VOL. XIV, NO. 3, OCTOBER 1968

OCEANUS

ON THE COVER—

NO, this is not a modern sculpture but an underwater photograph of possible pillow lava coated with manganese oxide. Taken at the base of Rehoboth Seamount by R. M. Pratt, the cover shows part of the landscape on the New England Seamount Chain. (See the article on page 2).

Few people, outside the oceanographic world, have heard of the discovery of this long belt of submarine volcanoes between New England and Bermuda.

Seven out of the 27 seamounts known to-day were named after our research vessels: 'Bear', 'Physalia', 'Mytilus', 'Balanus', 'Asterias' and 'Atlantis II'.

In view of the manyfold bottom features that have been discovered in the last 20 years and the fact that we know many more remain to be discovered, Murray and Hjort made quite an understatement in: "Depths of the Ocean" (1912): "It is not likely that any great changes in the contour lines will be revealed by future soundings, though it is possible that further submarine cones may be discovered".

WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930

Jan Hahn, *Editor*

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OCEANUS™

Vol. XIV, No. 3, October 1968
THE WOODS HOLE OCEANOGRAPHIC INSTITUTION
Woods Hole, Massachusetts

Drugs from the Sea

WHO knew at the end of World War II, that common dirt would hold the key to therapeutic advances which could control many of mankind's greatest scourges? The seas cover more than 70% of the earth's surface. Can't we assume that the seas might hold as much potential for antibiotics as does the land?

The future value of marine sources of medicines is almost entirely unknown; research is just beginning. We know, however, that certain antiviral, antimicrobial and an array of pharmacological effects are to be found in toxins and chemicals recovered from marine plants and animals.

A small step but an important one in this neglected area was the establishment in 1967 of an *ad hoc* committee on Marine Pharmacology and Toxicology by the Marine Sciences Council.

Progress in this area will result only from a greatly augmented effort involving Government and its health research agencies, the pharmaceutical and chemical industries, perhaps offshore mining and petroleum, the universities, and interested investigators.

DR. EDWARD WENK, JR.
Keynote address, first scientific meeting
of the Undersea Medical Society

Herring smoke houses at Monnikendam, North Holland

The New England Seamount Chain ranging from Georges' Bank toward Bermuda is shown on a preliminary bathymetric chart being prepared by the author. His research associate K. E. Prada indicates one of the seaward mounts.

An impressive belt of large conical peaks,
the New England Seamount Chain,
ranges over a distance of about 1000 kilometers
from Georges' Bank toward Bermuda.
Consisting of at least 27 seamounts, most of them were discovered
and investigated since the 1950's.

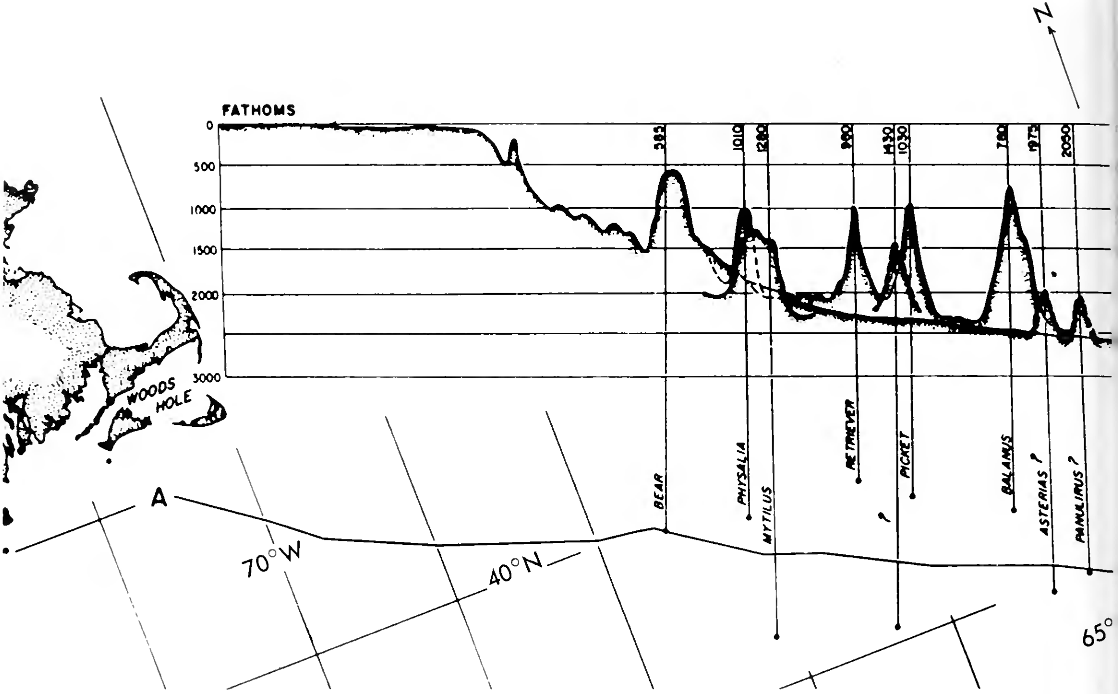
MEDEIROS

"Long lost Mytilus"

Today, island hopping in the Caribbean is a popular tourist pastime. Some forty to sixty million years ago, New Englanders could have island hopped to Bermuda. However, tourism was not popular in those days.

by E. UCHUPI

WHILE standing watch over the echo-sounder recorder many marine scientists have had the experience of seeing the ocean bottom rise sharply, perhaps after hours of watching a monotonous gently rolling or flat topography. The word that a seamount may have been encountered spreads through the ship and people begin to gather around the recorder. Within a few minutes the sea floor may climb hundreds and even thousands of meters. Interest quickens. How high will the seamount rise? Will it have a flat top? Has a seamount been reported from the area, and if so what is the minimum depth that has been recorded? Exclamations such as "don't lose the bottom!" are on everyone's lips. This refers to the vagaries of the recording system; when changing from one scale to another the bottom may be lost temporarily. The bridge is notified to take a fix on the ship's position. Then, as suddenly as the seamount appeared, the crest is reached, the sea-bottom descends to abyssal depths, and the man on watch finds himself alone again. Not, however, without a feeling of elation, akin to that of the old explorers when they discovered new mountains.



The New England Seamount Chain on a projected profile. Since this diagram was made by R. M. Pratt, several other seamounts have been discovered, one near the Kelvin Banks,

These seamounts or submarine volcanoes are probably among the most interesting features present on the ocean floor. They occur singly or in groups aligned along some structural weakness on the oceanic crust, their peaks are hundreds to several tens of meters below the sea surface, and some even rise above the surface to form volcanic islands, Bermuda, for instance. The seamounts may have single or multiple peaks, which sometimes are flat (such seamounts are known as guyots or tablemounts) and sometimes irregular. Bare rock is often exposed at the top or is covered by several meters of unconsolidated sediment. The crest often serves as a foundation for coral reefs and atolls hundreds of meters thick such as those found in the Pacific or Caribbean. The seamounts surveyed to date appear to have been dormant for some time, but earthquakes and cable breaks suggest that in the vicinity of the Azores some of them may be active. Several of the submarine volcanoes that rise above sea level have had dramatic histories. Krakatoa, near Indonesia, for example, after the discharge of a tremendous volume of volcanic debris collapsed to form a giant caldera. The volcanic ash ejected by Krakatoa was carried by winds around the world and tsunamis caused by the collapse of the volcanic cone swamped many of the neighboring islands causing much destruction and many deaths. Santorin in the eastern Mediterranean Sea is believed to have had a similar history.* This island may have been the site of the lost continent of *Atlantis*. Some other submarine volcanoes reach suddenly above the sea surface, as did Surtsey, off Iceland.**

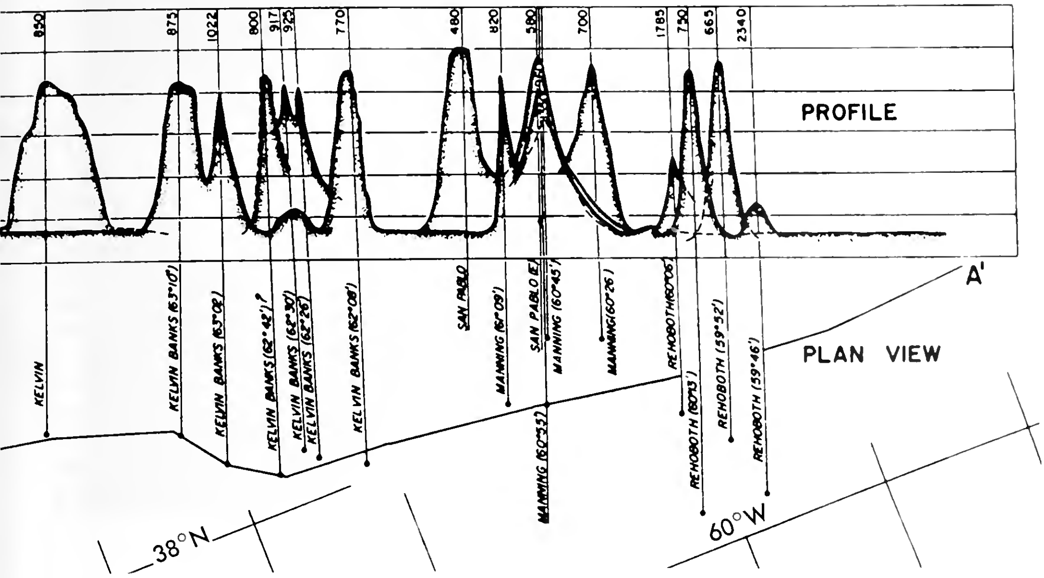
Most seamounts, however, do not appear to have had such spectacular histories. Yet each one is of particular interest to the geologist as it may help him to unravel the history of the oceanic basin in which it occurs.

