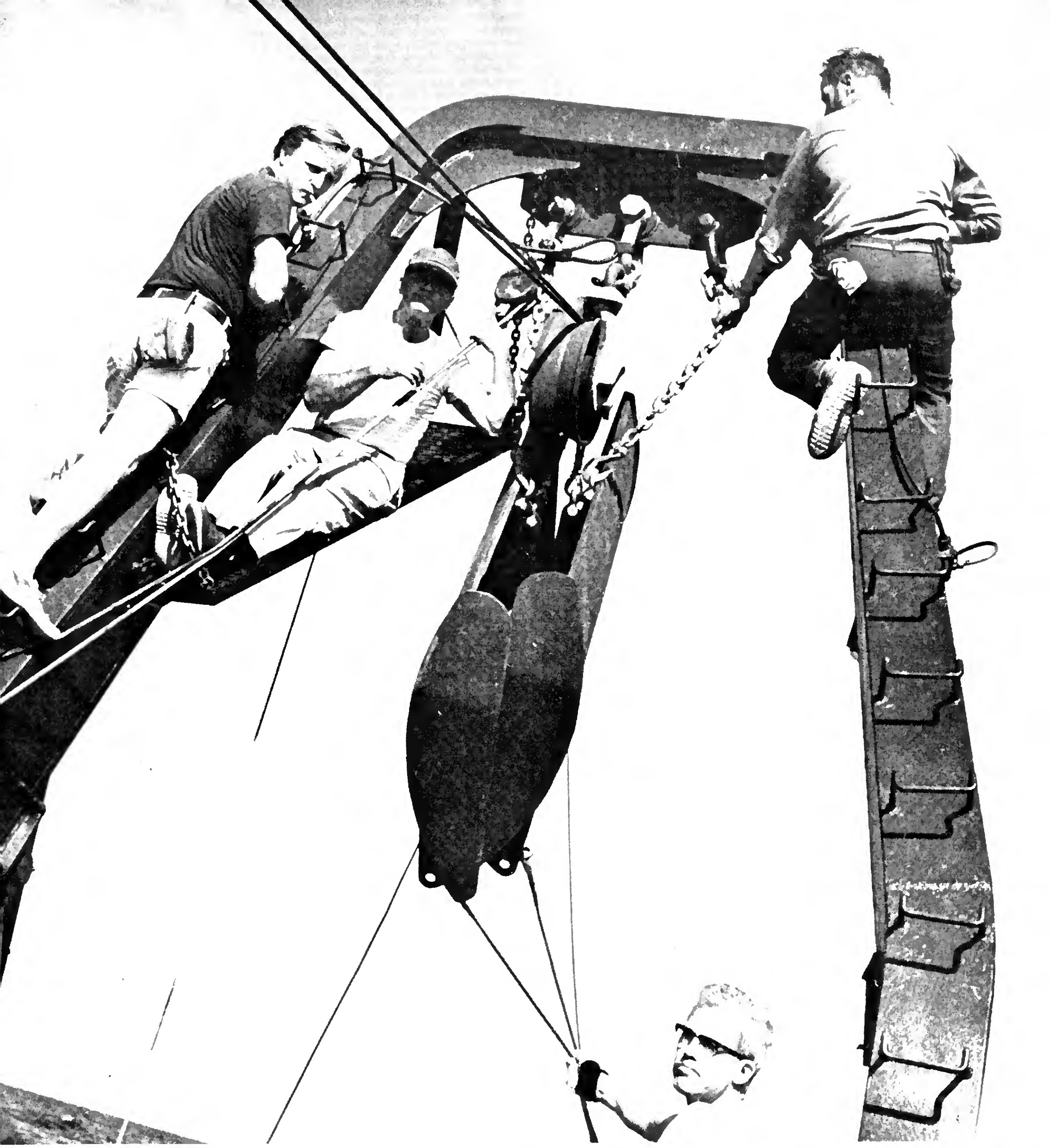
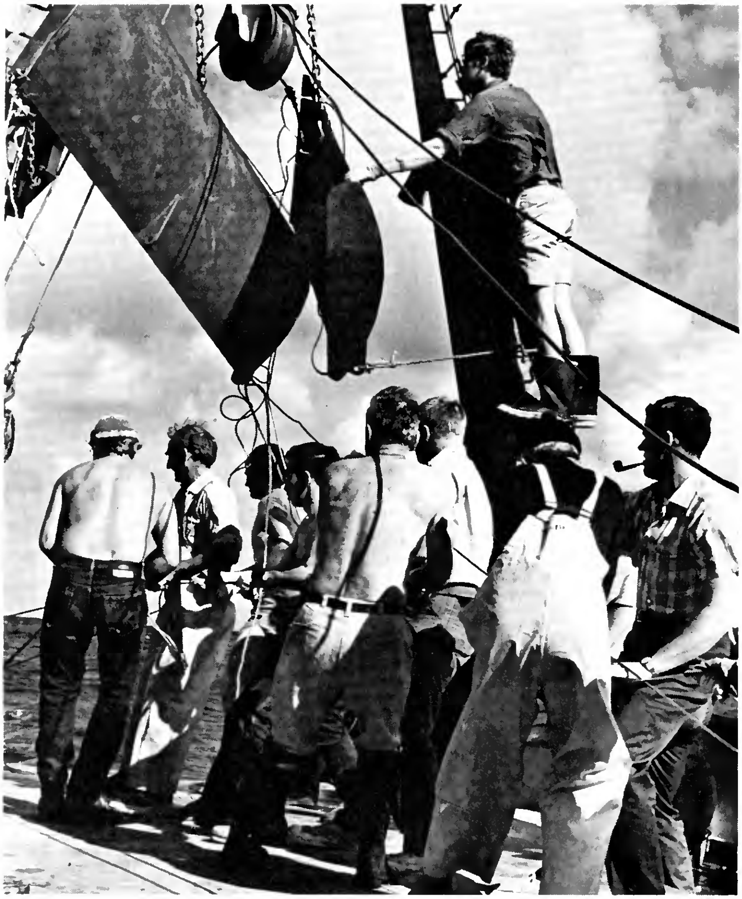


VOL. XV, NO. 1, MAY 1969

OCEANUS

ON THE COVER—



CLANKING loudly with the roll of the ship, the heavy steel doors of a midwater trawl are "two-blocked" and fastened to safety chains on the stern of our research vessel 'Chain'. The net then is brought on deck as shown here by "Norwegian Steam", an old seaman's expression for manpower.

ALL PHOTOS IN THIS ISSUE BY jh, UNLESS OTHERWISE CREDITED.

Jan Hahn, *Editor*

Vol. XV, No. 1, May 1969

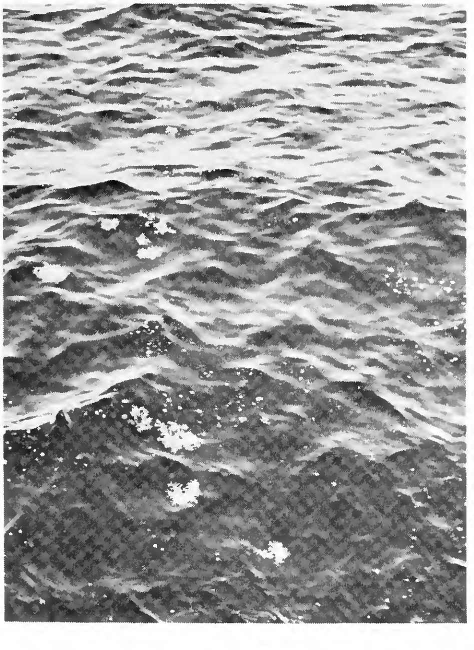
A Whole Ocean Polluted?

MUCH has been said and written about oil pollution from tanker disasters and oilwell spills. During Cruise 85 of our R.V. 'Chain', discussed in this issue, we came acrcss a new form of oil pollution. The neuston nets which skim the sea surface to collect marine life picked up quantities of oil-tar lumps. Each tow lasted from 30 minutes to one hour. After two or three tows, the nets had to be cleaned with a strong solvent and finally discarded. In a 30 minute tow the nets skimmed about 1800 meters of sea surface and contained a cupful of oil-tar lumps.

We understand that other concentrations of such lumps have been found in the South Atlantic Ocean and in the Caribbean. Since this is a rather new method of fishing we do not know if these lumps—ranging in size from droplets to five cm—have been floating around for a long time. Nor do we know where the oil originates. Is it spillage from tankers? (It has been estimated that 60% of the world's oil crosses the ocean and 1/10 of 1 percent is spilled). Does it come from undersea wells or from natural oil seepage? Or does it come from ships' bilges?

Since the concentrations were among the floating Sargassum weed which has a population of some 16 marine species, including the camouflaged Sargassum fishes and crabs, the biologists obviously are disturbed as to what effect this pollution may have on this unique ecological environment.

"The nets were so fouled with tar and oil that towing had to be discontinued"—



A good roll of the ship and the heavy weather gear on the scientists show that life was not all beer and skittles in the winter in the fabled Sargasso Sea.

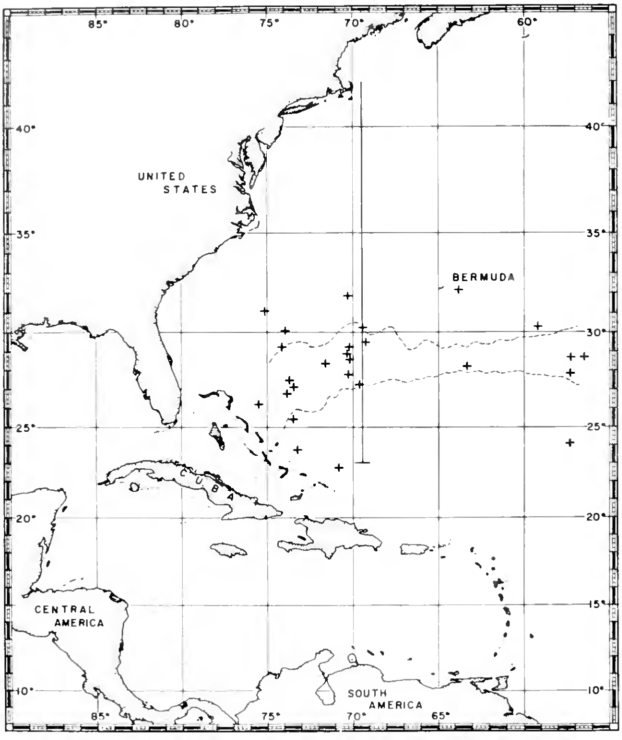
This issue highlights Cruise Number 85 of the R.V. 'Chain' (Captain C. A. Davis) which took place in November - December 1968

Chain - 85

by R. H. BACKUS

ONE long-range goal of fish studies at the Institution is to describe the patterns of geographic distribution of fishes of the upper 1000 meters of the open North Atlantic and then to explain why these patterns occur. So far, we have made about 400 collections. Each collection represents a two to four-hour tow with a midwater trawl pulled at about three knots. Most of these tows have been made with a 3 meter Isaacs-Kidd trawl whose mouth is about 2½ by 3 meters. A few have been made with a trawl of novel design (which we call the Marinovich trawl after its builder) whose mouth is 8 meters on a side. The mesh of these nets is fine because the fish to be caught are mostly small. Some species do not exceed three or four centimeters even at their largest. Many species are components of the so-called deep scattering layers. They move towards the sea surface at sunset and away from it at dawn and are detectable on the paper charts of echo-sounders.

In June, 1965, the 'Chain' was turned over to us in Barbados for Cruise 49. We cut across the northeast corner of the Caribbean Sea to Mona Passage sampling as we went. Then, after a short steam along the northeast coast of Hispaniola, we cut out through Silver Bank Passage into the open Atlantic and headed north to New England along the meridian 70°20'W. In going north through the western Sargasso Sea, we designed the midwater trawling operations to test the hypothesis that the then newly discovered thermal fronts were of some significance to fish geography.



Cruise 85 of the 'Chain' was shortened to a section from Wood Hole along 69-70° W. to 23° North and return. The crosses indicate where thermal fronts were encountered between 1958-1963. The dashed lines are indications to show that the fronts trend east-west. (Base chart after Voorhis and Hersey, 1964.)

