPLORATIONS BY *OREGON II* IN THE GULF AND CARIBBEAN

The program to assess the fishery resources and potentials of the Gulf and Caribbean was given impetus during fiscal year 1968 by delivery of the *Oregon II.*

Figure 18.–Interior view of *Oregon II's* wheelhouse.

A major concern of the program has been the United States snapper industry, which has vessels that now range as far south as the Caribbean coast of Colombia. The resource survey program is attempting to improve the harvest and harvesting methods of the snapper fishery in addition to locating stocks of foodfishes that are now not fished.

We have obtained positive results in the past with roller-rigged fish trawls for snapper and grouper. Now that a vessel is available with adequate horsepower and winches for heavy work in deep water, we are carrying out our program to resurvey Gulf of Mexico areas and to extend large fish trawl coverage onto the Continental Slope.

A preliminary survey for trawlable stocks of bottomfish in deep water (50-200 fathoms) in the Gulf of Mexico was made with bottom longlines during sea trials of the *Oregon II* in 1968. We made a total of 119 sets off the Texas coast, Yucatan Peninsula, west coast of Florida, and in the northern Gulf from Cape San Blas to the mouth of the Mississippi River.

The need for continuation of exploratory fishing in the Gulf was strikingly shown when the tilefish, *Lopholatilus chamaeleonticeps,* proved to be the most abundant bottom foodfish in number and weight taken during the entire cruise. Tilefish have occasionally been taken during deepwater shrimp trawling explorations and by commercial handline vessels, but never in abundance (fig. 19). The bottom longline catches provided the first indication of the existence of a commercial potential for this species in the Gulf. Tilefish were taken in all Gulf areas sampled. Highest densities were in the 150- to 200-fathom depth range. In this depth range off Texas, average catches approached 50 pounds per 100 hooks, and maximum catches approached 100 pounds per 100 hooks.

The yellowedge grouper, *Epinephelus flavolimbatus,* was taken in some abundance in depths of about 100 fathoms. Longlines took several other species of groupers and snappers but none in numbers sufficient to warrant commercial consideration.

The bottom longline served a useful survey purpose and appears to be more valuable as a tool for locating and assessing bottomfish stocks than as a method of commercial harvest by present-day standards. Results of the bottom longline explorations, along with positive knowledge on resource potentials of red snapper, *Lutjanus campechanus,* and silk snapper, *Lutjanus vivanus,* provide a good basis for beginning a foodfish trawling program in the Gulf of Mexico. Interest expressed by the Gulf coast petfood industry has led us to expand the bottomfish trawling program into areas where bottomfishes may be available for industrial purposes.

Little emphasis has been placed on pelagic fish assessment with the exception of swordfish, *Xiphias gladius.* Surface longline sets were made in January and February 1968 from DeSoto Canyon to the mouth of the Mississippi River. Eight sets (3,308 hooks) took 27 swordfish, which weighed 3,048 pounds and ranged from 19 to 270 pounds. Best fishing was off the Mississippi River in 330 to 350 fathoms where three sets (1,270 hooks) caught 21 fish that weighed 1,543 pounds (fig. 20).

During fiscal year 1969 exploratory fishing and gear development operations were made by the *Oregon II.* Eight cruises (490 stations) utilizing shrimp and fish trawling gear and pelagic longlines explored the shelf and slope in a continuing assessment of the marine resources of the Gulf of Mexico, the Caribbean Sea, and the southwestern North Atlantic Ocean. Additionally, we studied shrimp-trashfish separator trawls, trawl warp tension values, and deepwater trawling techniques to provide industry with more effective gear and techniques to harvest the resources of the Region.

Four of the cruises (2, 5, 6, 7), programed at the request of the Gulf States Marine Fisheries Commission, were primarily concerned with assessment of the marine resources in the waters contiguous to the Gulf States.

Cruise 3 was made in cooperation with the BCF Biological Laboratory, Galveston, Tex., for the purpose of providing ground truth data for the Apollo 7 space mission. Rhodamine-B dye and fish oil were released in the Yucatan Channel during overflights of the Apollo spacecraft to provide bases to evaluate photographic observations made from space.

Cruise 4 was programed to assess the marine resources of the western Caribbean shelf and slope.