New England Chain

A group of these mountains which may hold the key to the history of the North American Basin is the New England Seamount Chain, also known as the Kelvin Seamounts. Many peaks south of Georges' Bank were named by J. Zeigler for research vessels operated at one time or another by our Institution with the exception of Panulirus Seamount which he named after the vessel formerly operated by the Bermuda Biological Station for Research.

*See: J. W. Mavor, Jr., "A Mighty Bronze Age Volcanic Explosion", Oceanus, Vol. XII, No. 3, April, 1968.

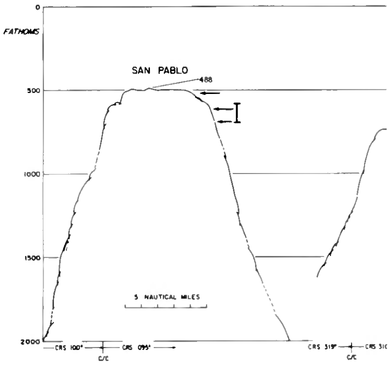
**See: D. C. Blanchard, "A New Volcanic Island", Vol. X, No. 4, June, 1964.



and several south of Rehoboth Seamount. The mounts are located along the base line A-A'. The profile has been turned to the left (note North) to fit this page.

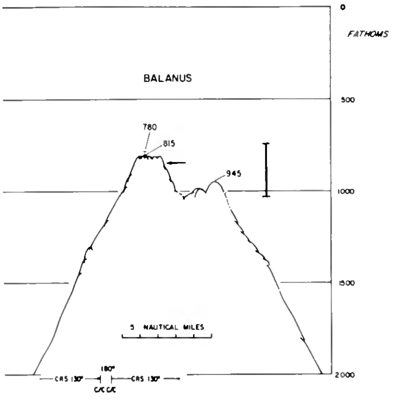
The New England Seamount Chain is a belt of at least 27 seamounts extending from the continental slope south of Georges' Bank to the northern edge of the Bermuda Rise, a distance of about 1000 km. Most of the peaks were charted since the early 1950's. The last one, 'Sheldrake' was found in the 1960's. It has been suggested that the seamounts, located in an arc approximately 110-170 km wide, are aligned along a fracture zone transecting the continental margin and oceanic basin. Kelvin Fault is the name generally given to this structure. Movement along this fault apparently has displaced the continental slope south of New York, a distance of about 90 km.

Most of the New England seamounts rise abruptly above the sea floor from depths of 1600 meters to as much as 4000 meters. The crests of the seamounts range from 893 meters below the sea surface on San Pablo Seamount to nearly 2000 meters on the vicinity of the Bermuda Rise. Some of the seamounts have single peaks, others have multiple peaks, but none appear to have flat-tops. Surrounding the base of some of the seamounts is a shallow depression 20 to 80 meters deep and one to four km wide. Some geologists believe that these depressions are due to the weight of the submarine volcano which



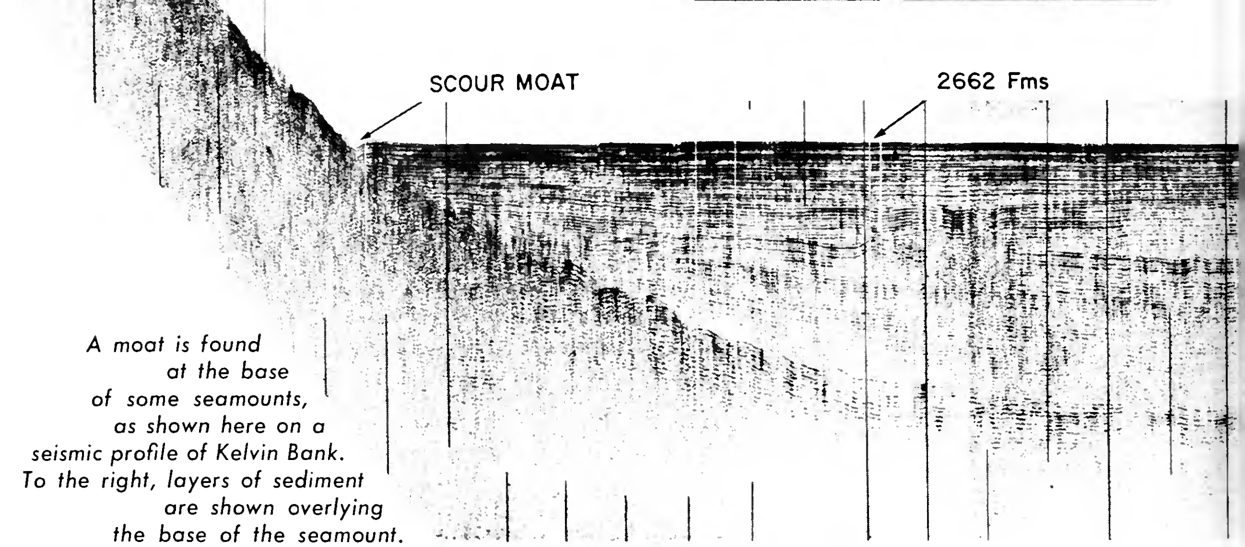
PRATT

Some of the seamounts have single peaks, others have multiple peaks, as shown on these echo-sounding traces. Arrows refer to dredge hauls. I *is a camera observation.*



PRATT

A bottom photograph taken on San Pablo seamount shows rock ledges with sand and gravel in the crevices.



A moat is found at the base of some seamounts, as shown here on a seismic profile of Kelvin Bank. To the right, layers of sediment are shown overlying the base of the seamount.

caused the sea floor along the base of the peak to sink. Others have suggested that the depressions are due to erosion by bottom currents.

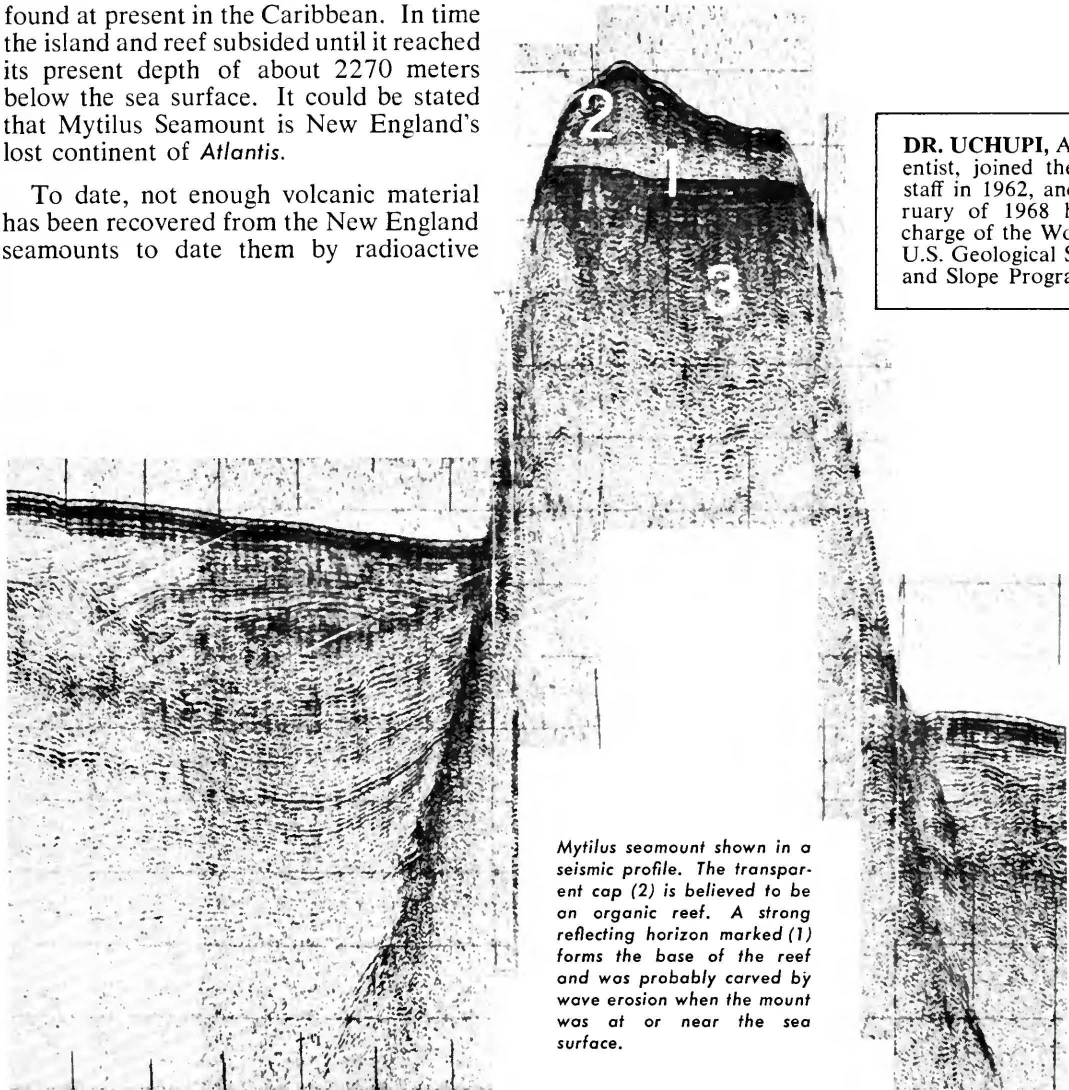
Sediments mantling the New England seamounts include boulders and cobbles, sand-size fragments of deepwater corals, globigerina ooze, and red clay along their bases. Much of the sandy material forms small waves or ripples which probably have formed when currents moved the grains along the bottom. The larger boulders are coated with manganese oxide, and bare rock is frequently encountered along the upper slope of the seamounts. Igneous and metamorphic boulders transported to their present site by icebergs 15,000 to 1,000,000 years ago are commonly dredged from the seamounts immediately south of Georges' Bank.

