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IN the winter and spring of 1949 the R.V. 'Caryn' and the 'Atlantis' were engaged in seismic refraction shooting in the Puerto Rico Trench area, the deepest part of the Atlantic Ocean.

Rolling continually in a heavy swell, life on the ships was far from comfortable while one or the other was hove-to for many hours acting as the listening ship. (see page. 14).

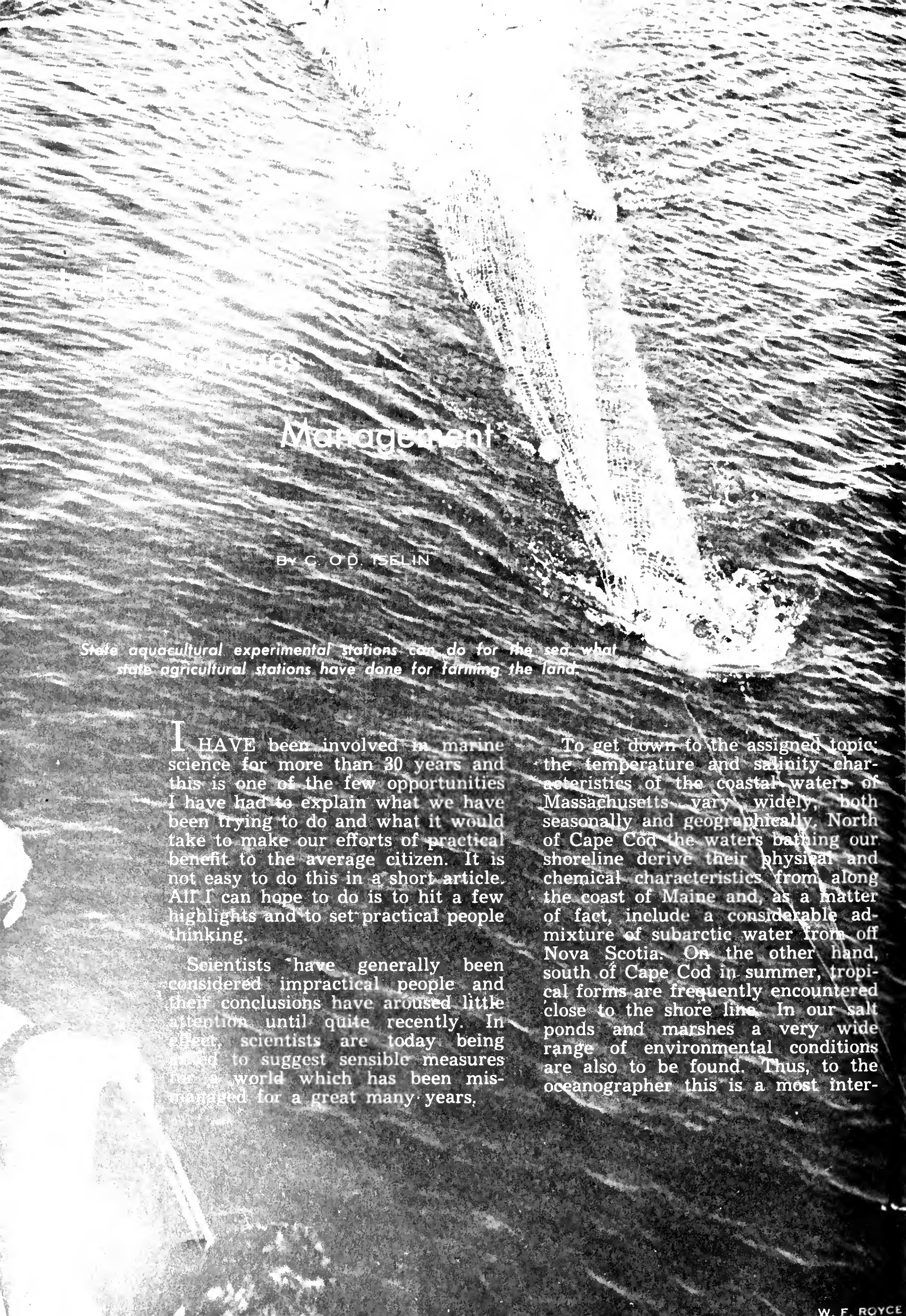
Editorial

VOL. VIII, No. 3, March 1962

FOOD from the sea to feed the expanding world population is mentioned repeatedly in popular articles. Actually, it is not known how much can be taken from the sea. Estimates vary from: "no more than now", to: "at least four or five times more than is being presently taken".