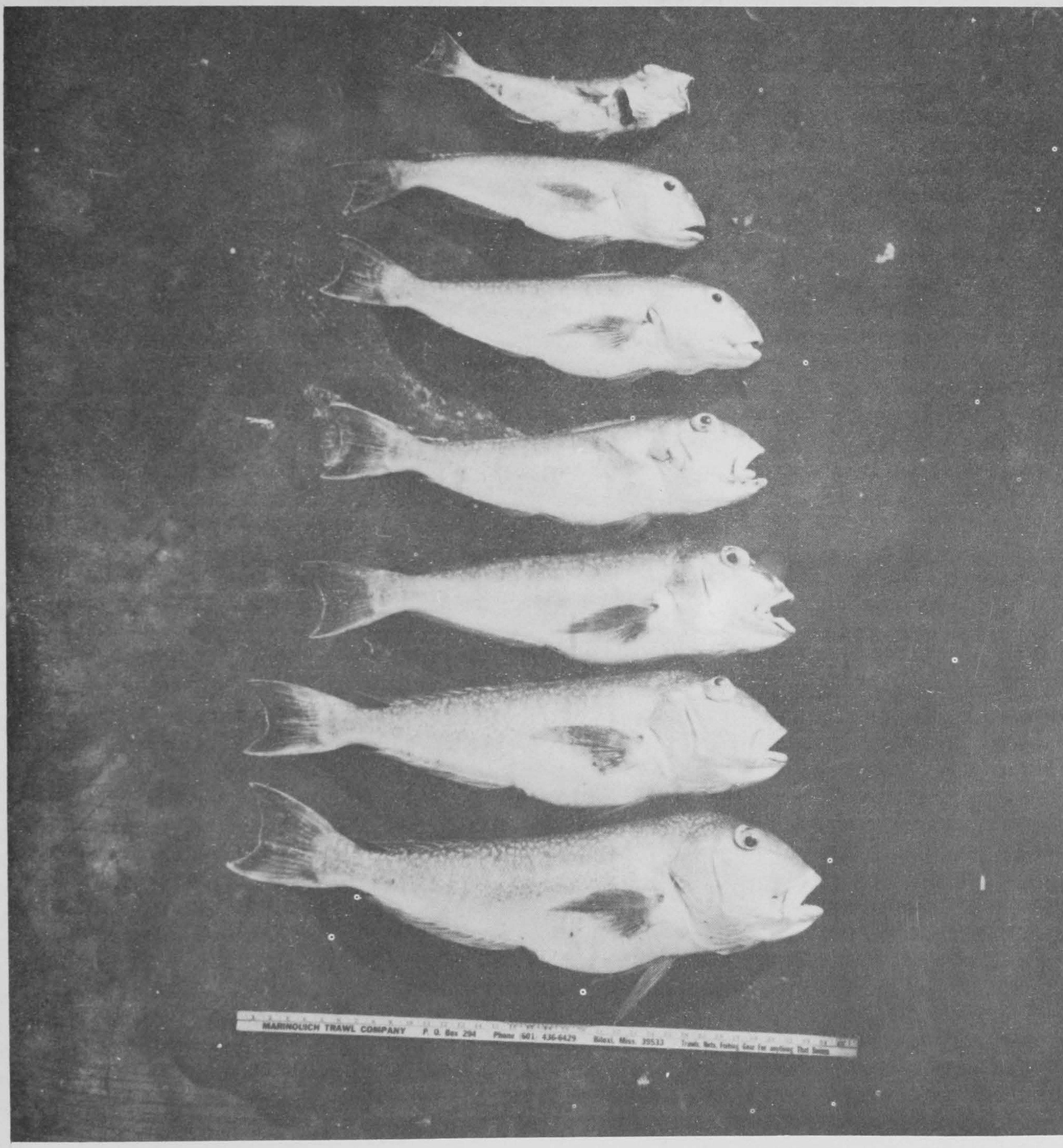

Figure 19.–A series of tilefish, *Lopholatilus chamaeleonticeps*, caught during exploratory fishing by *Oregon II*.

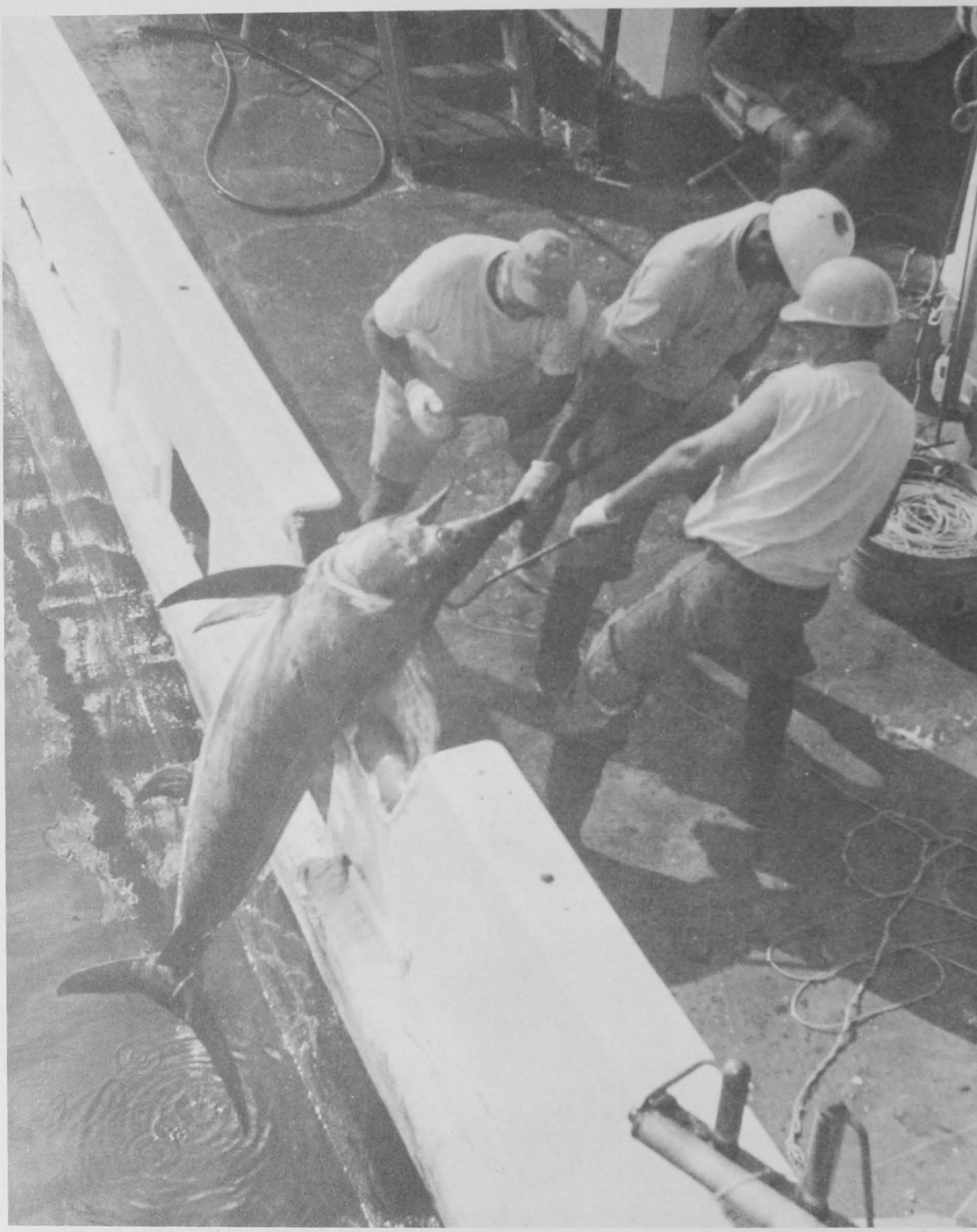

Figure 20.–Swordfish, *Xiphias gladius,* taken on a longline set off the mouth of the Mississippi River in January 1968.