Mytilus mount

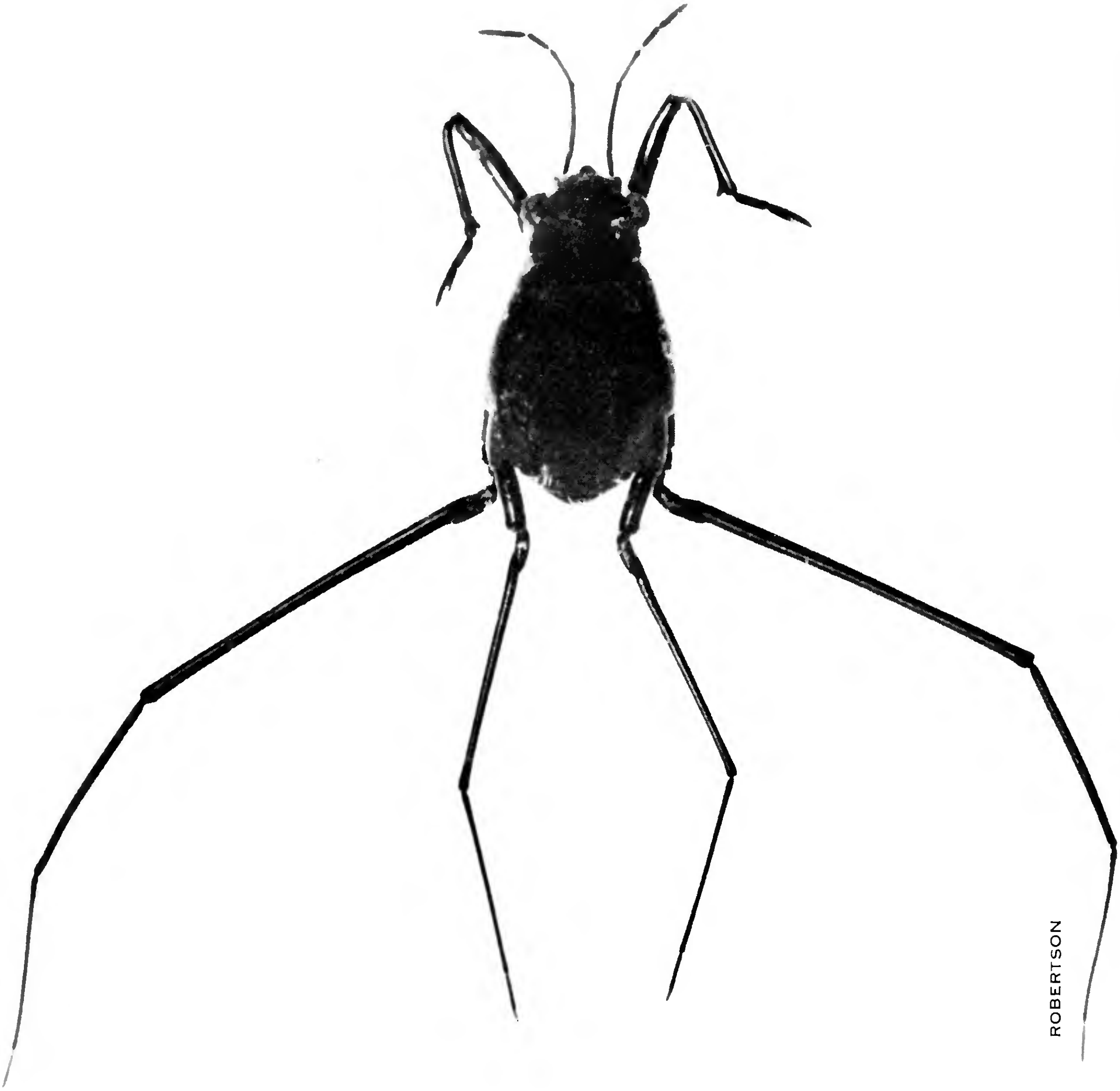
During July-September, 1967, and April-May, 1968, a geophysical survey was made of most of the New England seamounts aboard the R/V 'Chain' with the aid of the 100,000 joule sparker and a ten cubic inch air gun. The electric sparks and the air gun provide seismic records showing the structure of the sediments over one km beneath the bottom. The records reveal the relationship between the seamounts and surrounding sea floor and make it possible to reconstruct the geologic history of the seamounts. Most of the continuous seismic profiles show that the seamounts consist of some hard reflecting material which is probably basalt covered by less than thirty meters of sediment. Mytilus Seamount is the only exception to this rule. This volcanic cone is truncated by a strong internal reflecting horizon. This internal reflector probably represents an erosional surface formed by wave action indicating that in the past Mytilus probably was near the sea surface. No such evidence was seen on any of the other New England seamounts. Above this erosional surface is a poorly stratified conically shaped mound. Calcareous algae of Eocene age (40 to 60 million years old) were dredged from this seamount by Zeigler indicating that this mount is an organic reef which could only have been formed near the surface of the sea. When the reef was growing, parts of the seamount possibly extended above the sea level to form an island similar to those found at present in the Caribbean. In time the island and reef subsided until it reached its present depth of about 2270 meters below the sea surface. It could be stated that Mytilus Seamount is New England's lost continent of *Atlantis*.

To date, not enough volcanic material has been recovered from the New England seamounts to date them by radioactive methods. However, data from the seismic profiles makes it possible to assign some tentative ages to the submarine volcanoes. None of the sediments surrounding the volcanic cones show any evidence that they were intruded by the seamounts, that is, the volcanoes were already there when the sediments were deposited. From cores collected by the Lamont Geological Observatory from the North American Basin we believe that the strata surrounding the New England Seamounts are Cretaceous and younger. This would suggest that the New England seamounts are likely to be pre-Cretaceous in age, probably Jurassic (135-180 million years old) or possibly Triassic (180 to 225 million years old). The New England seamounts are inactive at present, but who can deny the possibility that they may become active volcanoes again. History is filled with too many disasters when man has taken nature for granted.

DR. UCHUPI, Associate Scientist, joined the Institution staff in 1962, and since February of 1968 has been in charge of the Woods Hole—U.S. Geological Survey Shelf and Slope Program.



Mytilus seamount shown in a seismic profile. The transparent cap (2) is believed to be an organic reef. A strong reflecting horizon marked (1) forms the base of the reef and was probably carved by wave erosion when the mount was at or near the sea surface.



ROBERTSON

Adult stage of the open ocean insect Halobates, taken on the equator at about 19° West. The long legs are used to push or row the insect over the sea surface.

Ocean Insects

by R. S. SCHELTEMA

*INSECTS are generally thought as being totally absent on the open ocean. Ships' portholes are screened only when in port. A few days after leaving for the open sea, the few remaining flies are extinguished and only under rare conditions are insects encountered at sea.**

There is one often neglected exception —a group of water striders—known technically as *Halobates.* These extraordinary creatures are marine forms belonging to the "true bugs" or *Hemiptera.* Although some of the species of these water striders live near the coast, others exist throughout their entire life on the surface of the open ocean, mostly in the tropics, but also in warm temperate regions. The water striders are adapted to their life. They have lost their wings and move rapidly on their elongated legs over the water surface, frequently congregating in large numbers.

Although the genus and the first three species were described by Eschscholz during Kotzebue's circumnavigation in the brig 'Rurik' (1815-1816), relatively little is known of the natural history or geographical distribution of these interesting insects. They are seldom captured in the conventional nets used by biologists, and found but rarely in plankton nets, the favorite means for making biological collections of small invertebrate organisms.

MEDEIROS

The oceanic water striders are quite small; one has to look hard to see them moving quickly across the water. This is possible only when the ship is hove-to. The long legs of the insect show even better than on the enlargement at left.