The fronts trend east-west and are irregular. There is a sudden change in the surface and near-surface temperature, the warmer water being to the south. The fronts have been noted at various places in the western Sargasso Sea between 25° and 30°N. They meander and their positions change with time. On several occasions a particular front has been followed for hundreds of miles. One big question about the fronts is whether there commonly is only one main front or a band of fronts, each showing about the same amount of temperature change across it. As a result of our 'Chain' 49 experience we came to favor the idea that there exists one main front.

Different communities

In any event, the question we tried to answer as ichthyologists on 'Chain' Cruise 49 was: "Is the community of midwater fishes north and south of the front the same or different?" Subsequent study of the 'Chain' 49 collections showed that, indeed, there were a number of species of fishes in the northern Sargasso Sea that were not found in its southern part and that the dividing line was in the region of the thermal fronts. The analysis of the data was complicated by the fact that the southern collections were smaller than the northern ones, this southwestern corner of the Sargasso Sea being much the poorest part of the North Atlantic that we had ever visited.

No, we did not bring up this specimen! Dr. Backus observing Dr. Craddock who had crawled inside the net to collect the tiny midwater fishes which had caught on the fibers. "That's the difference between being chief scientist and a peon", observed Backus.

For 'Chain' Cruise 85, we planned a line of trawl stations from the tail of the Grand Banks to Anegada Passage at the northeast corner of the Caribbean. This would sample a wide stretch of the western Sargasso Sea not previously visited by us and would give us another section across the region of the thermal fronts. By sharing the ship with physical oceanographers, we hoped to obtain a refined picture of the thermal structure in the region of the fronts. This would permit us to place our trawl stations more precisely with respect to the fronts and see more clearly, perhaps, their effect on fish distribution. Finally, after a visit to St. Thomas for reprovisioning and refueling, we intended to come northwest to Silver Bank Passage and repeat the line of stations made during 'Chain' Cruise 49. This time the season would be different by six months. How would our catches here compare with the earlier ones?

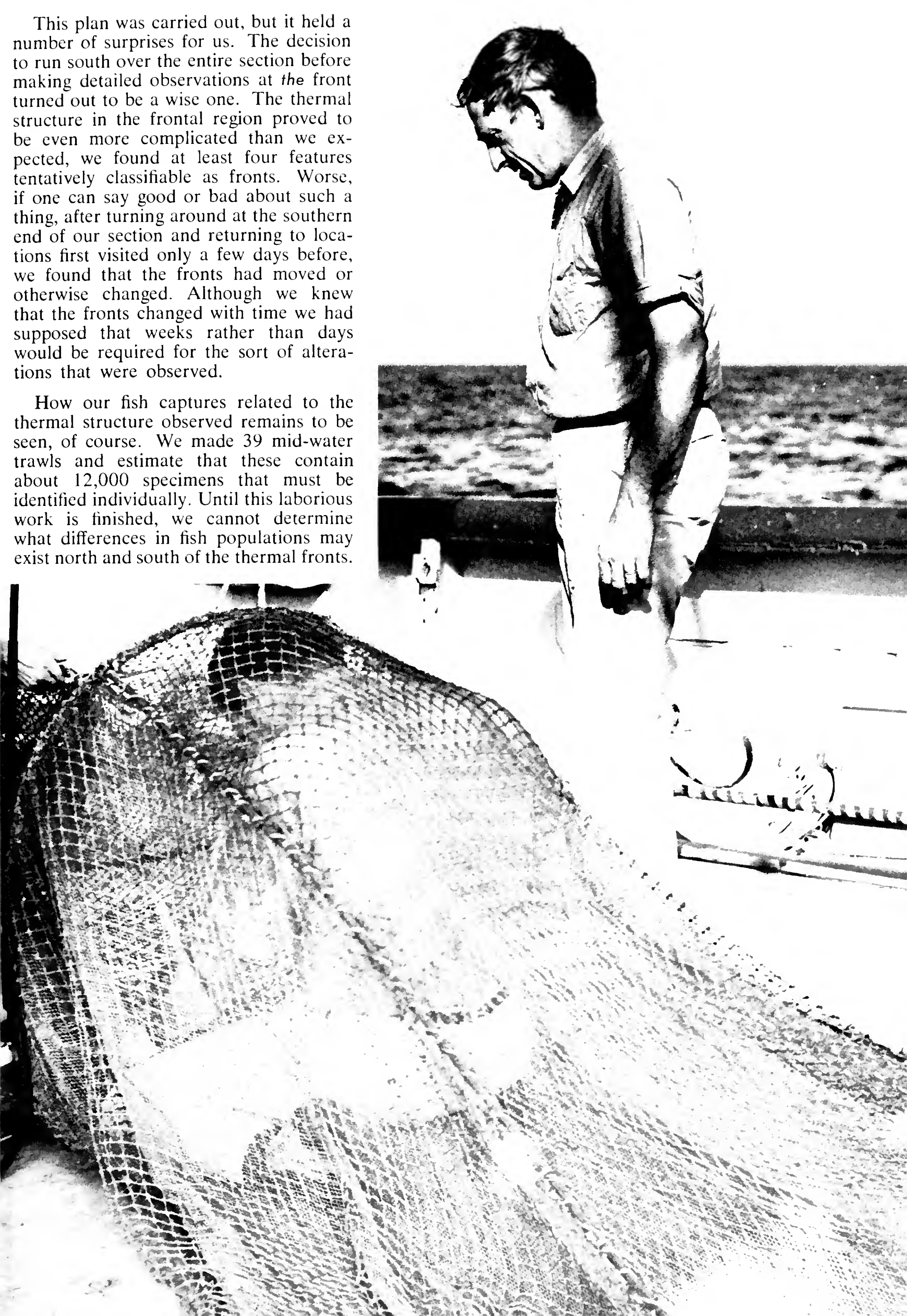
Delayed

This plan was put awry by the sinking of the 'Alvin'. The 'Chain' was diverted to the unsuccessful hunt. Our departure was delayed about one month, and the cruise duration was reduced from 33 days to 20. Obviously, a new plan was needed.

In place of the long quadrangular track interrupted by the visit to St. Thomas, we settled upon a simple south-north cruise from Woods Hole without the port call. We would run south rapidly through the western Sargasso Sea to about 23°N making plots of the surface and the subsurface temperature for locating the front (or fronts). Then, we would turn north and come back over the same track in a more leisurely way disposing our trawling and other sampling on the basis of what we had learned on the south-bound leg and studying the principal front in detail.

This plan was carried out, but it held a number of surprises for us. The decision to run south over the entire section before making detailed observations at the front turned out to be a wise one. The thermal structure in the frontal region proved to be even more complicated than we expected, we found at least four features tentatively classifiable as fronts. Worse, if one can say good or bad about such a thing, after turning around at the southern end of our section and returning to locations first visited only a few days before, we found that the fronts had moved or otherwise changed. Although we knew that the fronts changed with time we had supposed that weeks rather than days would be required for the sort of alterations that were observed.

How our fish captures related to the thermal structure observed remains to be seen, of course. We made 39 mid-water trawls and estimate that these contain about 12,000 specimens that must be identified individually. Until this laborious work is finished, we cannot determine what differences in fish populations may exist north and south of the thermal fronts.



Where is that thermal front? Hourly Bathythermographs (BT's) and expendable BT's were take by almost all members of the scientific party. Dr. F. G. Carey gets a little chilled when "One gets on board". The short stick in his hand is used to guide the wire on the drum of the winch.

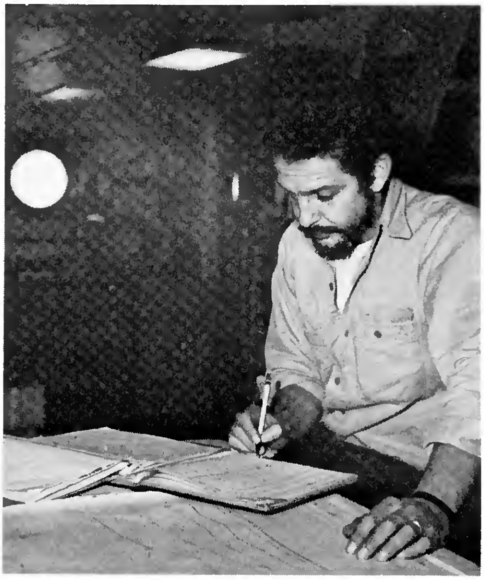
Physical Oceanography on a Biological Cruise

by E. J. KATZ

SIX months before 'Chain' Cruise 85, Dr. Backus crossed Water Street, shined a flash light down the corridors of Physical Oceanography and Geophysics and, pigeon-holing anyone not alert enough to take effective evasive tactics, asked the question: "Colleague, what is this Sub-Tropic Convergence"? The question was admittedly legitimate. German tomes, Russian Atlases and American textbooks are wont to draw a line through the western North Atlantic, in the vicinity of 30°N. and label it the Sub-Tropic Convergence. Nonetheless, the question was embarrassing, for while there is something happening in that vicinity which leaves its mark on hydrographic observations, our understanding is still sufficiently vague and our observations so hopelessly indirect that proposed hypothesis cannot be critically tested at this time. But Backus's interest was immediate.

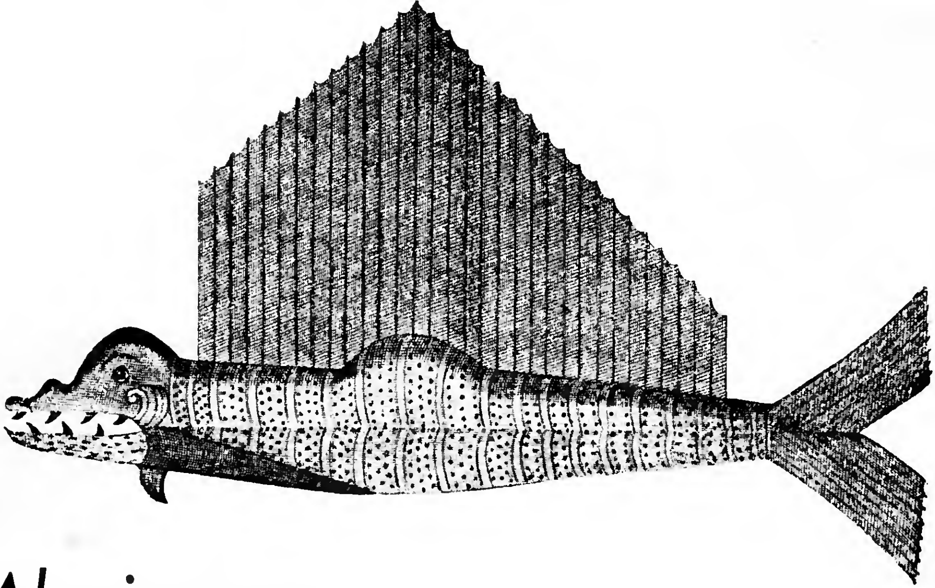
In a previous cruise transecting the region he documented a faunal distinction between mid-water trawls to the north and south. He was planning a return to confirm this important observation. Being unable to escape the feeling that we were failing a comrade, I rashly offered to join the cruise with the utmost confidence that, despite the questions of its origin, we could surely locate the frontal zone and thereby provide an on the spot hydrographic map on which to pin the biological observations.

This was the beginning which eventually found a fistful of scientists in the chief scientist cabin on the R/V 'Chain' a few hours out of Woods Hole and asking pointedly where the front would be crossed. In the interim, further interest had developed in making observations in that area and now long-liners wanted to know where to fish, chemists where to sample and geophysicists where to perform sound scattering experiments. To make a reply I was armed with preconceived notions of where it should be at this time of the year and also had one week old surface temperature tracks provided by M. Bratnick of the U.S. Naval Oceanographic Office. The hard facts were a nightmare of confusion. Instead of a well defined line of thermal discontinuity the tracks showed an assortment of possible fronts and my shipmates were heartless in their impatience at my efforts at explanation.



Dr. E. J. Katz, using the Omega navigation system trying to track a thermal front.