Cruise 8 began the trawling operations for the scarlet prawn, *Plesiopenaeus edwardsianus,* off the coast of northeastern South America.

Cruise 9 was off the eastern and northeastern Gulf. This was the first in a series of cruises programed to assess the potential stocks of fish and crustacean of the upper Continental Slope (200-500 fathoms) in the Gulf of Mexico.

Oregon II spent 177 days at sea.

Resource Assessment

Brown Shrimp, *Penaeus aztecus.*–During the interim October 1968 to April 1969, we consistently took 10/15 count[2] brown shrimp in trawls in the area between Alabama and Texas in depths of 20 to 50 fathoms. Catch rates, however, were generally low, averaging 25 to 30 pounds per 1-hour tow. Most productive fishing was in 40 fathoms where occasional tows took as much as 50 pounds per 1-hour tow. On one occasion east of the Mississippi River Delta in 40 fathoms, we caught more brown shrimp in daylight than at night.

Moderate catches of mixed (26/30 count) brown and pink shrimp were taken on the Caribbean Colombian shelf between the Rosario Islands and the Gulf of Darien in 20 to 30 fathoms.

Royal-Red Shrimp, *Hymenopenaeus robustus.*–At the request of industry, spot checks were made in the 200- to 300-fathom depth range throughout the Gulf to provide up-to-date information to the commercial fishing vessels that had begun harvesting this species.

The area west of the Mississippi Delta to Brownsville, Tex., yielded catch rates of less than 10 pounds per hour with a 40-foot trawl. These shrimp were of mixed sizes, ranging from 31/35 to 41/45. Optimum bottom temperatures (50° F.) for royal-reds varied from depths of 210 fathoms off Brownsville to 250 fathoms off Galveston. Light catches (up to 20 pounds per tow) of the pink spotted shrimp, *Penaeus megalops,* were made inshore of the royal-red shrimp depth range.

The area east of the Mississippi Delta to the head of DeSoto Canyon consistently yielded royal-red catches of commercial significance. The shrimp in this area were significantly larger than those taken west of the Delta, averaging 26/30 count. Several tows had a sizable number of 15/20 count royal-reds.

Small quantities of royal-reds were taken along the entire Colombian Caribbean coastline between 200 and 360 fathoms. The best catch was 60 pounds of large (10/12 count) royal-reds.

Scarlet Prawns.–Catches of commercial significance of the scarlet prawn were taken in May off the coast of Surinam, South America, in depths of 350 to 500 fathoms. Thirteen tows took 2,124 pounds of these shrimp, and 90 percent of the catch averaged better than 15/20 count. Forty percent of the catch was made up of 5/10 count. With the exception of a strong current, conditions were suitable for trawling and no hangups were encountered over an east-west distance of about 120 miles (fig. 21).

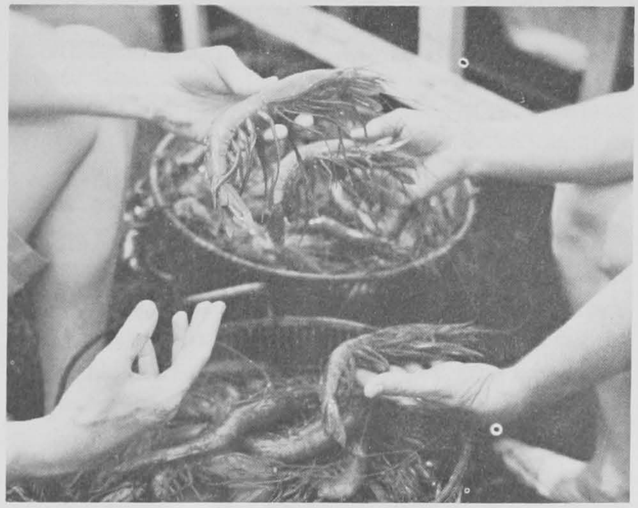

Figure 21.–Part of a 404-pound catch of scarlet prawn, *Plesiopenaeus edwardsianus,* taken in 400 fathoms of water off the northeast coast of South America.

Small catches of scarlet prawns (up to 11 pounds per tow) were taken along the entire Honduran-Nicaraguan-Colombian slope.

Swordfish.–We longlined for swordfish on three exploratory cruises to better define the hydrographic and ecological factors associated with the occurrence of these fish in the Gulf of Mexico. Seven night sets, which fished about 3,000 hooks, caught 22 swordfish. Although the catch rate realized is below that required for commercial harvesting, environmental factors and other observed phenomena–such as bait preference–give credence to the hypothesis that this species is present in the Gulf in commercial quantities.

Other Finfish.–We made moderate to heavy catches of both food and industrial fishes throughout the areas surveyed. The predominant species taken inside of 50 fathoms was the longspine porgy, *Stenotomus caprinus,* and the Atlantic croaker, *Micropogon undulatus.*

[2] Shrimp sizes and weights are given as heads on unless specified otherwise.

Figure 22.–*Geryon* crabs, a deep-sea delicacy not now caught by U.S. fishermen.

Catches of these species ranged up to 2 tons per 2-hour tow. Moderate concentrations of butterfish, *Peprilus burti*, were found in 30 to 40 fathoms east of the Mississippi River. Beyond 50 fathoms the predominate species taken was the wenchman, *Pristipomoides aquilonaris;* the hake, *Merluccius* sp.; and rat-tails, Macrouridae. Catches ranged from 1 to 4 tons per tow.