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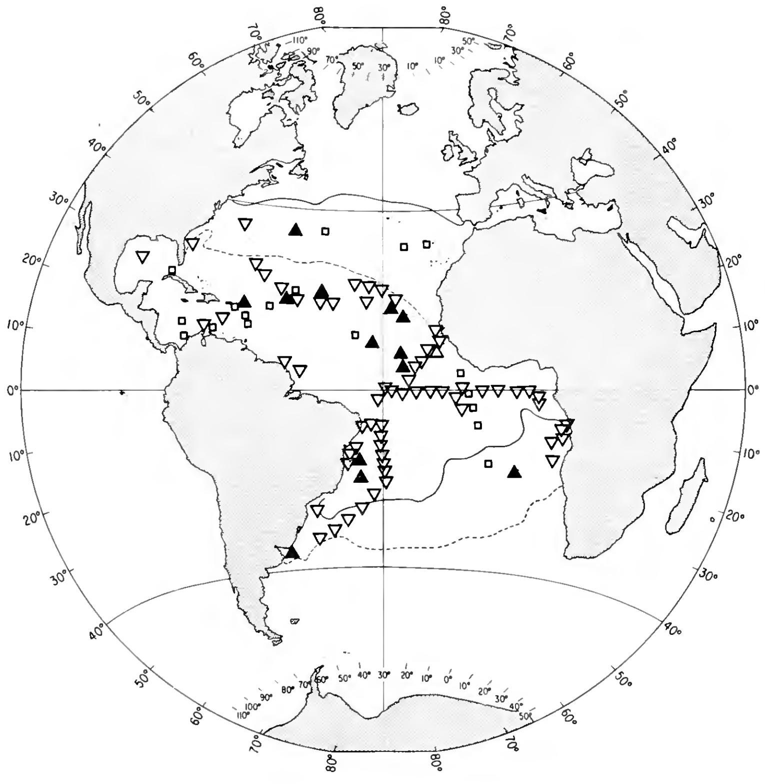
*See: "Bird and Moth Incident", by E. T. Bunce. Oceanus, Vol. XII, No. 3, April 1966.

During the last few years, on several cruises in the tropical and sub-tropical regions of the Atlantic, the opportunity arose to collect the insects by means of a neuston net—a fine meshed net on "water skis" which skims the top few inches of the sea surface.

Hair cover

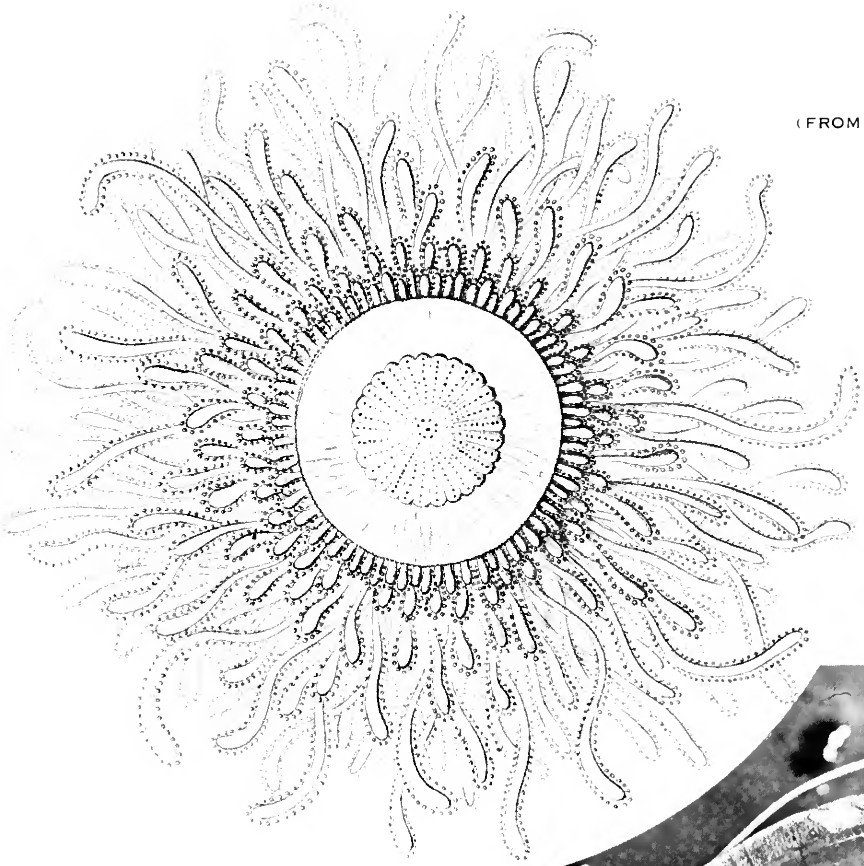
The bodies of *Halobates* are covered with fine hairs which repel water and prevent them from wetting should they be submerged. It is said that the insects sometimes swim under water, particularly during the nymphal stages. As all other insects, *Halobates* have six pairs of "walking" legs. In this instance, the middle pair is modified for rowing or pushing, while the hind legs control the direction of movement. The foremost pair of legs is for grasping. The striders are predatory in habit, feeding on the body fluids of their victims by puncturing them with their piercing and sucking mouth parts. They prey upon a variety of organisms that live on or near the water surface in the open sea; these include jelly fishes, such as *Physalia* (the Portuguese Man-of-War) or the smaller and beautifully symmetrical *Porpita*.

The *Halobates* are gregarious, often aggregating in large numbers near floating objects, such as bird feathers and driftwood upon which they lay their eggs. It has been suggested that the absence of driftwood in some ocean areas may limit the insect population.



The distribution of the oceanic water striders in the Atlantic is known from the 'Challenger' Expedition (1873-1876) shown by the dark triangles, the 'Dana' Expeditions (1921-1930) indicated by the squares, and most recently from some 'Atlantis II' voyages (1967-1968) located by the inverted open triangles.

The dashed lines indicate the approximate location of the 21 °C sea surface temperature during February; the solid line shows the same isotherm during August. The captures of Halobates beyond the winter isotherms were made during the summer months.



(FROM THE CHALLENGER REPORTS)

Prey for the water striders include many jellyfishes such as the beautifully symmetrical Porpita and the Portuguese Man-of-War.

In 1888, the first large monograph on these insects, written after the 'Challenger' Expedition, added six species to the five then known from Eschscholz. Today, 39 species of *Halobates* are recognized, six of them named since 1960. The complete development of only one of the 39 species has been studied. The duration of the development from egg through molting stages to adult is about two months. Biological studies of the water striders are difficult, in captivity their rapid motions cause them to strike aquarium walls and they soon die. It is difficult to understand how they survive in the open ocean and withstand the power of gale force waves.

Distribution

All of the 39 known species are widespread in the Pacific and Indian Oceans, but only one of these species is found in the Atlantic Ocean. This is *Halobates micans* Eschsholtz, 1822, which is the only circumtropical species found in the equatorial regions of the three oceans. This strange distribution is true also for two other species, one of which is found only in the Pacific, the other species only in the Indian Ocean.

The biologists, J. L. Herring and A. I. Savilov, who have most recently studied the oceanic water striders in the Pacific, conclude that their geographic distribution must be determined by climate and water masses. This is summarized by the Soviet scientist Savilov when he says that* " . . . the position of the limits of the areas of the various *Halobates* species is determined by the combined influence of factors of the atmospheric as well as of the aquatic environment. The significance of factors of the atmospheric environment such as the humidity and temperature of the air and the intensity and abundance of precipitation is particularly great. The torrential rainfall in the tropical convergence zone [of the Pacific] may operate as a factor causing continual freshening of the surface layer of the water, and as a mechanical factor that limits the penetration of species . . . into the near equatorial areas." (In translation) It is suggested by Herring that the northernmost and southernmost geographic distribution of the species *Halobates micans* may be determined in the Pacific by another competing species, found at the northern and southern boundaries of its occurrence. In the Atlantic where such competition is lacking, *Halobates micans* is able to extend its geographic range further north and south and in this instance the geographic distribution of the species may be the result of surface water temperature conditions. Savilov has concluded that water striders may be used ". . . as biological indicators of the processes of interaction between the ocean and the atmosphere and of the hydrometeorological regime at the water-air interface."

ROBERTSON

Eggs of Halobates laid on the feathers of ocean birds show that the insects lay their eggs on any available surface. When floating objects are scarce the striders occasionally lay eggs on one another. Eggs are laid also on congealed oil pumped from the bilges of ships.

DR. SCHELTEMA is an Associate Scientist on our staff. His principal interest is in the reproduction and development of bottom dwelling organisms.