Well, we sailed there, and each, according to his needs, made many observations in and about the shimmering and elusive frontal zones. Perhaps not all were made at the most appropriate latitudes and perhaps some were hydrographically redundant. When all the data is in and compared perhaps the results will be interpretable. But, if I am ever approached again, my answer is prepared: a neatly typed list of references which lies somewhere amongst the cluttered stacks of my room. "Please, read the references, sail your cruise, and let me know what you find."



Alepisaurus

by R. L. HAEDRICH

ONE of the delights of longlining is that you never know what will be the next catch. All you do know is that it will probably be big. The longlining on 'Chain' cruise 85 was as exciting as usual. In addition to sharks, swordfish, tunas, and large dolphin *(Coryphaenus)*, we caught several lancetfishes, genus *Alepisaurus*, long snaky inhabitants of the twilight zones of the deep sea.

Although lancetfish are not particularly rare on longlines, their appearance never fails to evoke admiration. A large lancetfish may be two meters long, yet, because of its slenderness and its light frame, a fish of that size will weigh no more than about 2 kilograms (five pounds). The great sail-like dorsal fin, the large emerald green eye, and the long pointed jaws armed with daggerlike teeth give the fish a striking appearance. The color is iridescent, green and bronze with a silvery cast. The back and fins are much darker than the rest of the body.

Long Known

Lancetfish were first noted over 250 years ago. In his account of Captain Dampier's round the world expedition of 1703-1704, William Funnell described and illustrated a sea beast (shown above) that is undoubtedly a lancet. Today, two species are recognized—one with a long pointed snout and pale coloration, the other with a shorter snout, darker hue, and generally smaller size. Both species have been found in all oceans, broadly distributed in the warmer waters between 40°N and 40°S, although strays are not uncommonly found as far north as Iceland. Although it is an oceanic fish, there are a few instances in which lancetfish were caught by anglers fishing in the surf.

Twilight Zone

The lancetfish, unlike the near-surface living (epipelagic) tunas and sharks, is considered a member of the deep ocean's midwater (mesopelagic) fauna. The large eye, light tissues, and general color pattern seem to be common trademarks of fishes from this twilight zone. However, the lancetfish does not possess light organs, which are found in many midwater fishes. Most mesopelagic fishes, also, are rather small, rarely exceeding ten or twelve centimeters in length. The two meter length attained by the lancet probably makes it one of the largest of all the midwater oceanic fishes.

Such a large fish requires a fair amount of food to keep going. The lancetfish is a voracious feeder, indeed, there are some oceanic fishes which are known only from a few specimens found in lancetfish stomaches. Thus, the lancetfish has been called "an excellent midwater trap." The distensible stomach of the lancetfish apparently stores food to be digested later in the intestine. Little or no digestion occurs in the stomach itself, and thus animals from lancetfish stomachs are in remarkably good condition.

Great Variety

A great diversity of midwater animals have been found in lancetfish stomachs, but only a few occur regularly and in abundance. These are certain small crustaceans, peculiar trunked molluscs called heteropods, barracudinas (family Paralepididae), one species of silver hatchetfish *(Sternoptyx),* and, strangely enough, other lancetfish. The lancetfish does not seem to discriminate in selecting its food. Included are small animals and large ones, fat ones, and skinny ones, transparent ones and dark ones, and animals with and without light organs. With such an indiscriminate diet it is remarkable that the common and abundant midwater lanternfishes, gonostomatids, and the predatory blackfishes are almost never found in the lancetfish's stomach. The reason for this is by no means clear. It cannot be ascribed to inadequate sampling, for hundreds of lancetfish stomachs have been examined. Nor is it the result of some regional peculiarity, for this omission is always the same, whether the fish are taken in the North Atlantic, South Pacific, or Indian Ocean.

It may be that the lancetfish and the animals it eats provide us with an example of a high-seas, midwater community. These fishes probably live within the same principal depth ranges, and to the extent that any of them migrate, do so together. In preferred depth levels, vertical migration and behavior, this community is distinct from other midwater communities, the members of which rarely or never appear in lancetfish stomachs. That behavior may be particularly important is suggested by the fact that members of the "lancetfish-stomach community" are rarely collected by midwater trawls.

Lancetfish are responsible for the loss of some of our deep-sea moored buoys. Their teeth have been found in mooring ropes as well as in some wooden panels suspended to study deep-sea marine fouling.

A neuston net haul (deposited in a plastic baby bath) shows a typical Sargassum weed population, at least two Sargassum fishes (arrows), various shrimps, worms, crabs and fish larvae.

NEUSTON FISHING

by J. E. CRADDOCK

A COMPARATIVELY new method of sampling the uppermost layer of the sea surface provides new information on biological activity including the fact that land insects form an important part of the diet of one species of lantern fish.

DRS. Backus, Haedrich, and I are most interested in how and where deep sea fishes live. Thus, most of our time at sea is spent fishing wth different types of midwater trawls, sometimes at great depths. It is often a shock to onlookers that we expend considerable energy fishing at the surface of the ocean with so-called "neuston" nets, which sample only the upper few centimeters of the water. (Neuston is an ecological term which refers to the community of animals and plants living at or on the surface of the water).

Bizarre Animals

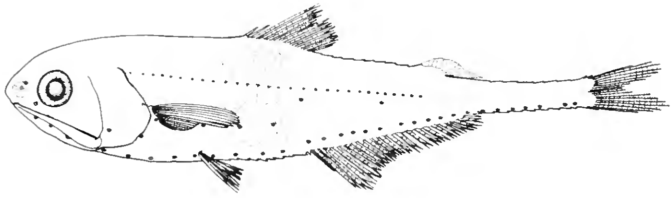
Neuston nets catch interesting and often bizarre animals. The nets may contain flying fishes, porcupine fishes, sargassum fishes, and young swordfish, sailfish, marlin, and tuna. The invertebrates are as interesting as the fishes — jellyfishes, salps, Portuguese men-of-war, argonauts, and young stages of various shrimp, crabs, and lobsters. Many of these species are found only on thc high seas, and are seldom caught since other types of nets do not sample the near-surface fauna well.

What are the relationships between such fishes as flying fishes and deep-sea fishes? There are, to be sure, many indirect relationships. All species living on the high seas, whether deep in the water column or near the surface, are influenced by the physical properties of the ocean itself — the currents,, convergences, upwellings, etc. But is this reason enough to fish at the surface if your primary objective is to catch deep-sea fishes? No, but . . .

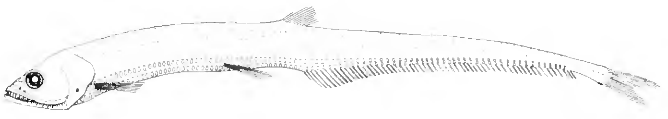
Many open ocean midwater fishes, especially the shallower living species (the mesopelagic as opposed to the bathypelagic), make daily, vertical migrations. During the day, these species generally live at depths of about 300 to 600 meters. But, at night, they swim upward into the upper 100 meters, where they feed and thus compete, in a sense, with fishes such as dolphins, jacks, and flying fishes which live all the time in the upper layers of the ocean. Furthermore, some mesopelagic species, environmental conditions permitting, swim right up to the sea surface at night, where they may be dipnetted, or caught with neuston nets.

Since neuston nets are easily fished while the midwater trawl is in the water, they require no ship time. The mesopelagic fishes that are caught by neuston nets usually are species that seldom are taken in midwater trawling. Three such fishes, distantly related but each bearing small light organs (photophores), are the myctophid *Gonichthys coccoi,* the astronesthid *Astronesthes niger,* and the gonostomatid *Diplophos taenia.* As an example, during 'Atlantis II' Cruise 13 between Woods Hole and the Azores, only 14 specimens of *Gonichthys* were taken in the midwater trawl nets while nearly 3000 *Gonichthys* were collected by a neuston net fished at the same times. Thus, what started out as an enjoyable experiment has become a regular and important part of our overall operation.

In one sense, we are able to learn some facts about fishes from neuston collections



Neuston fishing led to the surprising discovery that land insects made up over half the food found in stomachs of the midwater fish Gonichthys coccoi



Among the "deepsea fishes" which are found rarely in midwater trawls but caught at night with neuston nets is Diplophos taenia, a black fish with rows of light organs and a good set of teeth

Neuston fishing is done mostly at night. A sorting table on the deck is used to shake out the Sargassum weed while the remaining marine life is collected in a plastic pan

that cannot be learned from midwater trawl collections. This is because more than one neuston net can be towed with ease, (almost always we have four in the water at the same time, two side-by-side to port and starboard) and each collection can be of short duration. Midwater trawls usually remain in the water for several hours, which obscures such facts as whether or not a particular species lives in schools,* or segregates according to size or sex, etc. Such things are more easily observed from short tows — easily made with neuston nets. It is often quite remarkable how different the animals can be from two nets fished side-by-side. Two nets so fished often contain different species; seldom are the catches identical.

Neuston fishing, a bonus itself, has produced several unexpected sidelights, for instance, the study of insects. In addition to water striders *(Halobates)*, the only type of marine insects,** neuston nets have collected many specimens of terrestrial insects which were apparently blown to sea.

Land Insects

On 'Crawford' Cruise 172 during August 1968, collections were made in the Slope Water about 150 miles southeast of Woods Hole — terrestrial insects included: moths, butterflies, stinkbugs, lady bugs, and other beetles, dragon flies, and many kinds of small flies and aphids.†

One of the most unexpected findings to date has been the occurrence of terrestrial insects in the diet of the lantern fish, *Gonichthys coccoi*, one of the most abundant midwater species at the surface in the western North Atlantic. Perhaps unsurprising in retrospect, it came as quite a shock to find that, on the night of 25-26 June, 1968, during 'Gosnold' Cruise 121 in the Slope Water, terrestrial insects made up over half of the food of this 'deep-sea' fish.

*See: "Solving the mystery of 'Alexander's Acres", by R. H. Backus. Oceanus, Vol. XIV, No. 3, Oct. 1968.

**See: "Ocean Insects", by R. S. Scheltema, Oceanus, Vol. XIV, No. 3, Oct., 1968.

†This new fact belies our previous remark (Oceanus, Oct., 1968) that "only under rare conditions are land insects encountered at sea". (Ed.)

Radio-isotopes

by V. NOSHKIN

ON board 'Chain' Cruise 85 we continued our investigations of the changing distribution of radio-isotopes present in the marine environment as a result of nuclear testing in the ocean and atmosphere. Three large volume sampler stations were made, down to a depth of 4100 meters, along with ordinary hydrographic data (Nansen bottles) to determine the concentration of specific radio-isotopes in the Sargasso water masses. The resulting information will show how rapidly various chemical elements move from the sea surface towards their final end in the bottom sediment. By relating this information to other factors —such as how the isotopes move through the cycle of marine life—we can learn also something about the mechanisms responsible for the movements of the chemical elements. The water collected was of particular interest in that the first of the stations was made south of the subtropical convergence zone and the other two stations north of this boundary. The second station was located just north of the convergence as determined by Bathythermograph and surface temperature observations. This convergence zone seems to be an important boundary zone for fish, plankton and birds. It will be interesting to see whether there also is a discontinuity in radioactive fallout concentrations. From the same stations, water samples taken at various depths will be given to several collaborating investigators. These samples will be used in the determination of carbon-14, tritium and stable rare earth element concentrations.

Scavengers

In addition, we collected samples of Sargassum weed from regions of the sea in order to determine the activity of specific radioactive isotopes scavenged by these plants and to compare these concentrations with those observed in samples collected in past years from the same areas. Plankton collections were made during each mid-day and mid-night watch, primarily in the area draped by the subtropical convergence. These samples will be used to study the concentrations of stable elements and radio-isotopes in planktonic life.

Dr. Noshkin empties the noon plankton haul to study the concentrations of radioisotopes in zooplankton

(FROM HARDY)

SHRIMP – TEMPERATURES and PRESSURE

by J. M. TEAL

AMONG the most colorful animals in the open sea are the midwater decapods, the shrimps and prawns. These usually are either bright red or red and white, while many of them also secrete a cold-blue light substance into the water whenever they are disturbed.

The midwater prawns are comparable in size to the fish with which they share their environment, from two to six centimeters long. Occasionally, larger ones are caught, but since egg bearing females of most species are taken in the size range given, we can assume that they do not grow much larger.