On two occasions, massive concentrations of mixed midwater schools of round herring, chub mackerel, and rough scad were recorded by the vessel's acoustical fish detection equipment. Heavy, continuous concentrations were recorded along the eastern side of DeSoto Canyon over depths of 200 fathoms to 90 fathoms–an east-west distance of 17 miles. South of Cameron, La., over depths of 90 to 110 fathoms, dense midwater schools were recorded over an east-west distance of 35 miles.

Gear Development

Shrimp Separator Trawl.–During the fiscal year 1969, we began work on design of the shrimp separator trawl. Sixty-one stations were occupied, and catches varied from 50 to 100 percent shrimp. Initial tests were carried out in November off the Colombian coast while the *Oregon II* was on a general exploratory trip in the southwest Caribbean. Results of the first trials were moderately satisfactory in that 64 to 74 percent of the shrimp caught were separated into "clean" side bags. The shrimp caught during these trials were 26/30 count. The shrimp and very small fish apparently went through the 3-inch separator panels without much difficulty. The very small fish constituted 30 to 40 percent of the catch in the side bags.

After the initial testing, we modified the trawl slightly and then built another trawl, which followed the vertical separator panel design used by the BCF Exploratory Fishing and Gear Research Base at Seattle, Wash. Subsequent trials with these two nets have not been satisfactory. Large (10/15 count) brown shrimp were caught off Texas in March, and separation rate was only 30 to 40 percent. Separation of fish, however, was improved to the point that only 10 to 20 percent of the total catch was going into the clean side bags. The horizontal separator panel trawl was slightly more effective than the vertical separator panel trawl, though neither performed at an acceptable level of separation.

Although gear specialists felt that the 3-inch mesh separator panel was too small to allow large shrimp to pass through, arrangements were made to test the trawls on small shrimp to determine whether the problem involved mesh size of the separator panels or was due to inadequate net design and panel placement. The commercial shrimp vessel *Guiding Star* was chartered June 2 to 6 to test further the existing trawls before modifications were undertaken. Work was done in Breton Sound and in Mississippi Sound on 55/65 count brown shrimp in simulated commercial fishing with double rig. Separation percentages were essentially the same as those obtained in earlier tests on larger shrimp. The low separation rate on small shrimp by 3-inch panels indicates that the problem is basically one of trawl design and placement of panels.

Warp Tension Studies.–When Gulf shrimpers moved into the royal-red shrimp grounds, winch failures increased to alarming proportions. As a result, industry made innumerable requests for data on trawl winch loads.

Because *Oregon II* has a built-in system to monitor line tension and line speed and a pitometer log system, we made a series of trials aboard the vessel to determine the loads on the winch as related to trawl size and speed of trawl through the water. The significant data we acquired proved quite conclusively that the problem was due to excessive vessel speed through the water; i.e., speed of trawl through the water, caused by increasing the revolutions per minute of the engine to increase winch speed. This maneuver results in increasing vessel speed, since the engine is coupled directly to the propeller. Winch manufacturers and fishermen were provided with load data and suggestions for resolving the problem.

Public Relations

On two occasions, we held open house aboard the *Oregon II.* In January, the vessel was toured by attendees at the Louisiana Shrimp Association meeting in New Orleans, La., and in June, by attendees of the Southeastern Fisheries Association meeting in Tampa, Fla. About 2,600 industry people boarded the vessel during these meetings.

INDUSTRY ACTIVITY IN THE GULF OF MEXICO

Industry interest in the royal-red shrimp grounds delineated by the *Oregon* in the Gulf of Mexico reached an all-time high during fiscal year 1969. Ten large vessels fished the resource steadily during the spring and winter. They fished mainly on grounds east of the Mississippi Delta; at least one vessel reported good catches from the Tortugas grounds. Daily catches (24 hours) reached as high as 30 boxes (100 pounds of tails per box). Several vessels landed catches in the 80- to 100-box range after 8 to 10 days of fishing. Generally 50 percent of the catch was 31/40 count tails; however, in March about 50 percent of the catch was made up of under 30-count tails and 25 percent of 31/40 count tails.

A local shrimp vessel converted to longline fishing for swordfish during the winter season. Ten sets with Bureau gear caught 18 fish. A combination of increasing catches of sharks, damage to hooked fish by sharks, and the approaching shrimp season caused the vessel to stop fishing earlier than was planned. The fact that the vessel received $1.30 per pound for the fish marketed has stimulated considerable interest in this fishery. We expect more vessels will try longlining for swordfish when the current shrimp run is over.

EXPLORATIONS BY THE *OREGON* OFF THE EAST COAST OF THE UNITED STATES

In addition to the depth recorder transects for identifying masses of midwater fishes, reported in an earlier section, the *Oregon* made 11 exploratory cruises off the southeast coast of the United States and was used extensively in investigations of the calico scallop beds off the east coast of Florida.

One cruise in July 1967 had two goals: to assess the summer swordfish resource off the Florida east coast and northern Bahama Islands and to obtain seasonal and geographical data on royal-red shrimp.

Four 60-basket (600 hooks) longline sets made north of the Bahama Islands, between lat. 27° N. and 29° N., caught six swordfish weighing a total of 565 pounds. Other fish taken on longline gear were a 60-pound bigeye tuna, *Thunnus obesus;* a 40-pound wahoo, *Acanthocybium solanderi;* and 14 sharks weighing a total of 1,350 pounds.

At industry request 18 drags were made on the royal-red shrimp grounds in July between St. Augustine and New Smyrna Beach, Fla. The best catches were made east of Daytona Beach in 220 to 235 fathoms. Catches in the area ranged from 0 to 180 pounds of 26/30 count royal-red shrimp per 3-hour drag and averaged 115 pounds per drag.