Fishery problems cannot be solved by scientific investigations alone. There are many economical and sociological factors involved. As Mr. Iselin points out in this issue planned fisheries should be backed by the same experimental work that has placed U.S. agriculture on its highly productive level.

The success of wise management of our inshore New England waters, where sufficient scientific knowledge is available, could become a shining example to be followed in other areas in the world where proteins are sorely needed in the diet.



es Management

BY C. O'D. ISELIN

State aquacultural experimental stations can do for the sea what state agricultural stations have done for farming the land.

I HAVE been involved in marine science for more than 30 years and this is one of the few opportunities I have had to explain what we have been trying to do and what it would take to make our efforts of practical benefit to the average citizen. It is not easy to do this in a short article. All I can hope to do is to hit a few highlights and to set practical people thinking.

Scientists have generally been considered impractical people and their conclusions have aroused little attention until quite recently. In effect, scientists are today being asked to suggest sensible measures for a world which has been mismanaged for a great many years.

To get down to the assigned topic: the temperature and salinity characteristics of the coastal waters of Massachusetts vary widely, both seasonally and geographically. North of Cape Cod the waters bathing our shoreline derive their physical and chemical characteristics from along the coast of Maine and, as a matter of fact, include a considerable admixture of subarctic water from off Nova Scotia. On the other hand, south of Cape Cod in summer, tropical forms are frequently encountered close to the shore line. In our salt ponds and marshes a very wide range of environmental conditions are also to be found. Thus, to the oceanographer this is a most inter-

W. F. ROYCE

esting stretch of coastline and it has been studied intensively since the 1880's by many scientists not only from this country and Canada, but also from abroad.

Following the classical monographs of H. B. Bigelow in the early 1930's, advances in our understanding of what is going on in coastal waters were for a while exasperatingly slow. We lacked a general theory to explain the current systems prevailing over the continental shelf where most of the energy is derived from land drainage, rather than from the winds. Techniques for studying offshore currents were not applicable near the coast where tidal currents are so much stronger than in the open sea. We also lacked suitable instrumentation. Perhaps more to the point, we lacked the cooperation of biology in general. Biology has recently been concerned with quite different but perhaps more important problems involving physiology and genetics.

Beginning about 1950, a number of papers started to appear dealing with the mixing processes at work in an estuary. As B. H. Ketchum has since shown, the continental shelf is, in effect, an infinitely wide estuary. A laboratory was established in Chesapeake Bay and another one in Narragansett Bay to deal primarily with shallow water phenomena. More recently radio telemetering buoys, both free floating and moored, have been set out at a number of points along the coast to gain continuous information concerning the movements of our coastal waters. Thus, today the bottleneck is no longer physical oceanography; rather it is now the biology. We have at long last begun to acquire a rather satisfactory picture of the physics and chemistry of the inshore waters. We can even make successful predictions about coastal conditions, but we still lack an adequate understanding of a host of problems that I like to summarize under the general heading of:

"The goings and comings of fish."

The outstanding characteristic of the distribution of most coastal species is that it is either a feast or a famine. There are many causes for this pronounced variability and in a given situation it is usually difficult to put one's finger on the most important cause of a considerable increase or decrease in abundance.

Beginning about 1900 fisheries investigators, especially in Europe, became convinced that man was the primary enemy of fish and that overfishing would become a serious problem. Very few studies have demonstrated this is indeed ever the case. Natural fluctuations, rather than man-made fluctuations predominate. This is, of course, not true of some intensively fished waters close to the shore, for example, a clam bed. However, by and large the biological resources of the ocean are naturally renewable. All that is needed to increase the harvest is good management and **this is what we do not have.**

The old idea of the freedom of the seas is diametrically opposed to their wise utilization. Especially the convention of the three-mile limit makes no sense scientifically. Neither the water nor the animals recognize this most unnatural boundary.

While beyond the three-mile limit, which may soon change to six miles or more, fishermen are likely to remain hunters rather than to become farmers for a good many years to come, there is no good reason why we cannot begin to increase the yield of the inshore waters where convention does give the state some measure of control.