Since many of these prawns migrate up and down each day, with the coming and going of night, I thought it would be interesting to see what effect the vertical migrations have on their metabolism. When they go down at dawn they get into colder water. The water at 1000 meters is only 6 to 7°C., while the water at the surface may be 25°C. or more. Besides changes in temperature, prawns encounter changes in pressure during their migration. The pressure in sea water increases by one atmosphere for each 10 meters of depth increase. An animal that migrated between 1000 meters and the surface would experience pressure changes of 100 atmospheres. (1500 pounds per square inch)

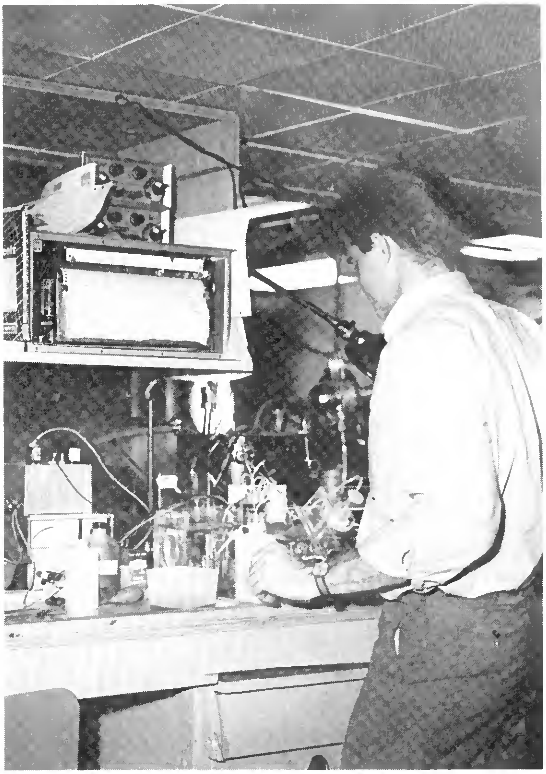
The great pressure change will not have any immediately obvious effect on prawns. There are no gas spaces in their bodies, and watery liquids, such as body fluids or tissues, are only slightly compressed by pressure changes of this magnitude. However, pressure changes affect chemical reaction within an animal. I was interested in looking for such reactions.

Oxygen Consumption

I have measured the rate of oxygen consumption of several species of prawn at temperatures between 5° and 20°C. and at surface, 500 m and 1000 m pressures (50 and 100 atmospheres). Oxygen consumption was measured because it is relatively easy to determine and provides a good overall measure of the rate at which the prawn is living.

Prawns were caught by towing nets either at the surface during the night, when the scattering layer has come up, or at

Prawns are picked out of a day-time midwater trawl



Drs. Teal and Carey shared a cluttered table in the main laboratory

depths during the day. The proper depth for towing the net was chosen by looking at the indication of the scattering layer on an echo sounder. The living prawns were picked out of the catch and were kept in dishes of water in a refrigerator, where they survive much better than at room temperature.

Respiration

The prawns respired, inside glass containers, placed in a pressure vessel aboard the ship. An oxygen electrode stoppered the animal containers and provided a means of following respiration when pressure was changed. This use of electrodes for measuring respiration has several advantages, among them that one can see at once if one of the prawns died, and, thus, waste no further time on that particular experiment.

Since we were still at sea when I wrote this, I cannot make any final statements about the effect of pressure and temperature on the respiration of these prawns. I must wait until we are ashore to weigh the specimens and put the results from the various individuals into a form that permits comparison between them. Due to the rolling of the ship, it is extremely difficult to weigh anything at sea.

I can say that pressure does have an effect on the respiration of these prawns. Increasing pressure increases the respiration rate. As would be expected, decreasing temperature decreases the respiration rate. Since pressure increases at the same time temperature decreases, when the prawn is going down, there is a tendency for the two effects to cancel each other. Respiration, hence, the prawn's activity, tends to remain constant throughout their migration. They are as active in the cold depths, as they are in the warmer surface waters.

I can only guess as to why this should be so. These are predatory animals. They live in a place where there is not a lot of food. Animals suitable as prey are widely dispersed, even in the scattering layers. Perhaps the prawns cannot afford to be sluggish from the cold during half of their lifetime but remain constantly active to get enough food to keep alive.

I have studied only a few species so far. There are many more of these prawns and shrimps to be investigated and much remains to be learned.

Acoustics

by P. T. McELROY

THE strong echoes from fish displayed on a precision graphic recorder (PGR) shows that sound can be a powerful tool for the marine biologist or fisherman. Echoes from schools and layers of fish as well as from individual fish can be seen and their depth determined, so that a net can be set at the correct depth or so that the fish distribution throughout the water column can be determined.

The same echoes from marine life are only so much noise, or interference, in other studies, such as long distance acoustic transmissions or the search for submarines. Fortunately, many investigations of acoustic scattering can provide information of use in both areas. Sound scattering must be better understood if we are to fish more selectively and if we are to use acoustics to portray the distributions of marine life. Similarly, the reduction of interference from sound scattering in other studies demands an understanding of the scattering mechanisms.

Three experiments

Three different groups of experiments were carried out during 'Chain' Cruise 85. Daily measurements of echoes at 12 Khz (kilocycles per second) were made at noon —the time when most scatterers have descended to their maximum depth. After processing to reduce the effects of sea noise and to correct for the weakening of sound with distance, the results will be a measure of sound scattering at 12 Khz. The variations during the cruise, particularly in different geographic regions—such as on the two sides of a thermal front—will further our knowledge of the distribution of scatterers.

The other experiments used the sparker sound source while we were trawling. The sparker creates a pulse of sound energy by the discharge of a powerful electrical spark into the water. Although much of the sound energy from this source is concentrated in low frequencies, there is some sound in the high frequency. Such "broadband" sources are useful in making comparisons how scatterers reflect sound at different frequencies*. The rest of the experimental apparatus was contrived to make a comparison of sound scattering at the depth of the trawl with the actual catch. This comparison can be made at various frequencies with an ultimate—as yet unattained—goal of characterizing the catch in different geographic regions in terms of a frequency response.

Targets

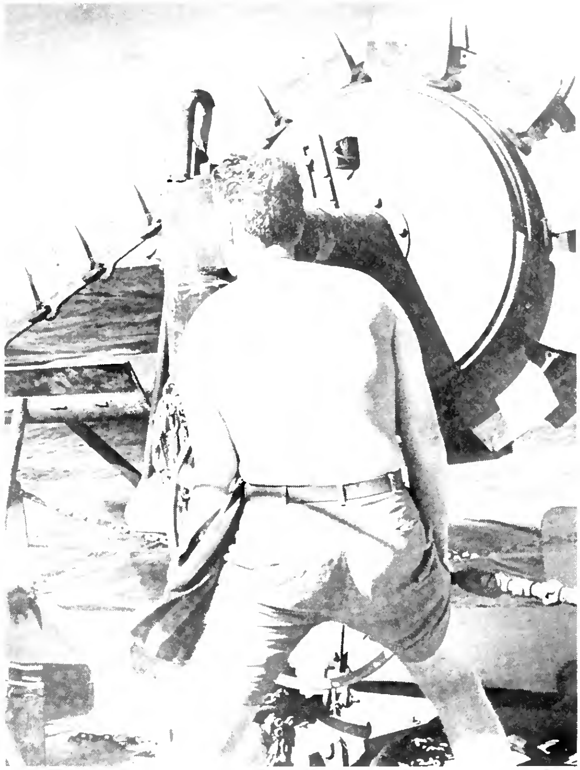
The amount of sound scattered by a fish is expected to change as one changes the angle between sound source and target (fish). In our third group of experiments we attempted to observe this effect by drifting away from our sound receiver, a sonobuoy. If successful, this could make it possible to characterize targets more precisely.

Finally, the PGR records provided a continuous log of scattering during the cruise and gave the necessary clues about fish location and permitted biologists to position their nets. The depths of the trawl nets was controlled by checking on the PGR the signals received from a "pinger" on the net. When the net deviated from the desired depth, we would get onto the intercom from the upper laboratory to the afterdeck to tell the biologists to adjust the net depth by either letting out or bringing in the trawl wire.

*See: "Sound Scattering", by R. H. Backus, Vol. VIII, No. 1, September, 1961.

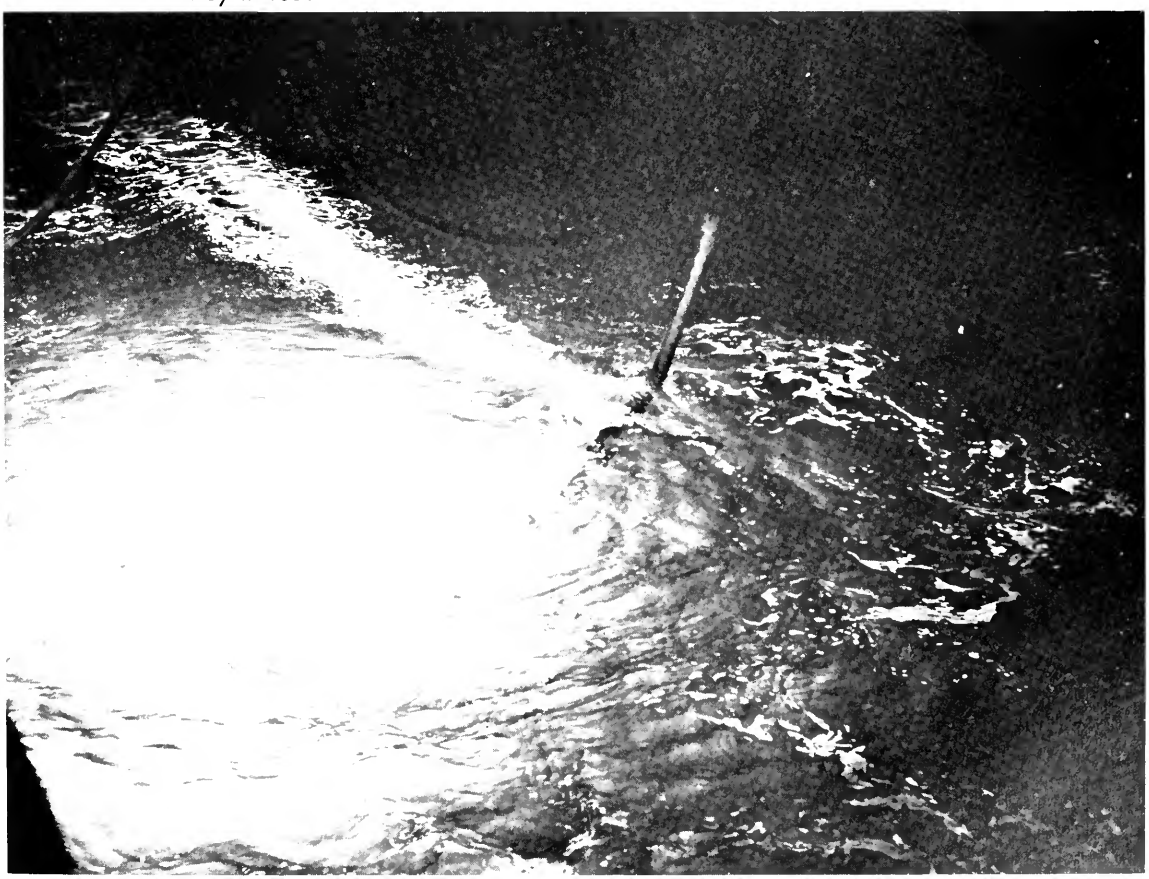
BOURNE

Dr. Backus checks the signals recorded on the PGR from the "pinger" on the net. Width between the lines indicate the depth of the trawl



Dr. McElroy lowers the "dinosaur tail" which contains the sparker cable. Acoustics, as all aspects of oceanography, includes hard physical labor