Limited trawling was done on the offshore brown shrimp and pink shrimp, *Penaeus duorarum,* grounds east of Melbourne, Fla., during five cruises (October, November, December, February, and June). Shrimp were caught over a depth range of 10 to 40 fathoms. The best catches occurred from 22 to 38 fathoms and ranged from 2 to 46 pounds of 10/15 count shrimp per 1- to 3-hour drags. In October catches of rock shrimp, *Sicyonia brevirostris,* ranged from 50 to 165 pounds per drag, and eight drags caught a total of 802 pounds of 36/40 and 41/45 count rock shrimp in 10½ hours of trawling.

We began a series of industrial development cruises August 1967 to provide an up-to-date assessment of the calico scallop resource off the Florida east coast. In all, 10 cruises were devoted to an intensive systematic resurvey of the Cape Kennedy grounds, which as shown by previous BCF explorations, have the greatest potential for a scallop fishery along the southeast coast of the United States. We had four monthly cruises from September to December and bimonthly cruises in February, April, and June 1968. We dredged at 1,378 locations within the 10- to 40-fathom depth range on the Cape Kennedy beds and located commercial concentrations of scallops over a broad area from New Smyrna Beach to Bethel Shoal (fig. 23).

Most of the time, we used 8-foot tumbler dredges constructed with 2-inch bag rings, 20 rings deep, and fished with 2½-inch mesh nylon liners. When full these dredges can hold about 50 bushels (about 3,500 pounds) of calico scallops.

We found three general areas of commercial concentrations and made standard dredging transects between 10 and 40 fathoms during each cruise to observe changes that may have occurred during the year. The three areas referred to are east of New Smyrna, east of Cape Kennedy, and northeast of Bethel Shoal (table 1).

Table 1 shows that in all three areas the counts of meats are lowest in August and September and the counts of meats are highest in April and June.

In September, we used the *Aluminaut* to make underwater observations in the exploratory dredging area east of New Smyrna Beach. Typical beds were observed lying in north-south bands 100 to 300 feet

Figure 23.–A 48-bushel catch of calico scallops on deck of the *Oregon* taken during scallop explorations on the Cape Kennedy, Fla., grounds.

wide and up to 1,500 feet long. Densities of four scallops per square foot were common, and some densities exceeding eight scallops per square foot were observed.

"Seed" scallops and subcommercial size scallops were found throughout all three areas surveyed by dredging at different times of the year. "Seed" scallops were especially evident during the June survey.

Since the transfer of the *Oregon* to Alaska in February, activities have involved the analysis of data collected during the previous 17-month period in order to maintain the closely coordinated program of stock assessment and technical assistance to industry.

INDUSTRY ACTIVITY OFF THE EAST COAST OF FLORIDA

Three shellfish drew some of our attention off the east coast of Florida: royal-red shrimp, calico scallops, and rock shrimp.

Royal-Red Shrimp

Fishing for deepwater royal-red shrimp off the Florida east coast continues intermittently. Fishing effort depends on the market demand for royal-red shrimp and availability of inshore shrimp. Three vessels based in Fernandina, Fla., are the most consistent producers of royal-reds. The most productive area, previously explored and delineated by BCF research vessels, is east of St. Augustine. Landings for a 4- to 6-day trip on the grounds generally average 25 to 30 boxes of tails. Catches in this area average about 60 percent 21/25 count tails and 40 percent 41/45 count tails. Further to the south, east of Daytona-New Smyrna, the count is reversed–41/45 count shrimp are 60 percent of the catch (fig. 24).

Calico Scallops

Four new scallop vessels have been constructed and are now dredging on the Florida east coast grounds. Vessels have automated shipboard processing equipment consisting of the following components:

1. A separator or culling device to sort out dead shell, fish, and other debris from live scallops.

Table 1.–Seasonal variation in the maximum catch and the count and yield of meats for three areas of the Cape Kennedy scallop grounds

Location	Item	August and September	October to December	February	April and June
East of New Smyrna Beach	Maximum catch, bushels	19.0	32.0	23.2	20.0
	Duration of drag, minutes	15	30	30	30
	Count, meats per pound	50-66	57-82	55-103	78-133
	Yield, pounds per bushel	6.0-7.2	5.5-6.7	3.9-5.6	2.8-4.1
East of Cape Kennedy	Maximum catch, bushels	16.0	32.0	29.0	18.9
	Duration of drag, minutes	15	30	30	30
	Count, meats per pound	68-76	68-106	68-144	73-101
	Yield, pounds per bushel	5.3-7.0	4.0-5.5	3.9-6.7	2.8-4.1
Northeast of Bethel Shoal	Maximum catch, bushels	16.0	32.2	14.9	14.7
	Duration of drag, minutes	30	30	30	30
	Count, meats per pound	88-115	88-120	70-143	97-151
	Yield, pounds per bushel	4.0-6.0	3.0-5.0	3.6-4.1	2.2-3.8

Figure 24.—A catch of royal-red shrimp, *Hymenopenaeus robustus,* taken during exploratory fishing.

2. A shucker to separate the adductor muscle and viscera from the shell.
3. An eviscerator to remove the viscera from the adductor muscle.

Some difficulties have been experienced with processing components, but equipment modifications have solved many of the initial problems. Modifications of gear and processing machinery have continued with the goal of increasing the production rate to about 1,000 bushels of scallops per day (fig. 25).

The most successful company to date began commercial fishing with two vessels in April 1969. These vessels landed over 29,000 pounds of processed meats during April, May, and June 1969.

Various vessels have made sporadic landings of shellstock and hand-shucked meats.

Figure 25.—The Brunswick, Ga., based automated scalloper *Crisway* processing calico scallops on the grounds east of Daytona Beach, Fla.

During fiscal year 1969 interest in the Cape Kennedy scallop grounds has remained high. We have provided detailed information to numerous corporations and individuals directly or indirectly interested in the resource. Also, we have maintained close contact with active scallop interests and continued to assist vessel operators (fig. 26).

Rock Shrimp

Commercial catches of rock shrimp have been landed at Port Canaveral, Fla. One vessel owner, using fishing positions furnished by the Exploratory Fishing and Gear Research Station at Brunswick, reported catches of over 1,000 pounds of rock shrimp per night. Production facilities and market outlets are currently being developed.