Now what could one expect to accomplish through the wise management of state controlled waters and how would one go about developing these capabilities?

As I have already indicated, in my opinion the bottleneck is not science, especially it is not the sort of science that one can do in a laboratory. Here in Massachusetts we already have an abundance of marine laboratories and, of course, at our universities the earth sciences and the biological sciences are being actively studied. What we lack, in my opinion, is the marine equivalent of an agricultural experiment station. We need to learn how to farm the inshore waters and we could probably gain this knowledge rather quickly, say in 10 years, if suitable facilities were made available and some areas set aside for experimentation.

No hay balers

The advantages of hybrid corn would not have become evident to farmers, if this desirable subspecies existed as a few plants in some botanical laboratory.

What our state agricultural experiment stations have done for farming the land can also come about in the case of the ocean. There is almost no engineering backup to the existing fisheries. Fishing techniques have not changed noticeably in the last 30 years. We have very efficient hay balers, but the equivalent machinery for harvesting quahogs is entirely lacking. A small group of imaginative marine engineers could in my opinion accomplish great increases in the efficiency of our fishing methods and in the general problem of wise management.

This group should be physically located close to an oceanographic laboratory so as to share the scientific library and instrumental facilities. They should also be close to suitable state controlled waters. However, it is essential that they be part of the University of Massachusetts and have close ties to other academic institutions.

DR. ISELIN, in addition to being a well known oceanographer, manages a successful farm on Martha's Vineyard, Mass.

One would unquestionably start operations in a large salt pond, but would also want to make a beginning as to how to manipulate a less confined area of salt water.

In a salt pond it is fairly obvious that what one wants to do is to devise efficient means of regulating the salinity, of adding the limiting nutrient chemicals and of helping the winds stir the waters. The energy requirements are very low compared to the cultivation of a similar area of land. The yield could be as much as three times greater than for the same area of land.

In a less confined area, such as Buzzards Bay, the same considerations exist, but in addition here one would need to devise cheap fencing. More than anything else fencing has made meat and poultry farming on land possible. A marine fence will probably turn out to be an acoustical fence, rather than an electrical fence. For shellfish it may well be a chemical fence. One will not know the answers to these questions until bodies of water are set aside as a marine experimental farm.

I know very well that the concept of management in the fishing industry, either inshore or offshore, is most unpopular. It will not come about overnight or painlessly. My principal point is that we should begin to acquire these capabilities in areas where the state already has some jurisdiction. A rather modest setup would suffice. We have much of the necessary science at hand. What we lack is engineering in the broadest and best sense. We lack the organization that can make marine

This is the text of a speech delivered at the Conference on Marine Resources at the State House in Boston on January 3, 1962.

See also: "Sea and Air Resources", by A. F. Spilhaus, Vol. IV, 2; "Food Productivity of the Ocean", by H. F. Taylor, Vol. IV, 1; "On Fish and Fisheries", by H. B. Bigelow, Vol. IV, 2; "Fish, Fisheries and Environmental Factors", by J. N. Carruthers, ibid; "Clams", by H. J. Turner, Vol. VII, 1.

science practical, including the social and economic aspects of a complex situation that has been allowed to develop in a most illogical manner over the years.

How can the selectmen of towns A, B or C deal wisely with management problems in local waters, if the state does not have a team pointing the correct course to steer?

I also expect to hear a cry of rage from sports fishermen. However, the same measures that would increase the yield of our commercial inshore fisheries would also increase the number of sports fish. The way an amateur fisherman goes about catching a fish is hardly a threat to a well-managed commercial fishery. After all they catch the fish one at a time and no commercial operation could any longer descend to such inefficient tactics.

Conclusions

In closing I would like to emphasize once again my primary conclusions.

1. Marine science in Massachusetts is as good as it is anywhere in the world.

2. We obviously have a sick fishing industry.

3. The technology exists or can rapidly be brought into being to correct this situation, at least in waters under state control.

4. We cannot only hope to provide for wise management of our inshore waters on the basis of existing knowledge, but we can expect very considerable increases of productivity once we begin to practice the marine equivalent of agriculture.

5. There need be no real conflict between the interests of commercial fishermen, sports fishermen or skin divers. They all want the ocean to yield more.

Neither the water nor the fish recognize the convention of the three-mile limit.