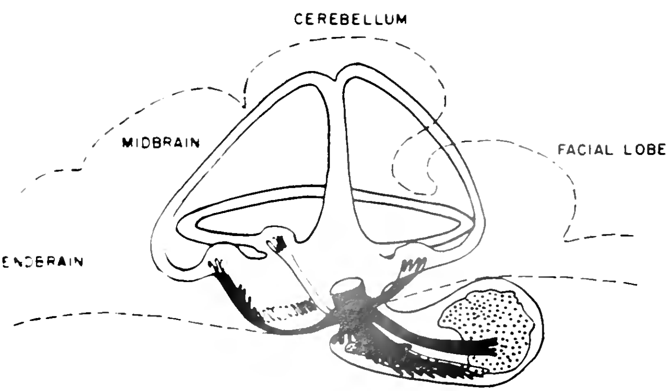
A brilliant display is made by the sparker going off at night below the sea surface. It is wise not to have a fishing line out or be in any other way in touch with the water



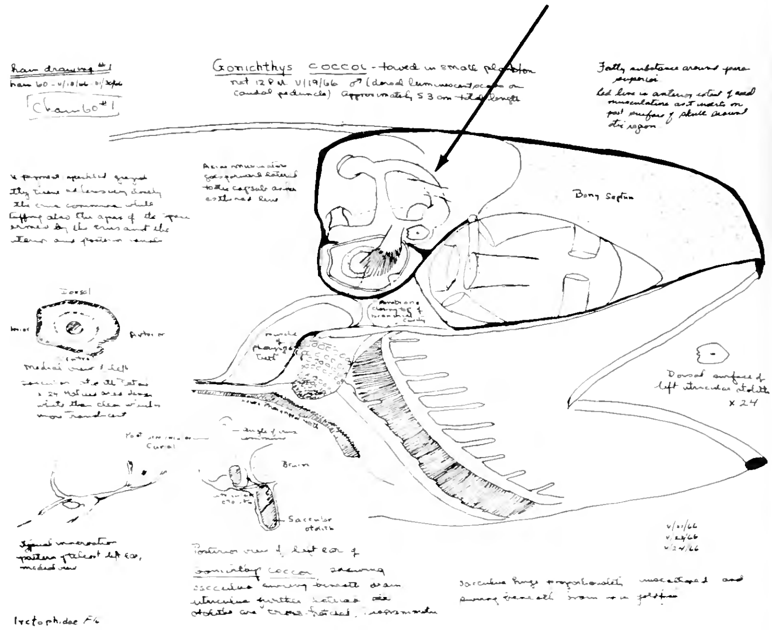
MUNNS

Fish Ears

by J. M. MOULTON



The right ear of a goldfish.



Dr. Moulton has the naturalist's habit of making precise drawings and notes. This is the head of a Gonichthys coccoi, the ear is indicated by an arrow. The total length of the fish was 5.5 cm or about the width this caption.

DESPITE great interest in sensory matters, the form and structure of the bony fish ear has attracted few morphologists since the beautiful work of Gustav Retzius in the last century. The labyrinth of the inner ear of most fishes is, despite its fragility, likely to remain undamaged because of its protected position in the head, after much of its owner has been either digested or cut up for various purposes. As one interested in the hearings and responses to sound of fishes, I have found oceanographic cruises valuable opportunities to work on the inner ear morphology of fishes, not only because a wide variety of fishes is likely to come aboard and can be worked on in relatively fresh condition, but also because the general activities on a research voyage are invariably of interest to me, and I enjoy participating in the work. (The hard work of oceanography is frequently not appreciated by those most likely to reap its benefits.)

My work requires the use of a dissecting microscope and fine surgical instruments, not always in the best of weather. A niche for such work was found on 'Chain' cruises 60 and 85 and on Cruise 18A of the 'Anton Bruun' in the southeastern Pacific Biological Oceanographic Program. I have now had the opportunity to determine the inner ear morphology of a wide variety of fishes not commonly available to zoologists, and the study begins to show an interesting picture.

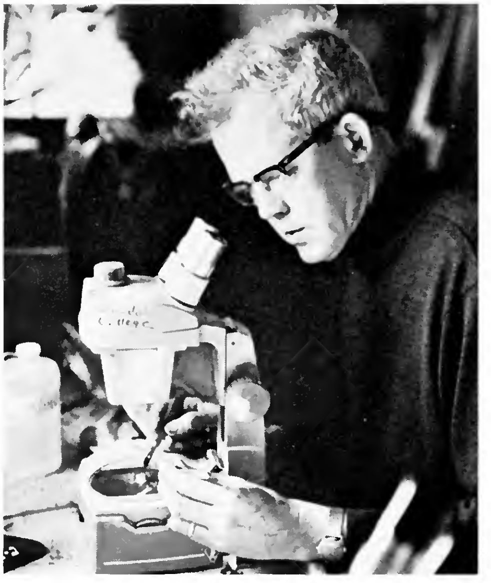
Beyond the basic division between cartilaginous and bony fishes, in the former of which the inner ear is completely enclosed in cartilage, and between true minnows and other bony fishes with so marked a difference in form of the main chamber (sacculus) lies a significant adaptive evolution which has culminated in the beautiful labyrinth of man's ear.

Variations

Actually, this work began for me under Institution fellowships working in Great Harbor in 1954, 1955, and 1957, when I began to look at the inner ears of a variety of local fishes such as sea robins, the toadfish, the menhaden, and the barrelfish.* It soon became evident that fishes of various taxonomic groups differed noticeably in their inner ear morphology. A mention of the thin skeletal bridge supporting the frontal semi-circular canal of the barrelfish to Dr. Haedrich at Woods Hole in 1964 led him to encourage my looking further for variations in the ear structures. With several undergraduate students at Bowdoin College, I have continued this work. 'Chain' cruise 85 provided an opportunity for more field work.

The inner ear of bony fishes lies behind, or in some larger species above the eye, alongside the tough outer membrane of the brain. In this position, the inner ear is well protected from damage. Some fishes which are difficult to collect are found in partly digested form in the stomachs of larger pelagic and midwater fishes.† Often the inner ear of such partly digested fishes will be intact. During 'Chain' cruise 60, we drew the ear of a fish that was so digested that it could not be identified. Four years later on 'Chain' 85, an identical ear was discovered in a dissection of the midwater fish *Astronesthes niger* caught at the sea surface at night.

Ears do not keep pace in size with the increase in body mass of vertebrates. Even in the large fishes — such as dolphins, swordfish, and tuna—in which the balancing (upper) part of the ear can be seen with the naked eye when the surrounding



tissue is removed, the hearing (lower) portion requires careful microscopic analysis.

Our first task to obtain the small piece of skull housing the inner ear of such large fishes requires careful work with a gross dissecting tool—a hand saw! Other inner ears studied at sea — those of the snipe eel, of *Cyclothone* and of *Notolychnus,* for example—are only a few cubic millimeters in size.

DR. MOULTON, Professor of Biology at Bowdoin College, also is an artist who made remarkably fine drawings of his microscopic subjects. His enthusiasm and wonder for his subject is infectious. My bench was next to his on the 'Chain'. Time and again, Dr. Moulton would look up from his microscope and call out "Jan, Jan! Come look. I've never seen anything more beautiful!" (Ed.)

The basic form of the bony fish ear is quite invariable. But there are many interesting variations, some of systematic significance, such as the extent of skeletal support of the ear canals, the relative size of the upper and lower parts and the form of the ear stones, or otoliths. In most fishes, the blood supply of the inner ear is rich and may include a remarkable rete (an elaborate network of blood vessels).*

*See: Moulton, J. M. "The Sounds of Fishes", Oceanus, Vol. V, Nos. 1 and 2, Winter 1957.

†See page 8 of this issue.

*See: "Why is a tuna warm?" by F. G. Carey and J. M. Teal. Oceanus, Vol. XIII, No. 1, Nov. 1966.

In the swordfish, a great rete deserving of further study, occupies the space enclosed by the sensory chamber and the semicircular canals. This was called to my attention on 'Chain' 85 by M. T. Webb, a Bowdoin College undergraduate. Is this a way of damping blood pressure through the ear so that variations in pressure do not interfere with auditory functions?

It may not be out of place to remark that the beauty of design of the inner ear must leave one somewhat breathless on first acquaintance. There can be little doubt that there is a great variation in usefulness of the ear, in fishes of widely varying ways of life and from different concentrations of population. It appears likely that the swordfish has reduced the hearing part of his ear, perhaps depending more on the vision of its relatively huge eye for sensory information. Reduction of the lower (hearing) part commonly occurs in small midwater fishes with large jaws. But the small lantern fishes (myctophids) have large and ornate earstones in the main chamber (sacculus) and corresponding emphasis on the size of the sensory areas. The lantern fishes also have impressive pharyngeal teeth which, in some other fish, produce rasping or grinding sounds which in turn set up resonant vibrations in the swim bladder. The combination of good hearing organs and sound-making ability suggests that it may be a pretty noisy world in the rich life of the scattering layers and that acoustic clues may help to unravel the problem.

"Perhaps the swordfish depends more on vision with its relatively huge eye."

ESCAPE TAIL-FLIP

A flip of the tail, resulting in escape of amphibians and bony fishes, is believed to be a reflex action resulting from a sound stimulus. Certain nerve cells in the brain, called Mauthner neurons—after their discoverer Mauthner (1859)—were shown by Moulton and Dixon in 1966 to provide a directional-hearing escape mechanism in the goldfish, *Carassius auratus.*

Working under Prof. Moulton at Bowdoin, I was invited to go along on the 'Chain' cruise. Since I had become involved in the problems of the Mauthner cells, the cruise provided an opportunity to collect unique and varied specimens. Fresh, well fixed materials is of great importance in making preparations of nerve tissues. The material collected was fixed and embedded on board ship, for indefinite storage. The peripheral benefits of the cruise were equally rewarding. As a "landlubber", I found no end to the fascination of the sea. The insight gained into the activities of the Institution was enlightening and I felt privileged to contribute to the research program.

M. Webb

"We spent a rough night, morning dawned a bit grey and cold. the smell of swordfish on the grill fills the ship" (From the log of D. Masch)

WARM FISH

by F. G. CAREY

CERTAIN sharks and the tuna are warm bodied fish and can maintain a considerably higher temperature than the water in which they swim.* As physiologists, we have been interested in the means by which these fish stay warm and the advantages which they obtain from their high body temperature. These are active fish, strong and swift swimmers with a high metabolic rate. They require large amounts of oxygen which must be obtained from the water by the gills and carried by the blood to the tissues. The circulatory system is strong and well developed, and the oxygen-carrying capacity of the blood is comparable to that of man.

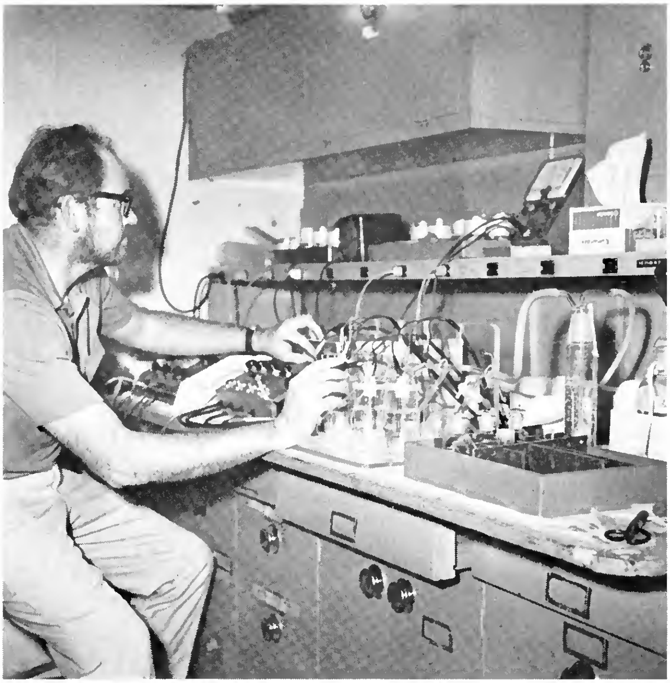
One of our interests during 'Chain' Cruise 85 was the fact that the blood is alternately cooled in the gills and warmed in the tissues with each circuit through the blood vessels. In all other vertebrates the affinity with which the blood binds oxygen is markedly affected by temperature. We have found that the blood from warm-bodied fish, such as the yellowfin tuna taken during this cruise, is unique in that temperature has little effect on its affinity for oxygen. Fish, such as the dolphin and white tip sharks which we caught, are not warm-bodied but live in warm waters of constant year round temperature. Their blood is markedly affected by temperature.