EXPLORATORY DATA CENTER

Fiscal year 1969 marked the establishment of an Exploratory Data Center that is responsible for the collection, storage, and retrieval of data by a central data repository and processing system. Subsidiary functions carried out when required include data analysis and interpretation. Primary input to the Center are data gathered by field projects; hence, much of this year's activities were directed toward consultation with field programs regarding applications of automatic data processing.

The Center functions through three projects: (ADP) Automatic Data Processing, Distributional Analyses, and Specimen Distribution.

Figure 26.–Testing an industry-designed calico scallop culler on the *Oregon*.

The ADP Project operates the Data Center facilities, which consist of a UNIVAC 9200 card processor with 12,287 byte memory, 200-cards per minute reader, 250-lines per minute printer, and 75-cards per minute punch (fig. 27). Punch card processing is supported by an IBM 029 keypunch (fig. 28) and 083 electronic card sorter. Programing is done either RPG (Report Program Generator) or BAL (Basic Assembly Language). Data are stored on punch cards; a permanent historical file of 200,000 cards is maintained.

This year the ADP Project provided some 1,100 pages of data output for the use of the Base, industry, and science. These pages included reports on various subjects from distribution of red snappers to statistical analyses of behavioral studies.

Project staff developed some 75 programs in RPG and BAL in producing this output.

The Distributional Analyses Project was established for ad hoc analysis of the historical and current data files regarding the distribution and abundance of marine fauna in Region 2. In fiscal year 1968 we undertook two primary studies based on data collected according to experimental designs developed by program staff.

The first study concerned the development of a model for the calico scallop fishery off the Florida east coast. Results of the study, now being prepared as a manuscript, have provided valuable knowledge on the life history, distribution, abundance, and yield of this shellfish.

Figure 27.–The UNIVAC 9200 computer used to process exploratory fishing data.

Figure 28.–Technician keypunching data cards in the Exploratory Data Center.

The second study concerned the analyses of tracer recordings of fish concentrations collected during six cruises off the eastern seaboard from Cape Hatteras to Fort Pierce, Fla. One aim of the study was to determine the feasibility of using depth recorder tracings to calculate the abundance and distribution of schoolfish. Such calculations are based on the percentage of the water column the fish occupy as recorded by tracings. The second aim of the study was to describe and delineate school configurations in terms of susceptibility to commercial harvesting gear.

Conclusions from several computer programs indicated that our aims were indeed feasible. Though we used rudimentary methodology, we could ascertain north-south distributions, seasonal trends, and diurnal variations in the abundance of fish and the configuration of the schools.

Other studies begun during the year were on relation of depth and water temperature to snappers and on the zoogeographical distribution of the scarlet prawn.

The Specimen Distribution Project is responsible for collection, identification, and dissemination of biological materials taken on exploratory cruises. The most valuable product of the project is that eminent collaborators verify the species identified in the field. This information is incorporated into the data file. In 1969 the project shipped over 4,000 specimens to cooperating scientists (fig. 29).

Figure 29.–Staff members of the Specimen Distribution Project preparing biological materials for shipment.

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1968. Shrimp-behavior studies underlying the development of the electric shrimp-trawl system. U. S. Fish Wildl. Serv., Fish. Ind. Res. 4: 165-181.

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STAFF

FISCAL YEAR 1968

Pascagoula

Harvey R. Bullis, Jr., Base Director
Martin R. Bartlett, Fishery Methods and Equipment Specialist
Joseph A. Benigno, Fishery Biologist
Michael D. Brown, Physical Science Technician
Johnny A. Butler, Supervisory Fishery Methods and Equipment Specialist
Francis J. Captiva, Supervisory Fishery Methods and Equipment Specialist
James S. Carpenter, Supervisory Fishery Biologist
Alice Colmer, Librarian
T. Arlene Daniel, Clerk-Typist
Helen M. Davies, Clerk-Typist–EOD 7/30/67
Kirby L. Drennan, Supervisory Oceanographer–EOD 1/24/68
Shelby B. Drummond, Fishery Biologist
Suzanne W. Drummond, Administrative Clerk
Hilton M. Floyd, Fishery Methods and Equipment Specialist
Judith C. Gatlin, ADP Technician
James E. Higgins, Fishery Biologist–EOD 7/2/67
Frank J. Hightower, Jr., Fishery Methods and Equipment Specialist
Kathryn M. Hoffman, Clerk-Stenographer
Rosetta D. Holloway, Clerk-Typist
Betty H. King, Clerk-Stenographer
Edward F. Klima, Supervisory Fishery Biologist–Entered regional Bureau training program at Utah State University, June 1967
Walter W. Langley, Biological Technician–Terminated 4/5/68
Dorothy M. Latady, Administrative Assistant
Bruce W. Maghan, Fishery Biologist
Jack C. Mallory, Fishery Biologist–EOD 8/13/67
Bobby Joe McDaniel, Administrative Officer
George B. Miller, Summer Trainee–EOD 6/3/68
Marilyn M. Nelson, Secretary
Walter R. Nelson, Fishery Biologist–EOD 10/9/67
Norman L. Pease, Supervisory Fishery Biologist
Lawrence A. Polk, Caretaker
Michael H. Quinn, Physical Science Technician–Terminated 9/15/67
Gladys B. Reese, Fishery Biologist–EOD 7/2/67 (Transferred from Technological Laboratory, Pascagoula)
Luis R. Rivas, Fishery Biologist (summer seasonal)–Terminated 9/8/67, EOD 6/3/68
Richard B. Roe, Supervisory Fishery Biologist
Ronald C. Rogers, Summer Trainee–EOD 7/3/67, Terminated 9/30/67
Bennie A. Rohr, Fishery Biologist (summer seasonal)–Terminated 8/25/67, EOD (summer seasonal) 4/29/68
Charles M. Roithmayr, Fishery Biologist–Returned to duty station Pascagoula from FAO Sierra Leone assignment 11/8/67
Gary M. Russell, Biological Aid–EOD 6/10/68
Thomas S. Sawyer, Biological Aid–EOD 3/25/68, Terminated 6/6/68
John D. Schlotman, Biological Aid
Edith J. Seamen, Administrative Clerk
Wilber R. Seidel, Mechanical Engineer
Sven J. Svensson, Supervisory Fishery Methods and Equipment Specialist
John R. Thompson, Assistant Base Director
Donald A. Wickham, Fishery Biologist