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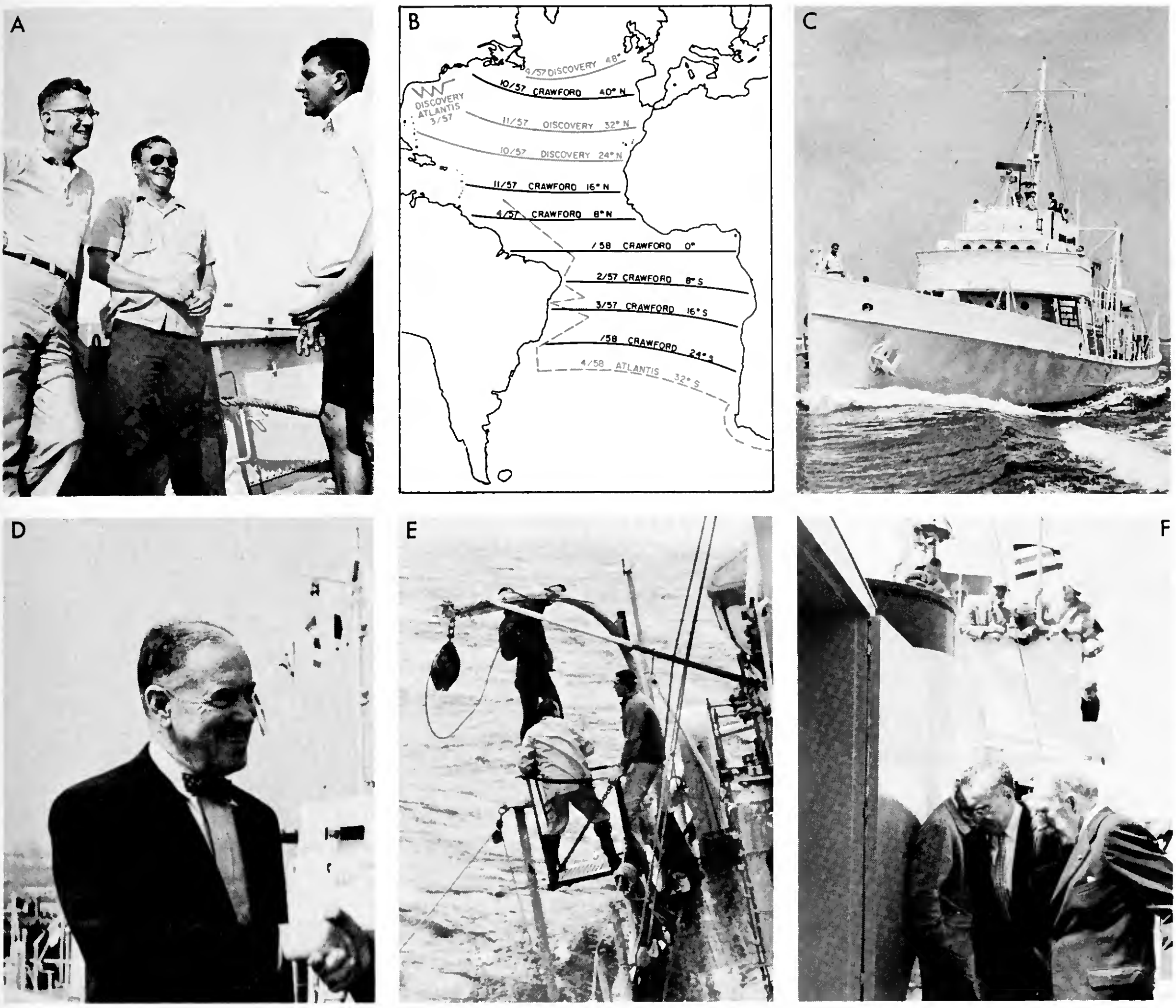
*A. I. Savilov. "Oceanic insects of the genus Halobates *(Hemiptera gerridae)* in the Pacific Ocean". Okeanology, Vol. 7, p. 325. 1967.



A. The success of the 'Crawford's' cruises was in no little way due to the three officers who stayed on board since she was acquired. From left: Chief Engineer C. Backus, 1st mate J. Q. Bumer and Captain D. F. Casiles. B. The 'Crawford' made seven out of the eleven sections during the International Geophysical Year. D. The late Admiral E. H. Smith, then our director, was responsible for the acquisition of the ship. F. The late Senator T. F. Green of Rhode Island dedicated the 'Crawford' on Associates' Day, June 30, 1956.

R.V. 'Crawford' laid-up

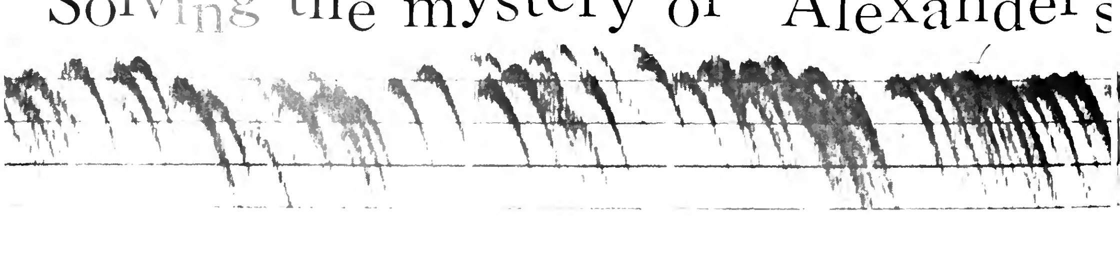
THE brave little research vessel 'Crawford' (Captain D. F. Casiles) will be laid-up in October due to the general budget cut in federal grants this year.

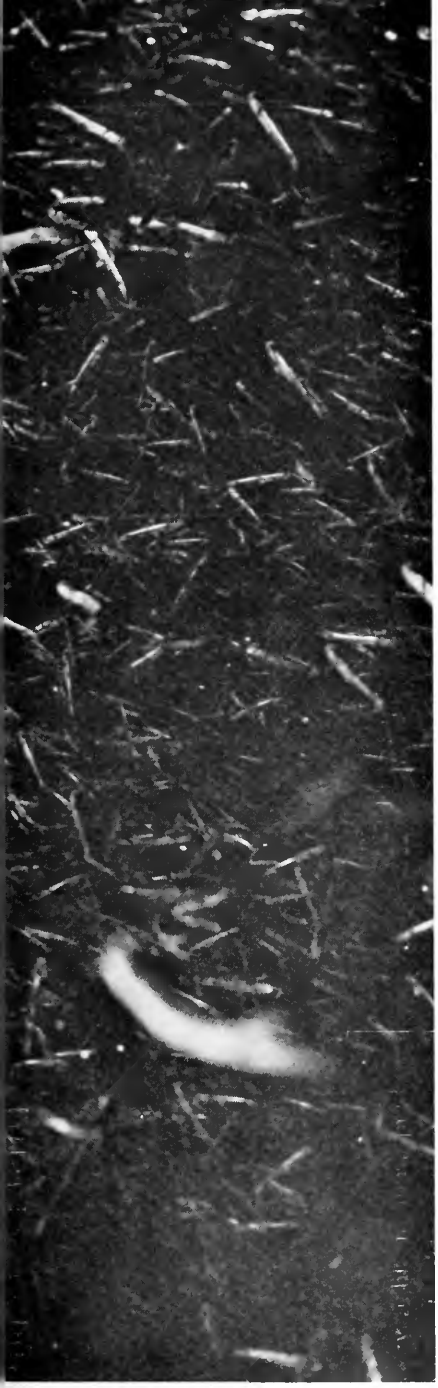
The 125 foot vessel has done a magnificent job since she was converted from a U.S. Coast Guard Cutter in June 1956. She made seven out of the eleven transatlantic sections during the International Geophysical Year. Some 2600 hydrographic stations were occupied and over 17,000 Bathythermograph observations made. Her last cruise, No. 174 in her career, was a Gulf Steam eddy study led by Mr. F. C. Fuglister who has made many such studies on the 'Crawford' even in the worst of our North Atlantic winters.

Well done, 'Crawford'!

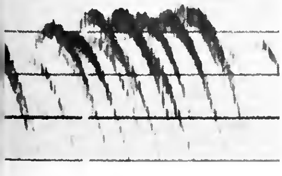
Numerous myctophids, or lantern fishes, photographed from the DSRV 'Alvin' were found to be responsible for a mysterious sound scattering layer named "Alexander's Acres". Each of the beautiful little black and silver fishes with rows of luminescent organs is about 65 millimeters long. They were identified as: Ceratoscopelus maderensis.

Solving the mystery of "Alexander's





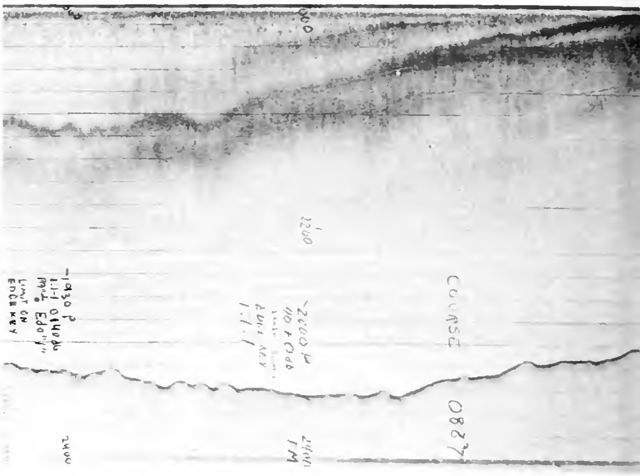
Acres”



by R. H. BACKUS

I REMEMBER seeing the peculiar midwater sound-scattering feature that we later called “Alexander’s Acres” first around the end of July in 1955. The ‘Atlantis’ was hove to and drifting in about 2000 fathoms in the Slope Water south of Woods Hole. When the loud echoes began to show up on the echo-sounder record, we could not believe that they were real. Modern echo-sounder systems for oceanographic research were in the early stages of development then, and we thought that surely something was wrong with the gear. However, when the ship got underway and some adjustments were made to the sounding equipment, the now-familiar pattern of echoes revealed itself. Instead of appearing as a diffuse, even band of faint echoes as in ordinary deep scattering layers, this pattern was composed of a layer of dark haystack-like echo sequences. The pattern suggested that widely separated schools of animals were responsible for the sound-scattering, not single animals uniformly distributed throughout the water as must be the case in ordinary scattering layers.

Sometimes we saw only little patches of "Alexander's Acres"; sometimes it was continuous for miles and miles.



Like ordinary scattering layers, shown here, the special layer of "Alexander's Acres" moved up to near the surface at night—

As our echo-sounder systems became better and better and as we spent more and more time at sea, we began to run into "Alexander's Acres" fairly frequently. Curiously enough, we never saw the layer outside the Slope Water, that part of the Atlantic between the continental shelf edge and the Gulf Stream from Cape Hatteras to the tail of the Grand Banks. We never knew where in the Slope Water the special layer might appear. Sometimes we saw only little patches of it; sometimes it was continuous for miles and miles. Like ordinary deep scattering layers, it moved up to near the surface at night from its day-time depth of 150 to 200 fathoms.* As with all such tracings on the echo-sounder record, we asked ourselves, "What causes it?" The answer was a dozen years in coming.