Intermediate between these extremes was the blood of fish such as swordfish which we caught and, after taking samples, ate. The blood of such fish, which swim in both warm and cold water during seasonal migrations or in passing from surface to deep water, is not as susceptible to temperature changes as the dolphin blood, but more sensitive to temperature than the warm bodied tuna and sharks.

The 'Chain' is a fine vessel for longlining and the fishing operations were enjoyed by everyone on board. The ease of fishing and the roomy laboratory space formed a fine combination for obtaining the fish and carrying out the measurements.

*See: Why is a Tuna Warm?" by F. G. Carey and J. Teal. Oceanus, Vol. XIII, No. 1, Nov., 1966.

With a syringe, Dr. Carey assisted by P. R. Boutin takes a blood sample from a live dolphin (Coryphaenus)



Swirling and humming, water samples are measured for trace elements on board the 'Chain'. Mr. Fitzgerald is a graduate student in the joint program of the Institution and M.I.T.

TRACE ELEMENTS

by W. F. FITZGERALD

IN 1942, when "The Oceans" was published, some 50 elements were known to occur in seawater as dissolved solids, some as minute in quantity as parts per billion parts of water. Some trace elements too dilute to be measured with the techniques then existing were found accumulated in the skeletons and bodies of marine plants and animals. It has long been known that trace elements are important to marine life. For instance Prof. H. Gran wrote in 1931 that he believed that low concentrations or lack of iron might be a limiting factor in the growth of diatoms.

Unlike the major constituents of seawater*, the trace elements are not constant in relation to chlorinity. There are a number of mechanisms which may control the concentration of trace elements. The main supply routes are from land drainage and from the atmosphere. These sources vary geographically and seasonally. The removal routes, such as biological activity and precipitation or absorption on particulate matter are also variable in space and time. Thus, the concentrations of trace elements depend not only on the circulation of the ocean but also on biological and geochemical processes. These factors then may be an important controlling agent in the distribution of trace elements. This is particularly applicable in regions of upwelling and in the waters of the continental shelves. Thus, variations in the concentration of trace elements can be expected that are quite independent of observed salinity differences.

*See: "Beards, Salts and Decimal Places", by F. A. Richards. Oceanus, Vol. VI, No. 2. Feb. '59.

Contamination

For sometime, workers have been attempting to formulate a marine economy for certain elements. However, accurate measurement in the parts per billion range is most difficult. Most measurements have been beset with analytical hazards due to the pre-concentration and extraction procedures. It is extremely difficult to avoid contamination when a number of chemical manipulations are necessary to obtain a suitable detection level.

In the last few years, new techniques have been able to avoid much of the earlier troubles. Many of the previous sources of contamination have been eliminated by the more extensive use of neutron activation, isotope dilution and atomic absorption. Nevertheless, it is still often necessary to concentrate samples of seawater in order to measure many elements.

These advanced methods also have to deal with sample storage. Rarely have trace metal measurements been done on board ship. We are dealing with such minute concentrations that there can be a serious source of error from absorption on the walls or leakage of ions from the storage container.

The reported amounts of trace metals present in seawater, with few exceptions, do not distinguish the chemical forms of the metal that may be present. Although extremely sensitive, these newer techniques have not discriminated, for example, between the free form of the metal and the metal that may be held by organic molecules suspended in the water. Generally, the values reported take in all forms of the trace metal present. The metal held by organic molecules may be a relatively small part of the total but could be of great ecological importance.

Goal

Our goal in the chemistry of trace metals in the marine environment has been aptly stated by Høgdahl (1963). It is: "to determine, not only the total concentrations of the trace elements in the oceans, but also the concentration of the various forms in which elements can exist in the seas, as a function of time, location, and depth and to correlate the results with biological activity, geochemistry and the physical chemistry of the elements, and the hydrodynamical picture of the ocean." This is obviously a formidable task.

A new development makes it possible to resolve some of the older uncertainties and to make measurements directly on board ship. A method (Matson, 1968) developed in Professor Carritt's laboratory at the M.I.T. allows direct analysis of a seawater sample. This technique is anodic stripping voltametry using a thin film mercury graphite electrode. It permits the examination of extremely small quantities of the free metals present in natural waters with a precision as good as 5%. On 'Chain' Cruise 85, I was able to measure zinc, copper, lead and cadmium. These vary, respectively from several parts per billion to 1/100's parts per billion.

Some Statistics

'CHAIN' Cruise - 85 (Captain C. A. Davis) left Woods Hole on November 24 in a drizzle and returned December 14 in a drizzle. On board was a scientific party of 21 with Dr. R. H. Backus serving as chief scientist. During the cruise 39 midwater trawls were taken and some 12,000 mid-water fishes collected. Six long line sets were made which collected a dozen blue sharks, 2 mako sharks, 1 white tip shark, 10 dolphins, 6 yellowfin tunas, 4 Alepisauri, 1 false albacore and 2 swordfish.

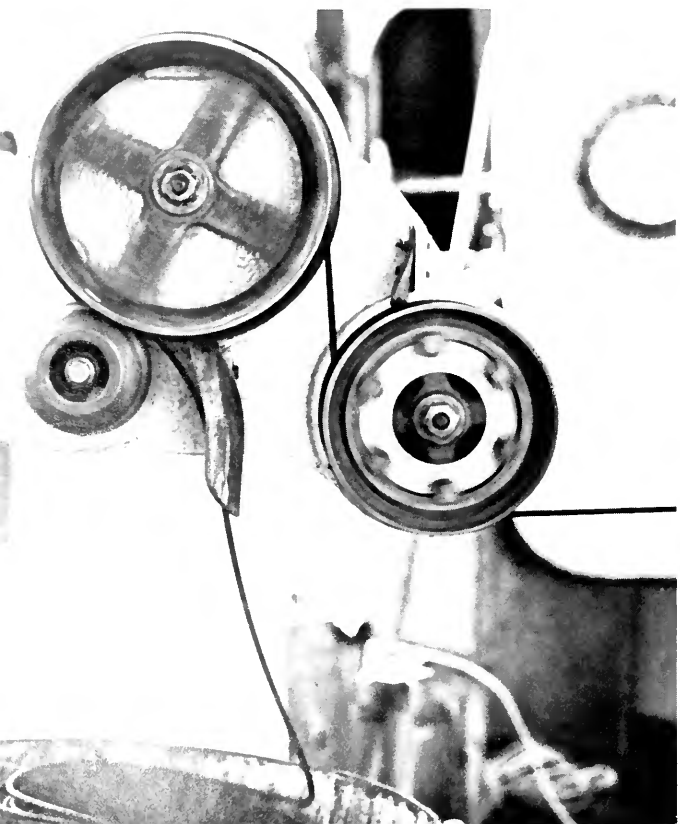
182 BT observations were made; 98 expendable BT's; 15 casts with the STD (Salinity-Temperature-Depth) were made to a depth of 1000 m each; 3 hydrographic stations to the bottom and 3 large volume water sampler lowerings.

In addition to the scientific party the officers and crew of the 'Chain' should be mentioned not only for their time-honored co-operation with "science", but also because many of them helped with the heavy work. Fishing is fun!

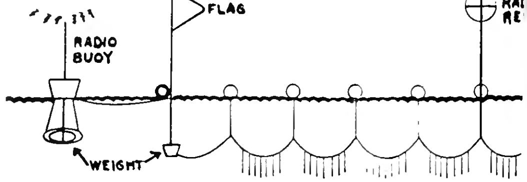
And sobbing sweethearts, in a row,
wail o'er the ocean foam.

*Our departure
was normal*

LONG



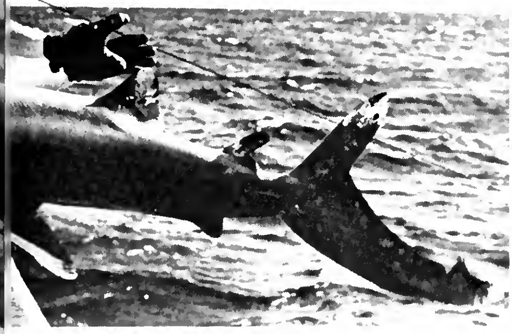
THE so-called Japanese long line consists of 200 meter long synthetic lines, each filling one tub. Ten hooks with leaders are fastened with snap-on clips as the line goes over the side of the ship. Each hook is baited with a herring. On 'Chain'—85 some twenty tubs were set out, so that the total length of the



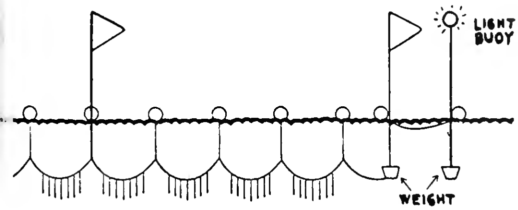
Top left: Long lines on board a commercial fishing vessel.

Bottom left: Japanese designed and built this winch hauls in the line and coils it at the same time.

Bottom center: After the haul, off-watch crew

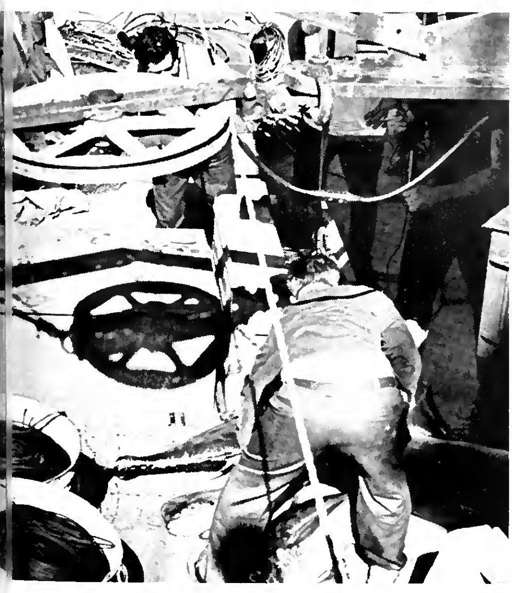


'ine was 4000 meters with 200 hooks. Gen-
erally the line was set soon after midnight
and hauled again about ten o'clock in the
morning. In the intervening hours the ship
went on with its many other activities. Long
'ining is exciting but hard work.

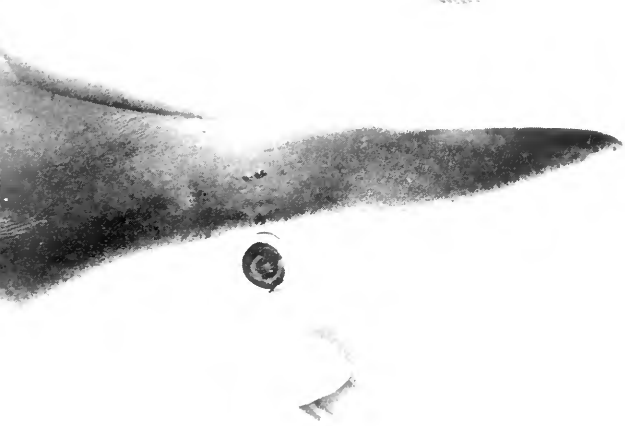


nembers admire two yellowfin tuna and a dolphin shown just to the right of the tubs.