St. Simons Island

Robert Cummins, Jr., Supervisory Fishery Biologist
Linda F. Arnold, Clerk-Stenographer
Robbin R. Blackman, Fishery Biologist–Terminated 12/30/67
Irene G. Drew, Clerk-Stenographer–EOD 5/6/68
Linda L. Jackson, Clerk-Stenographer–Terminated 10/14/67
Harriette S. Lamb, Administrative Assistant
Leonard L. May, Fishery Biologist–EOD 2/7/68
Raymond D. Nelson, Fishery Biologist
Floyd A. Nudi, Fishery Biologist–Terminated 7/1/67
Joaquim B. Rivers, Fishery Methods and Equipment Specialist

RV *Oregon* (St. Simons Island)

Abraham J. Barrett, Master
Robert M. Mattos, Chief Engineer
Jake M. Marinovich, First Assistant Engineer–Transferred to Pascagoula 7/1/67
James M. Higgins, Second Assistant Engineer
Joseph Bowens, Skilled Fisherman–EOD 7/9/67
Robert B. Martin, Cook
Frederick Weems, Steward–Transferred to Pascagoula 7/1/67
Peter F. Rosetti, Skilled Fisherman–Transferred to Pascagoula 7/1/67
Edward A. Thompson, Skilled Fisherman–Transferred to Pascagoula 7/1/67
Harvey M. Bledsoe, First Officer
Ernest Williams, Skilled Fisherman
James E. Joyner, Skilled Fisherman–EOD 7/9/67, Terminated 12/29/67
Julius W. Harper, Skilled Fisherman–EOD 7/2/67
William F. Myers, Second Assistant Engineer–EOD 7/9/67, Terminated 3/11/68

RV *Oregon II* (Pascagoula)

Richard E. Adams, Master–EOD 7/16/67
Edward Erickson, First Officer–EOD 7/31/67, Terminated 8/25/67
Louis S. Nelson, First Officer–EOD 9/11/67
Ralph C. Texcell, Second Officer–EOD 8/11/67, Terminated 1/5/68
Louis Guirola, Chief Engineer–EOD 8/7/67
Frank M. Haviland, First Assistant Engineer–EOD 7/16/67
Jake M. Marinovich, Second Assistant Engineer–EOD 7/2/67 (Transferred from St. Simons)
Prince Wiley, Ordinary Fisherman–EOD 7/31/67, Terminated 1/12/68
Peter F. Rosetti, Skilled Fisherman–EOD 7/2/67 (Transferred from St. Simons)
Edward A. Thompson, Skilled Fisherman–EOD 7/2/67 (Transferred from St. Simons)
Frederick Weems, Leading Fisherman–EOD 7/2/67 (Transferred from St. Simons)
Wilmer S. Lamey, Mess Attendant–EOD 11/27/67, Terminated 2/23/68
Michael W. Strahan, Mess Attendant–EOD 9/21/67, Terminated 11/10/67
Charles E. Durgan, Mess Attendant–EOD 9/5/67, Terminated 9/15/67
John R. Anderson, Engine Utilityman–EOD 7/31/67, Deceased 12/25/67

RV *George M. Bowers* (Pascagoula)

J. B. Randall, Master
Anthony F. Veara, Chief Engineer
Laurence Vice, Skilled Fisherman
Julius W. Harper, Cook–Transferred to St. Simons 7/1/67
Charles Birds, Jr., Steward–EOD 7/3/67, Terminated 1/4/68

FISCAL YEAR 1969

Pascagoula

Harvey R. Bullis, Jr., Base Director
Martin R. Bartlett, Fishery Methods and Equipment Specialist
Joseph A. Benigno, Fishery Biologist
Michael D. Brown, Physical Science Technician
Johnny A. Butler, Supervisory Fishery Methods and Equipment Specialist
Francis J. Captiva, Supervisory Fishery Methods and Equipment Specialist
Jimmy B. Cagle, Engineering Technician–EOD 9/10/68
James S. Carpenter, Supervisory Fishery Biologist–Resigned 11/7/68
Alice Colmer, Librarian
Frederick Cook, Summer Aid–EOD 6/2/69
Mary Ellen Crawley, Clerk-Stenographer–EOD 6/16/69
T. Arlene Daniel, Clerk-Typist
Helen D. Pease, Clerk-Typist–Resigned 5/12/69
Kirby L. Drennan, Supervisory Oceanographer–EOD 1/24/68
Shelby B. Drummond, Fishery Biologist
Suzanne W. Drummond, Administrative Clerk
Sylvester Durden, Laborer–EOD 3/24/69, Terminated 4/8/69
Louis A. Eaton, Conservation Aid–EOD 5/20/69
Hilton M. Floyd, Fishery Methods and Equipment Specialist
Robert S. Ford, Jr., Biologist–EOD 6/16/69
Judith C. Gatlin, ADP Technician
Elmer J. Gutherz, Fishery Biologist–EOD 4/6/69
James E. Higgins, Fishery Biologist
Frank J. Hightower, Jr., Fishery Methods and Equipment Specialist
Cleveland Hill, Summer Aid–EOD 6/2/69
Kathryn M. Hoffman, Clerk-Stenographer
Rosetta D. Holloway, Clerk-Typist
Betty H. King, Clerk-Stenographer
Edward F. Klima, Supervisory Fishery Biologist-Returned to active duty Pascagoula from Regional Bureau training program 7/4/68