Echoes named

By 1957, we had seen enough of "Alexander's Acres" and had talked about it enough to need a name for the feature. Alexander was Sidney Alexander, skipper of the U.S. Coast Guard Cutter 'Yamacraw', a fine ship that the geophysics group at the Institution used in 1957 and 1958. The name was born in the careless, accidental way that such names are, from some pungent remarks that the then Lieutenant Alexander made as he walked through the ship's laboratory one day when the strange scattering layer was appearing on the echo-sounder record.

Between 1959 and 1961, we made several attempts to photograph the animal that caused "Alexander's Acres". We lowered a combined echo-sounder-camera to layer depth and hoped that the drifting ship would carry this gear into one of the groups of sound-scatterers.** The echo-sounding camera was so designed that echoes returning from sound-scatterers immediately in front of the camera would trigger the camera. This scheme never paid off. There seemed to be just too much water between sound-scattering groups, so that scatterers and apparatus never met.

In the spring of 1961, we learned some new things about "Alexander's Acres", which brought us a trifle closer to the identity of the animal responsible. On May 15, as the 'Chain' entered the Slope Water on the long trip home from the Romanche Trench in the equatorial Atlantic, we ran into the peculiar layer. Following some work that had been originated at the Institution by Dr. J. B. Hersey, we made sound-scattering observations of "Alexander's Acres" during its evening climb towards the sea surface, using explosives as sound sources.† Now, an echo-sounder operates at a single sound frequency, but an explosion is rich in sound frequencies all the way from low ones to high ones. When our tape-recordings were

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*See: "Sound in marine research", by J. B. Hersey. Oceanus, II, 1, autumn 1954. "Sound Reflections in and under Oceanus", by J. B. Hersey, Vol. XII, No. 2, Jan. 1966.

**See: "New instruments", by J. Hahn. Oceanus, III, 2, winter 1955. "Oceanus goes to the bottom of the sea", by J. Hahn. Vol. V, Nos. 1 and 2, Winter 1956.

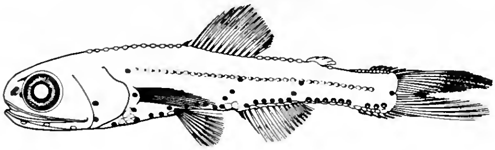
†See: "Sound scattering", by R. H. Backus. Oceanus, Vol. VIII, No. 1, September 1961.

brought home and analyzed, they showed some telling things about the sound-scattering properties of "Alexander's Acres". Late in the afternoon "Alexander's Acres" scattered sound best at about 12 kilocycles per second. This helped to explain the loudness of the signals to our echo-sounders, which operate at a frequency of 12 kcps. This accidental match assured dark traces of these scatterers on the echo-sounder record. As the sun went down and the layer moved up towards the surface, it scattered sound best at lower and lower frequencies. By the time the layer had reached 15 or 20 fathoms, about as shallow as we could follow it, the frequency at which it scattered sound best had fallen to about 3 kcps. The relationship between changing layer depth and changing frequency of best sound-scattering showed that the effective scatterers were bubbles of gas. Now we knew that "Alexander's Acres" was caused by some bubble-bearing animal, very likely a species of fish having a gas-filled swimbladder.

When it became clear that deep-diving submarines for oceanographic research were not only feasible, but would soon become a reality, I often imagined how we would use one to solve the mystery of "Alexander's Acres". Guided by the echo-sounder of a surface ship, we would dive to the depth of the layer. Then, using the submarine's echo-ranging sonar (which it was supposed any research submarine would have), we would "look" around ourselves until we located one of the sound-scattering groups. Then, we would go towards it, and when we got to it we would look out the submarine's observation ports, and that would be that. Too simple? No, that is exactly what happened when we got our first chance with the DSRV 'Alvin' early in October 1967.

Since the October dives were to be the first that my colleagues and I had made, we had no elaborate plan. We simply wanted to go down and look with our eyes at the midwater environment through which for so many years we had pulled nets and looked at with echo-sounders. The 'Alvin's' diving schedule permitted no lengthy search for "Alexander's Acres". The diving site chosen was simply the nearest one to Woods Hole that would put us in a truly oceanic environment — just over the edge of the continental shelf in about 900 fathoms. This Slope Water site also filled the bill for the geologists and biolo-

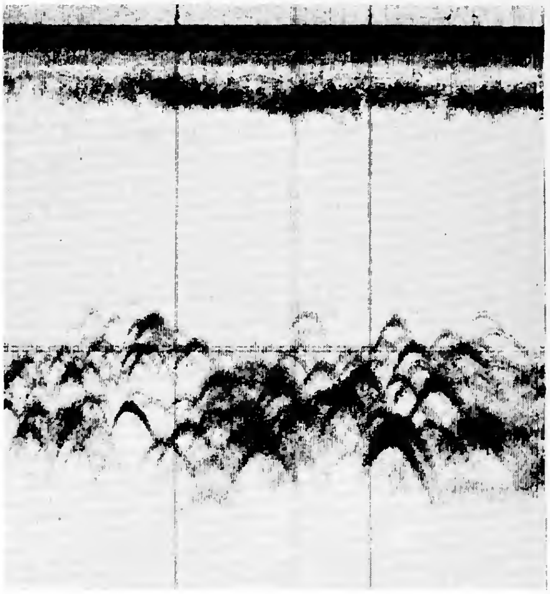
The U.S.C.G.C. 'Yamacraw', here shown in the Mediterranean Sea, was used by the Institution's geophysics group in 1957 and 1958.



gists who were to work with the 'Alvin' just before us. Thus, it came about that the submarine and its catamaran tender operated for several weeks in the place in which we would later dive. Part way through this period "Alexander's Acres" showed up on the tender's echo-sounder records. This was an exciting development, and we hoped, of course that the peculiar layer would still be on the scene when it came our turn to go down.

Range zero

This proved to be the case. "Alexander's Acres" is not distinguishable from other sound-scatterers when it is up near the surface at night, but when we turned on the echo-sounder on the tender shortly after sunrise on October 2, the day of our first dive, there the layer was, beginning its morning descent into the depths. After the complicated readying procedure had been gone through and the 'Alvin' had been launched, two of us and Pilot M. McCamis slowly descended to near the bottom of the layer at about 300 fathoms. At 300 fathoms we put the 'Alvin's' horizontally-looking sonar into operation and scanned the water around us. The sonarscope showed a number of bright spots, sound-scattering groups of some kind, and we chose a good big one about 200 yards away. Dousing our outside lights and guided by the sonar, we made for the target. There was no sound but the whispering of the sonar. When it told us "range zero", we flicked on the outside lights and looked out the viewing ports. The submarine lay in the middle of a fantastic fish school. Thousands and thousands of little fish swam around us. They were all of a kind and all about 60 to 65 millimeters long. We recognized them as one of the species of lanternfishes, a widely distributed oceanic family containing 200 or so very-much-alike kinds. There were 10 to 15 individuals for every cubic meter of water, and now they were beginning to swim down and away from the submarine. McCamis drove the submarine back and forth through the school and managed to capture several gallons of specimens in a crude net that we had rigged on the 'Alvin's' bow. After watching the lanternfish for a few minutes,



Alexander's Acres showed up on the echo-sounder recorder of the 'Alvin's' tender on the morning of our first dive.

Captured by the Alvin', the myctophids proved to be all of one species: Ceratoscopelus maderensis, drawn about true scale on top of this page.

"The Sonarscope showed a number of bright spots, sound scattering groups of some kind and we chose a good big one, about 200 yards away."

my companion, J. Craddock, decided the species was the one called *Ceratoscopelus maderensis* and so it proved to be when, after returning to the sea surface, we examined the captured specimens.

During eight dives on this and the next three days, we repeated the simple procedure about 25 times—choosing a target on the 'Alvin's' sonar scope, closing the target with the lights off, putting on the lights at "range zero", and looking out the window. The result was always the same—a school of *Ceratoscopelus.* The fish were not arranged as menhaden or herring arrange themselves in their schools. There was no lining up of individuals and moving about as one. Rather, the fish in the schools were headed every which way and reacted to us individually, gradually moving down and away from the lighted submarine. Until disturbed by us, they seemed to hang motionless in the water. No feeding or spawning activity was observed. The fish simply seemed to be at rest. The schools appeared to be disc-shaped, 20 to 100 or more meters across, but much less from top to bottom. The average distance between schools seemed to be between 100 and 200 meters.

Surprised

We were surprised by the identity of the fish in "Alexander's Acres". Since this sound-scattering feature is known only from the Slope Water, we expected the responsible animal to be one with a restricted geographic range and more or less unique ecological requirements. Not only is *Ceratoscopelus maderensis* found all over the northern North Atlantic, but it is only one species of a family containing dozens of species that are both morphologically and ecologically similar. Why are deep scattering layers of the "Alexander's Acres" type not seen over all the deep North Atlantic and over all the world's deep ocean? Answer one question and you get yourself another.