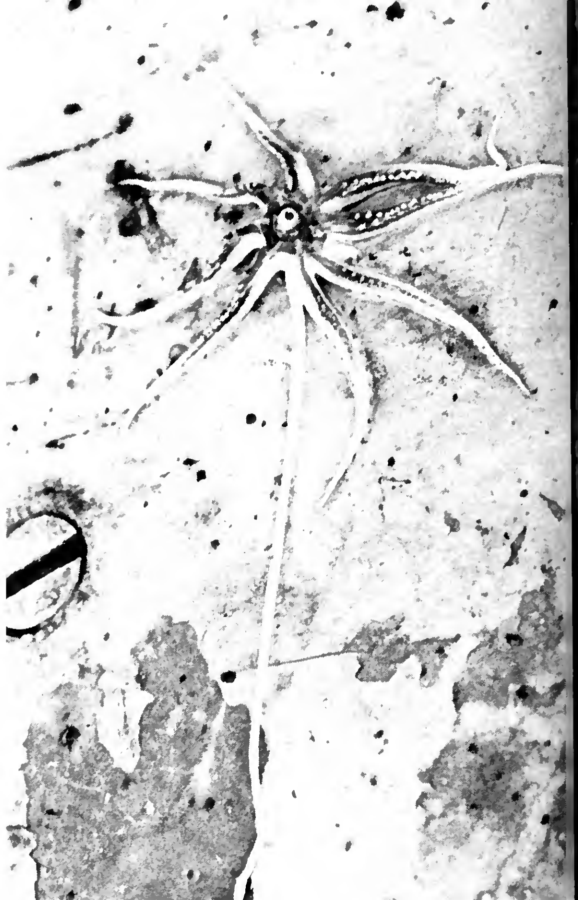
Top center and bottom right: Small sharks such as this white tip are manhandled but large blue sharks are hoisted on board, thrashing wildly.



LINING

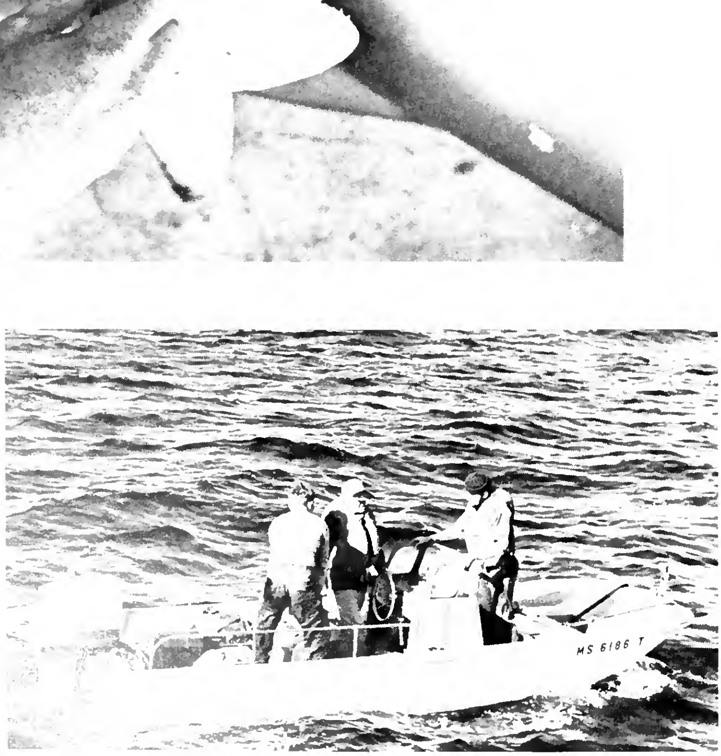


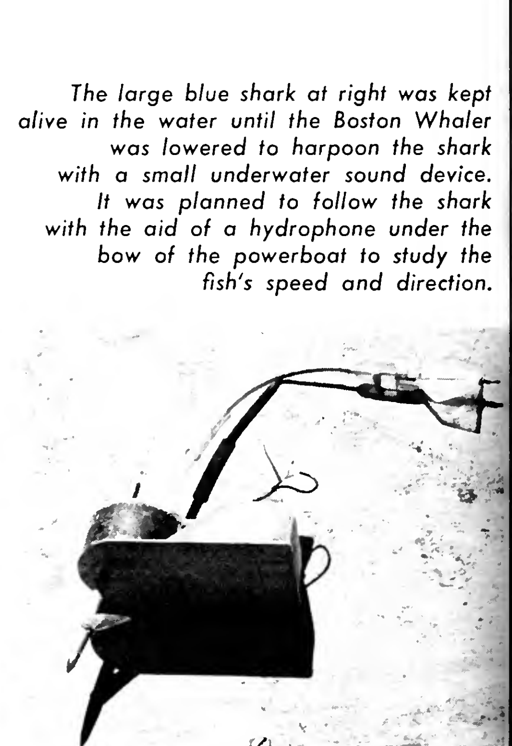
Although most fish do not have eyelids, sharks can close their eyes, probably to protect them when attacking another animal that fights back.

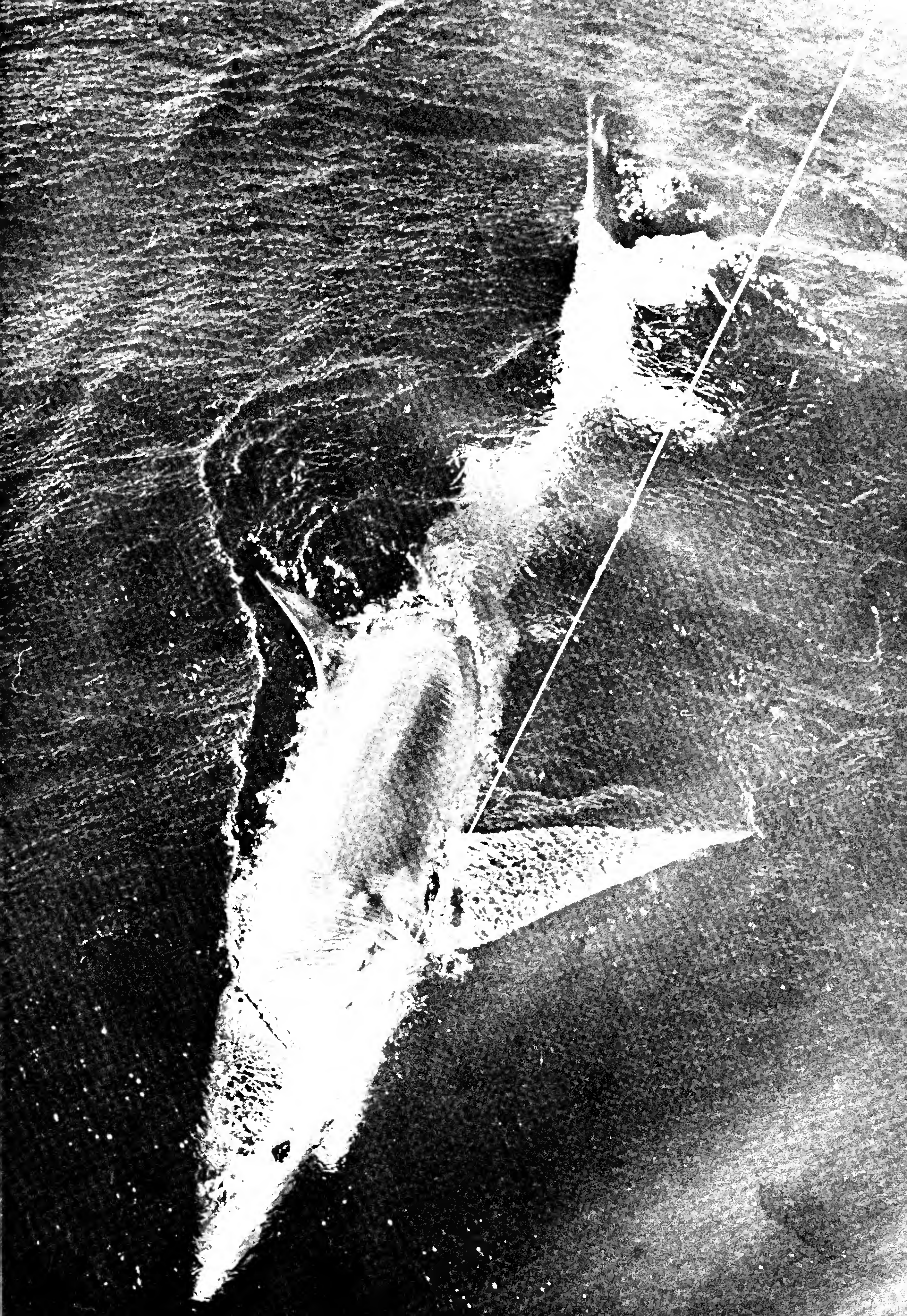


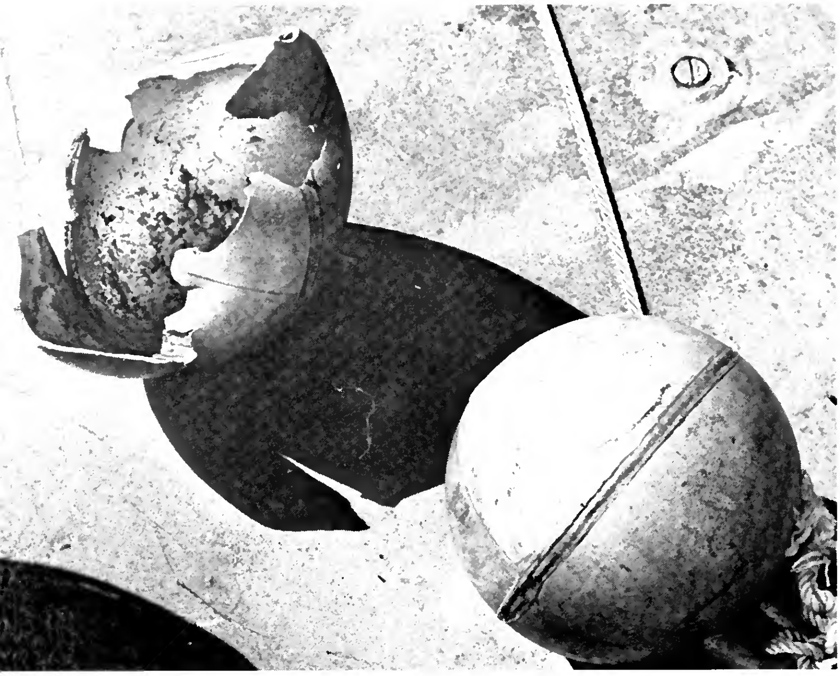
The beak and tentacles of a squid found in a shark's stomach. One of the long tentacles is missing.

The large blue shark at right was kept alive in the water until the Boston Whaler was lowered to harpoon the shark with a small underwater sound device. It was planned to follow the shark with the aid of a hydrophone under the bow of the powerboat to study the fish's speed and direction.



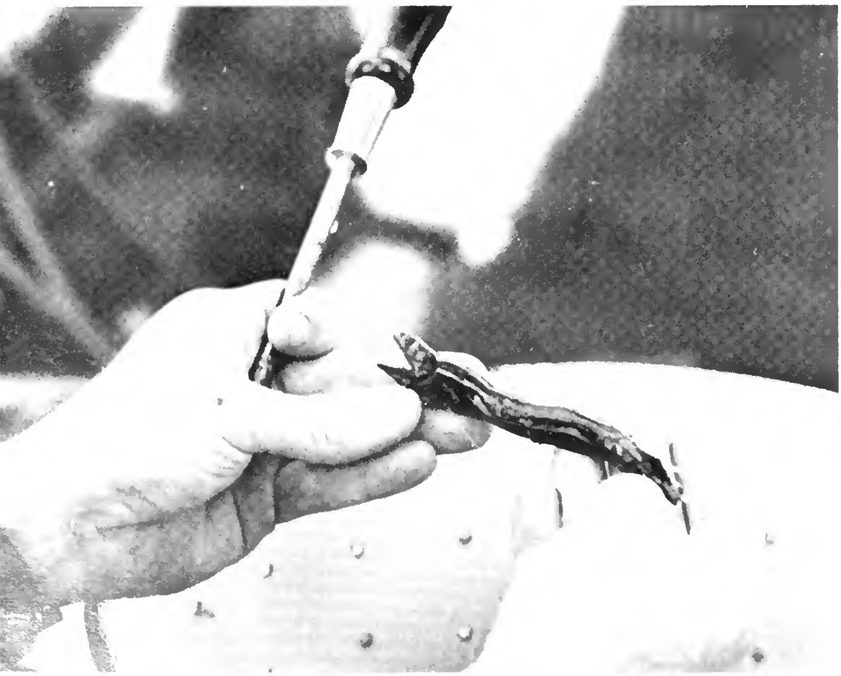




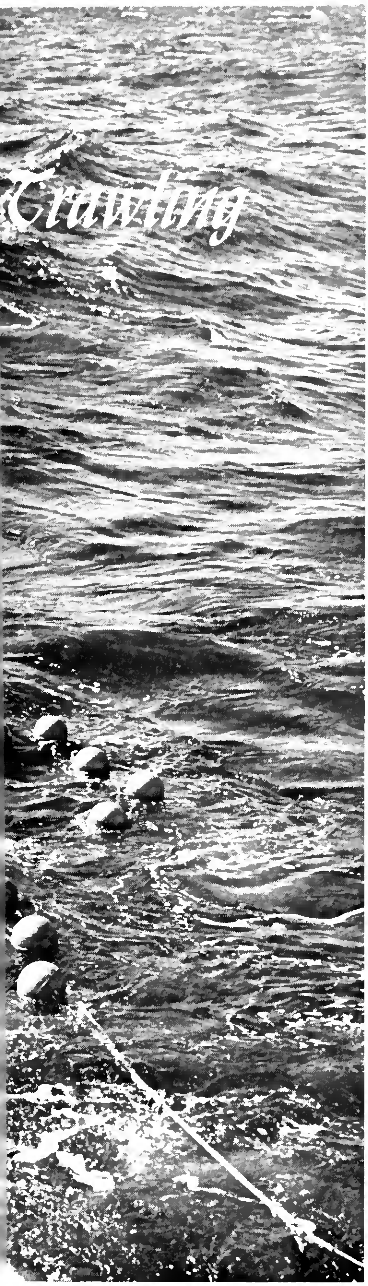


One of the aluminum floats of the midwater trawl imploded during a lowering of the net.