Dorothy M. Latady, Administrative Assistant
Richard W. Litchtenheld, Fishery Biologist–Detailed from Beaufort, N. C., 3/9/69 to 7/11/69
Bruce W. Maghan, Fishery Biologist–Resigned 5/9/69
Jack C. Mallory, Fishery Biologist
Bobby Joe McDaniel, Administrative Officer
George B. Miller, Summer Aid–Terminated 8/30/68, EOD 5/26/69
Marilyn M. Nelson, Secretary
Walter R. Nelson, Fishery Biologist–Detailed to Washington Central Office 6/29/69
Charles Patty, Biological Aid–EOD 3/24/69, Terminated 6/13/69
Norman L. Pease, Supervisory Fishery Biologist–Detailed to FAO (Africa) 1/69 to 5/69
Lawrence A. Polk, Caretaker
Gladys B. Reese, Fishery Biologist
Luis R. Rivas, Fishery Biologist
Richard B. Roe, Supervisory Fishery Biologist
Bennie A. Rohr, Fishery Biologist (summer seasonal)–Terminated 8/23/68, EOD 1/6/69
Charles M. Roithmayr, Fishery Biologist
Gary M. Russell, Biological Aid–Terminated 9/8/68, EOD 12/30/68, Terminated 3/21/69
John D. Schlotman, Biological Aid
Edith J. Seamen, Administrative Clerk
Wilber R. Seidel, Mechanical Engineer
Anthony F. Serra, Fishery Methods and Equipment Specialist–EOD 3/10/69
Sven J. Svensson, Supervisory Fishery Methods and Equipment Specialist
John R. Thompson, Assistant Base Director
John W. Watson, Biological Aid–EOD 3/24/69
Gregory E. Welsh, Biological Aid–EOD 9/9/68, Terminated 3/21/69, EOD 6/15/69
Donald A. Wickham, Fishery Biologist

St. Simons Island

Robert Cummins, Jr., Supervisory Fishery Biologist
Linda A. Fennell, Administrative Clerk–Terminated 5/16/69
Irene G. Drew, Clerk-Stenographer
Harriette S. Hightower, Administrative Assistant
Raymond O. Maurer, Fishery Biologist–EOD 1/13/69
Leonard L. May, Fishery Biologist
Raymond D. Nelson, Fishery Biologist
Joaquim B. Rivers, Fishery Methods and Equipment Specialist
Eleanor Y. Waters, Librarian–EOD 4/6/69

RV *Oregon* (St. Simons Island–Transferred to BCF Juneau, Alaska, 2/4/69)

Abraham J. Barrett, Master–Transferred to Pascagoula 3/2/69
Robert M. Mattos, Chief Engineer–Terminated 3/2/69
James M. Higgins, Second Assistant Engineer–Terminated 3/2/69
Joseph Bowens, Skilled Fisherman–Terminated 10/1/68
Robert B. Martin, Cook–Transferred to Pascagoula 3/2/69
Anthony F. Veara, Skilled Fisherman–EOD 8/26/68, Terminated 3/2/69
Harvey M. Bledsoe, First Officer–Transferred to Pascagoula 3/2/69
Ernest Williams, Skilled Fisherman–Transferred to Pascagoula 3/2/69
Julius W. Harper, Skilled Fisherman–Terminated 1/6/69
William F. Myers, Skilled Fisherman–EOD 8/1/68, Terminated 1/7/69

RV *Oregon II* (Pascagoula)

Richard E. Adams, Master
Louis S. Nelson, First Officer–Terminated 3/7/69
Louis Guirola, Chief Engineer
Frank M. Haviland, First Assistant Engineer
Jake M. Marinovich, First Engineer–Detailed from 9/3/68 to 11/4/68
Peter F. Rosetti, Skilled Fisherman
Edward A. Thompson, Skilled Fisherman
Frederick Weems, Leading Fisherman
Leon E. Hasty, Cook–EOD 11/4/68, Terminated 2/14/69, EOD 6/11/69
James M. Collier, Second Officer–EOD 7/15/68, Terminated 2/14/69
Gerald G. Broadus, Messman–EOD 8/7/68, Terminated 8/16/68
Charles R. Chezem, Messman–EOD 8/19/68
Paul L. Higginbotham, Wiper/Day Worker–EOD 8/6/68, Terminated 10/22/68
Prince Wiley, Ordinary Fisherman–EOD 11/13/68, Terminated 12/17/68
Robert L. Roper, Second Assistant Engineer–EOD 9/3/68, Reassigned to Engine Utilityman 11/3/68, Reassigned to Wiper/Day Worker 6/29/69
Robert B. Martin, First Cook–EOD 3/2/69, Resigned 6/27/69
Abraham J. Barrett, First Officer–EOD 3/2/69
Harvey M. Bledsoe, Second Officer–EOD 3/2/69
Ernest Williams, Skilled Fisherman–EOD 3/2/69

RV *George M. Bowers* (Pascagoula)

J. B. Randall, Master
Anthony F. Veara, Chief Engineer–Transferred to St. Simons 8/25/68
Laurence Vice, Skilled Fisherman

Julius W. Harper, Cook–Transferred to St. Simons 7/1/67

Charles Birds, Jr., Steward–EOD 7/8/68, Terminated 7/24/69

Leroy Waters, Assistant Cook–EOD 5/1/69

Gordon K. Nelson, Ordinary Fisherman–EOD 8/5/68, Terminated 10/18/68

K. C. McLeod, III, Oiler/Watch Stander–EOD 8/8/68, Terminated 8/29/68

Anthony F. Serra, Oiler/Watch Stander–EOD 9/3/68, Terminated 1/10/69

Oliver J. Steiner, Ordinary Fisherman–EOD 4/21/69

Leon E. Hasty, Assistant Cook–EOD 8/5/68, Terminated 10/18/68

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