DR. BACKUS is a marine biologist and a Senior Scientist on our staff. He is interested in deep scattering layers and other problems in which underwater acoustics and marine biology overlap and also in the patterns of geographic distribution of midwater fishes and what determines these patterns.

Beautiful Sight!

Few people know what it is like to go down in a deep submersible. The following excerpts of a tape recording made by Dr. Backus during a dive with the 'Alvin' give a feeling of "being there". The omissions in the text indicate garbled recording. (j.h.)

Now we propose to go from 750 m. where we've been up to 550 m. and then do some horizontal cruising there. Now *Chauliodus* hanging head down at 45° right next to the submarine. Beautiful sight! He was perfectly immobile in the water, he seemed oblivious of all our disturbance, he drifted up to within two feet of the submarine probably, head down at 45° about 15-16 inches long. Beautiful sight! There's a large *Stomias* a foot or 15″ long horizontal in the water just below the submarine, ... the right port I can see his barbel hanging down at a 45° angle.

A great crown

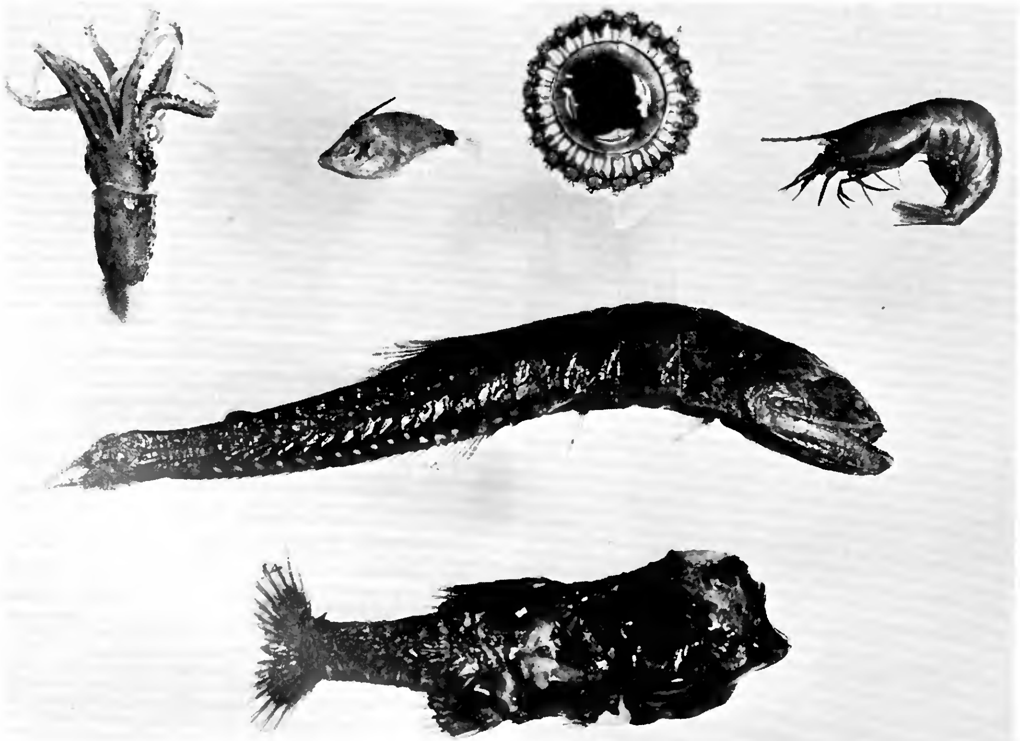
There's really a significant amount of these fishes around. This is quite a layer of myctophids. The depth now is 390 m. I tried for a number of shots with the Edgerton camera of these fellows. Now, here comes a myctophid drifting right up in front of the T-bar, no, he's not really drifting up, he's making slow swimming motions down. There goes a . . . . . . ctenophore. Some of these myctophids seem to be going slowly down with us. Oh, a magnificent jellyfish, a magnificent jellyfish, like a great crown with long red tentacles hanging down. The barrel is up, the oral surface up, the tentacles streaming down back over the aboral surface. A few of the myctophids are making slow, swimming motions and sort of turn to the dive of the submarine, some of them. We're still hearing sperm whales quite clearly over the UQC.

Now a fair number of red-ball shrimp in the water, lot of particulate matter lots of miscellaneous looking things. Now a siphonophore, swimming right by the T-bar, hope to take its picture. Silvery fish swimming head down off the end of the T-bar might be a gonostomatid, or maybe a myctophid. I tried to take its picture. Depth 651 m. Another of the same fish off the end of the T-bar, I tried to take its picture. Oh my soul and body what's that? One of those animated paint brushes, whatever they are. Long, feathery looking object. Now I see a snipe eel swimming slowly down in the water about 2½ cycles of swimming motions in the body length. Now three or four jellyfishes, ... at various distances . . . . myctophids hanging horizontally in the water. Another snipe eel swimming slowly head down, perfectly vertical in the water. I wish one of the snipe eels would get close enough to the end of the T-bar to have its picture taken. Depth is 628 meters now and we're going to hover here, there are a fair number of snipe eels around and we're going to go snipe eel hunting.

Vertical swimming

Okay still ahead Bill, I think I see another snipe eel. Now there seems to be a *Benthodesmus* 5° right please. There seems to be a *Benthodesmus* hanging head up or down in the water. Just up a little if you can Bill, up a little if you can. Easy left, now, if you can, easy left, about 5° left. About 5° left, the depth is fine. No I had us overshoot a little bit. No, I had you come up too high, he's sinking down in the water. He's below us now. Up until now I was conning Bill Rainnie from the window here but my instructions are clumsy and second-hand, even if they were any good, so what we're going to do now is look for one of these fishes hanging vertically in the water, a *Benthodesmus* or a snipe eel, or anything of particular interest like that and I'm going to give Bill the window and Bill is going to steer us up to the thing and when the thing is just off the end of the T-bar, Bill is going to tell me and I'm going to punch the Edgerton camera button. We're cruising along now looking for, okay Bill. I'm looking out the right window now.

Most of these are snipe eels, but some of them will be trichiurids, *Benthodesmus*, or *Diplospinus*. One of the questions is exactly what are they doing when they are vertical in the water? What part of their body do they move and when they move away from us, how do they do it? Depth now is 535 m.



Whenever a trawl is brought on deck of a research vessel people crowd around to look at the animal life brought up from the depths. No matter how interesting this is, how much more interesting must it be to be able to look at the animals in their own environment!

Sea Spray and Whitecaps

by E. C. MONAHAN

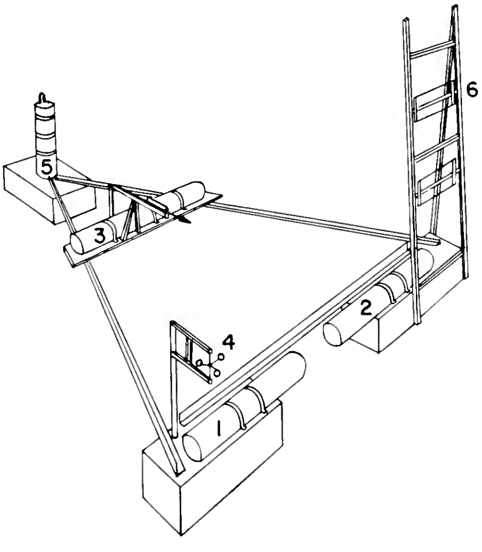
Spray droplets play an important role in the interaction between the ocean and the atmosphere.

BREAKING waves on the open sea trap air beneath the water surface in the form of numerous bubbles, which range in size from less than a hundredth of a centimeter up to several centimeters. I have spent most of the past six years, much of this time at Woods Hole, looking at whitecaps and at the sea spray that comes from the disruption of the bubbles which make up the whitecaps. My original purpose in studying sea spray was to determine the role played by sea spray in coupling the air to the sea, or specifically to find out the contribution made by spray droplets to the downward transport of the momentum of the air. This study had been suggested to me by Dr. E. Kraus when I visited the Institution in 1962.

A few hours in the library showed that an answer could not be obtained by using the available data. Investigators such as A. H. Woodcock and D. C. Blanchard* had concerned themselves primarily with the numerous small spray droplets, in their studies of salt particles which seem to play an important, if not essential, part in rain formation and in atmospheric electricity. For my purpose, I would have to observe and study the sparse but massive larger spray particles, those with diameters greater than one-tenth of a millimeter.

Odd raft

In May, 1963, I went to Woods Hole for what turned out to be a 27 months' stay. During the winter I had assembled equipment in the laboratory of Dr. Edgerton at the M.I.T. which, I hoped, would be able to take flash photographs of the large spray droplets just above the sea surface. It did not take long to find out that the apparatus had to be mounted in such a way that it was reasonably sure to photograph naturally produced spray and not spray caused by the waves hitting against the supports. This resulted in a decidedly odd looking, three cornered raft, rigged with a bridle and a sea anchor which I took along for several months of data gathering off Aruba on the Canadian ship 'Baffin'.



An odd looking raft was designed to photograph sea spray. 1, flash unit. 2, camera. 3, battery power. 4, anemometer. 5, electromechanical wind speed recorder. 6, frame supporting brackets with salt collecting wires.