Most midwater fishes are smaller than this specimen. Many are black, have good size teeth and rows of luminescent organs along the body.

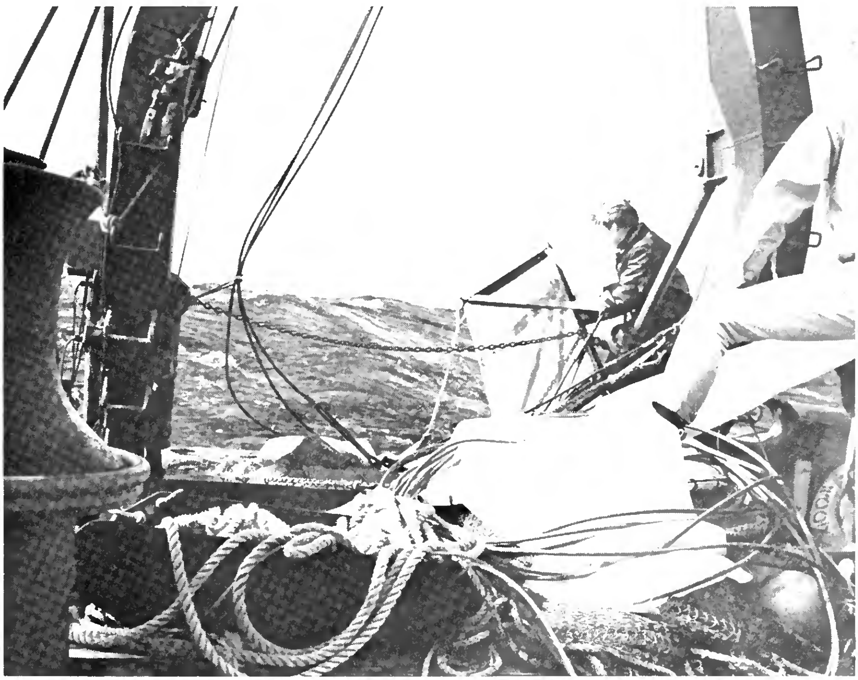


A BIOLOGICAL cruise is exciting and interesting. Although most of the midwater trawls take place during the night there is a chance to do some day-time photography. Above: the Marinovich trawl (see page 3) is being set. When one notices the general confusion on deck at lower right,

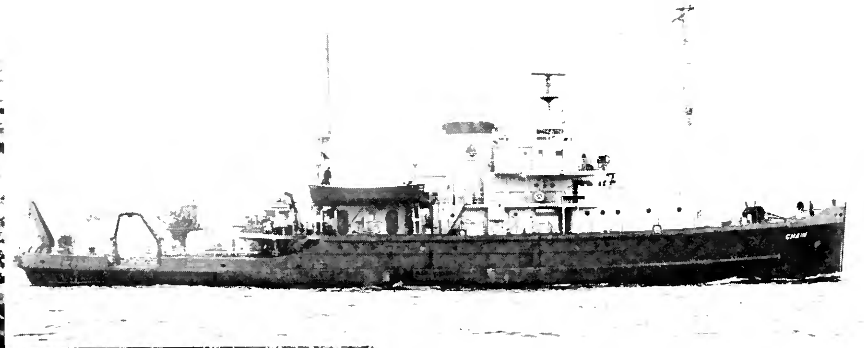


Midwater trawls have a fine mesh which is easily damaged. Captain S. E. Poole kept busy repairing the nets.

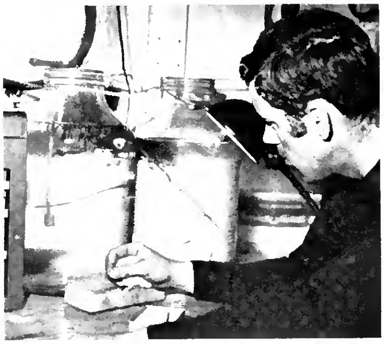
The depressor of the Isaacs-Kidd midwater trawl is seen beyond the many cables, floats and ropes attached to the net.



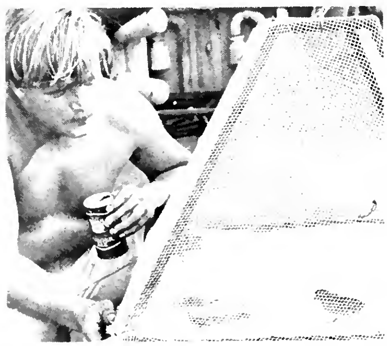
is a surprise that when the net es over the side all the many bles seem to straighten themlves out. This is a tribute to e skill of the biologists. Hower as D. Masch said: "This fishg is delightful business as long you don't have to count on it r a living".



This is the ship—



The salt water aquarium kept everyone interested—



A snowbird came on board and was brought back to land—

Scrimshawing kept many hands busy—

BACK ISSUES

THE editor would like to hear from individuals and from libraries who may have a complete set of Oceanus, as of Volume I, Number 1. Presently we know of some 20 complete sets. Back copies, particularly prior to Volume VII, are in great demand. We shall be glad to pay postage to anyone who has such copies and does not wish to retain them. On the other hand, we stand ready to fill in incomplete sets, as available, since Volume VIII.

Due to the great demand (some 30-40 requests per week) we urge non-library recipients to share their copies. Never-never-never throw one away, please; give it to the local public library, high school or other facility.

PHOTO CREDITS

We have been asked several times recently what was meant by the hen scratches next to many photographs. Those are not hen scratches but rather rooster scratches, since Hahn means rooster. ᛁᚳ stands for the editor's initials.

SURTSEY

"Surtsey, the birth of an island", was a recent television special which attracted wide attention and rave reviews. Readers of "Oceanus", of course, were well acquainted with the volcanic island since it was discussed by Dr. D. C. Blanchard in the June, 1964, and November, 1966, issues.

AQUACULTURE

Since the article in our last issue, a new book has been published. "Farming the Sea", by Alexander McKee. Thomas Y. Crowell Company, New York. $6.95.

RECENT HONORS

Columbus O'Donnell Iselin received an honorary Doctor of Science degree from the University of Rhode Island. This was his second honorary degree in addition to a long list of other honors.

The prestigious Alexander Agassiz Gold Medal of the National Academy of Sciences was awarded to Frederick C. Fuglister for "—your very stimulating and successful observations of the Gulf Stream and its vortices".

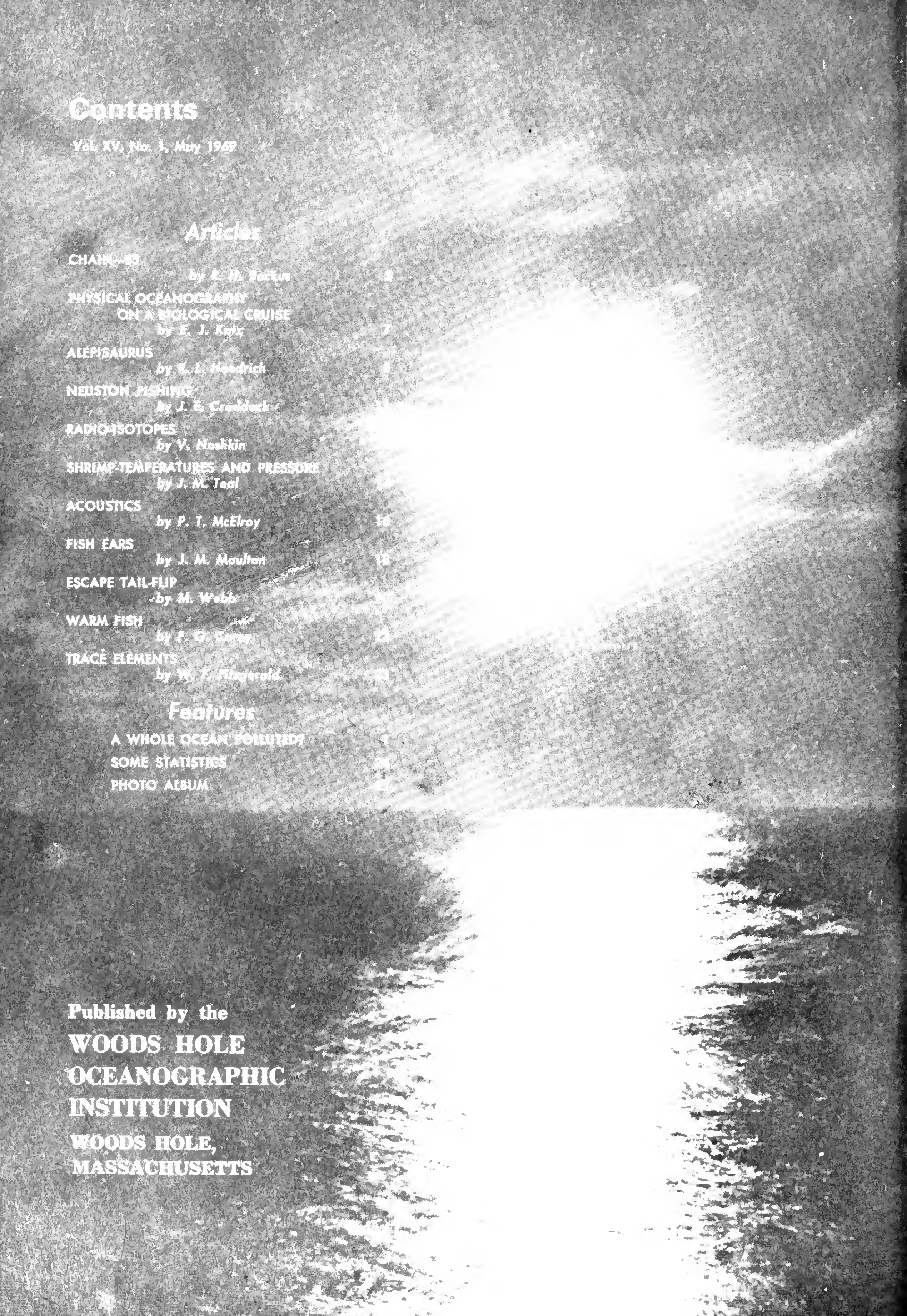
Dr. Kenneth O. Emery became the third recipient of the Francis P. Shepard Award for Excellence in Marine Geology from the Society of Economic Paleontologists and Minerologists.

***

Associates of The Woods Hole Oceanographic Institution

President	TOWNSEND HORNOR
Executive Assistant	L. HOYT WATSON

MEMBERSHIP inquiries are invited. They should be addressed to Mr. L. Hoyt Watson, Woods Hole Oceanographic Institution, Woods Hole, Mass. 02543.



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