When I returned from my 1965 cruise on board the U.S.C.G. 'Campbell' in the North Atlantic, several new facts about sea spray had come to light. At wind speeds of 20 knots or less, sea spray does not play a significant role in coupling the air to the sea. (All the spray one encounters in a small boat in a 15 knot wind is due to the interaction of the boat with the sea. If you were not there, the spray would not be there either.) Equally interesting was the fact that the concentration of large spray droplets, some five inches above the sea surface, showed an abrupt increase for wind speeds greater than 17 knots. This was reminiscent of the "critical wind velocities" reported for other air-sea related events, such as wind-driven currents and air convection evidenced by the soaring patterns of seagulls. Unfortunately, the raft with its photographic equipment was not rugged enough for use in winds much over 20 knots, where, so to speak, "the action is".

More bubbles

The last months of 1965, I was teaching at Northern Michigan University, on the south shore of Lake Superior. This large body of fresh water reminded me of an interesting side result of my studies. To investigate the numbers and size of bubbles produced by a breaking wave, I had made a laboratory experiment by spilling a glass of water into a water filled tank. D. Blanchard suggested that the results would be different if I switched from the fresh water I had used to sea water. This was true. A glass of sea water poured into a tank of sea water produced many more bubbles with diameters less than one millimeter than the fresh water. The reader can duplicate this experiment by simply

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*See: Woodcock, A. H. "Bubbles, Saltdust and Raindrops", "Oceanus", Vol. IV, No. 3, Spring, 1956.
Ibid: "Lava and the Sea", "Oceanus", Vol. VI, No. 3, March, 1960.
Blanchard, D. C. "The Fingerprints of a Storm", Vol. IV, No. 3.
Ibid: "Atmospheric Electricity and the Oceans" Vol. VII, No. 4, June, 1961.

FRAZEL

More small bubbles are produced by pouring salt water into salt water than by pouring fresh water into fresh.

DR. MONAHAN is an Assistant Professor of Oceanography at Hobart and William Smith Colleges in Geneva, New York. He received his PhD. from M.I.T. in 1966. He was a summer student Fellow at our Institution in 1963 and '64.

pouring fresh water from one glass to another, then repeating the action after adding some table salt to the water. There will be an increase in number of small bubbles caused by the presence of the dissolved salt. Since whitecaps are rafts of bubbles produced by breaking waves, it is reasonable to suspect that there are more small bubbles in oceanic whitecaps than in lake whitecaps.

More whitecaps

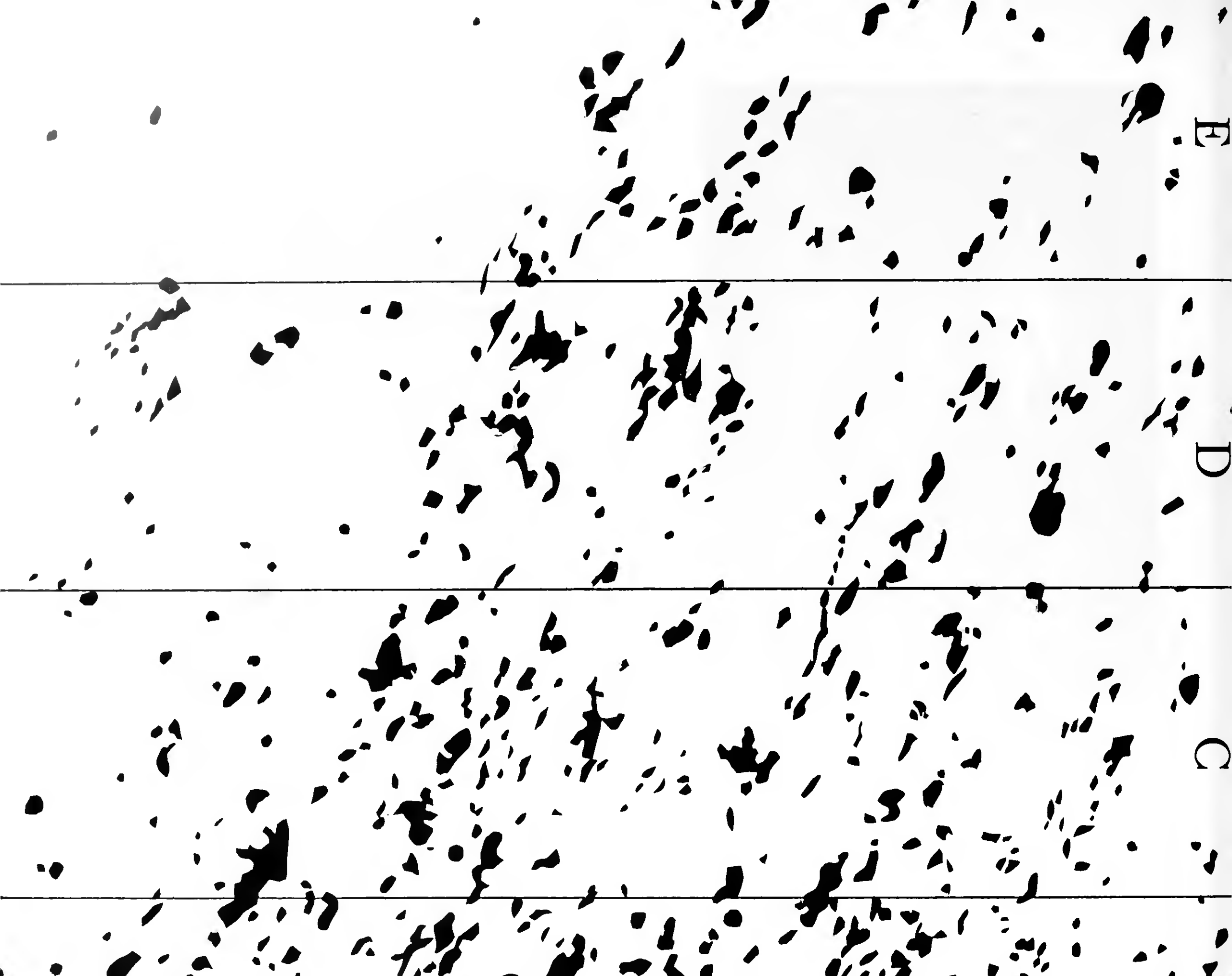
Since the smaller bubbles take longer to reach the surface from the depth where they were formed and appear to live longer once they reach the water surface, we are forced to conclude that whitecaps on the ocean should persist longer than those on a lake. Finally, if we assume that for identical meteorological conditions an equal number of whitecaps are formed per unit area of lake as per unit area of ocean, than we have to conclude that under identical conditions a greater fraction of the sea area should be covered with whitecaps. Is this found in nature?

I also was curious to determine if whitecap coverage increased abruptly with wind speed, as did the spray concentration. Since the spray comes from the whitecaps, it was logical to expect this to happen, but the two published studies which discussed wind and whitecaps disagreed on this point. So, with the support of the Office of Naval Research, I started to study whitecaps on the Great Lakes as well as on the ocean. I took with me to Michigan the first model of a whitecap photosystem. This unit mounted in the rigging of a ship automatically photographs the sea surface alternately to port and starboard. Several features were built in to protect the camera optics from flying spray and the unit was designed to operate in winds well above the 20 knot limit of the spray photographic system.

Observations were made in 1967 and 1968, primarily from 200 meter long iron ore bulk carriers sailing from Duluth or Marquette to Buffalo and other lake ports. Relative wind speeds and directions, as well as air and water temperatures were recorded while the photographs were being taken of the water surface.

Now, after a summer of oceanic whitecap studies, it may be premature to describe the tentative results of the work, but well to review its aims.

The steward of the lake steamer 'Pontiac' related to me one day his observation that for the same wind in the fall there were many more whitecaps on the lakes than in the summer. This is just what one might expect from a consideration of the influence of the seasonal variations in the thermal stability of the air overlying the lake surface. This seasonal effect has been noted before; but unfortunately in these same qualitative terms. It is hoped that the quantitative determination of such a simply measured parameter as whitecap coverage varying with wind speed, atmospheric stability, water temperature, and salinity, will shed new light on the fundamental processes of air/sea interaction and the generation of waves.



MONA

GUESS the percentage of the sea surface covered by whitecaps (shown in black) in each section of this illustration. The graph was produced by cutting out the whitecaps shown on an aerial photograph of the sea surface. Holding the page on its side will make it easier to view each area. The answers are found on the inside back cover.

Associates' News

TOWNSEND HORNOR, a general partner of White, Weld & Company, New York, was made President of the Associates of the Woods Hole Oceanographic Institution at the Annual Meeting held on June 20th in Woods Hole. He succeeded Homer H. Ewing, President since 1961, who was made Honorary Chairman of the Associates. Mr. Hornor has been an Associate since 1958 and is a member of the corporation of the Woods Hole Oceanographic Institution. He is a graduate of Harvard University and served in the U.S. Navy during World War II. He is a director of the Kollmorgen Corporation, the Ealing Corporation, and Simon and Schuster. Mr. Hornor has summered for many years in Osterville on Cape Cod, and is active in the current revival of the classic Cape Cod catboat.

* * *

THE editor is pleased and flattered to announce that we received several dozen congratulatory letters after the publication of the Bigelow issue of Oceanus. Many readers also asked for spare copies of the issue.

* * *

Associates of The Woods Hole Oceanographic Institution

President	TOWNSEND HORNOR
Secretary	JOHN A. GIFFORD
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.

ANSWERS — PAGE 24

The answers to the question on page 24 will surprise many qualified observers.

A = 2.1%. B = 14.2%. C = 8.8%. D = 6.7%. E = 3.9%.

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