6. This could be accomplished through the establishment of the marine equivalent of an agricultural experiment station. Already other states with less versatile environmental situations are doing more than we are.

7. In farming on land, besides fencing, as already mentioned, the critical thing has been to learn how to discourage the weeds and other pests. As fishing is now practiced, we are doing just the reverse. We are diligently, if somewhat inefficiently, picking the "flowers" and deliberately leaving the weeds. The weeds and the flowers all depend on the same supply of basic nutrients. No wonder the fishing industry is not profitable and unable to afford engineering developments.

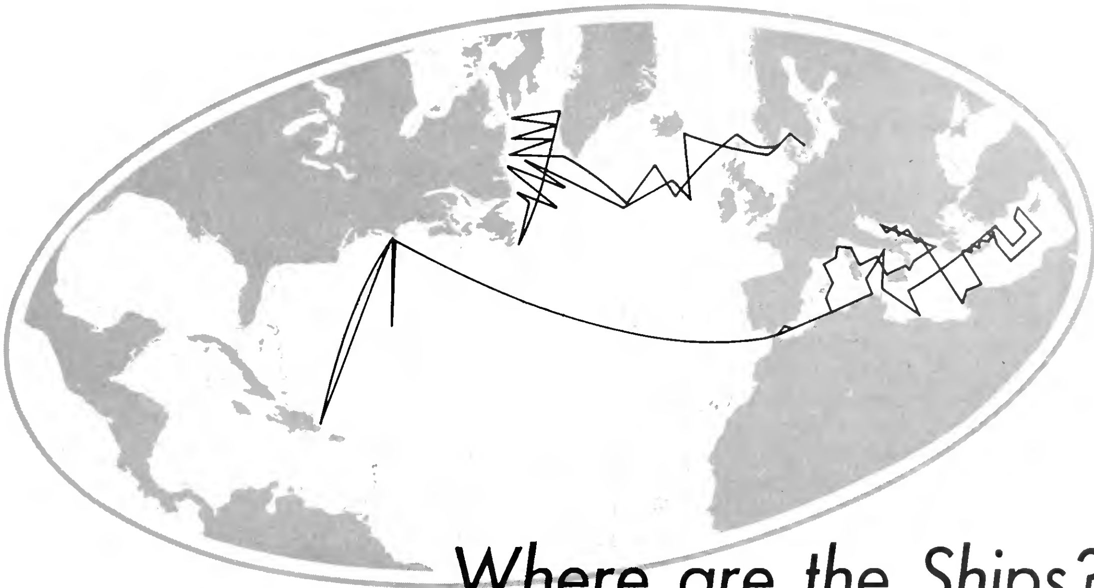
8. Finally, you may well ask, is sensible management practice being applied anywhere to a fishery, and the answer is yes. I can cite examples of a whole national fishery being well managed and being profitable, namely South Africa, both for the fishermen and for the state. I can also cite examples of more limited salt water areas where primitive marine agriculture has begun to appear. These are all in foreign countries, thousands of miles away from here. So, in conclusion, I ask a simple question, why does the Commonwealth of Massachusetts have to remain so backward?

Perhaps we have been waiting for the Federal Government to take the lead. Yet beyond the three-mile limit, where traditionally the Federal Government takes over, the problem is an international problem and much more difficult to deal with from the standpoint of long-established international custom.

Should we not start by learning how to clean up in the technical sense our own backyard? This is something that would require initially perhaps ten people and well-selected facilities. If we choose to develop this area of technology, we will not be in competition with the Bureau of Commercial Fisheries. In fact, we will be helping not only ourselves, but also the people worrying about international waters.

The idea that man must necessarily always "kill the goose that lays the golden egg" should be set aside. We have by chance recently done prettly well in agriculture, although it took a good many years, certainly hundreds of years, after the necessary basic knowledge was available. Is there any real need why we also need to drag our feet in developing the potential resources of the sea?

When one thinks of the sea as a whole, rather than just the first few miles inside an arbitrary extension of our headland, the picture is somewhat rosier. International organizations have recently come into being to make a beginning at the logical technical development of potential marine resources. In international waters such developments will clearly be slow. However, we have a more specialized job to be done in local waters and it is by no means beyond our capabilities. All we lack is leadership and the means of proving that obstacles, long regarded as natural ones, can be overcome.



Where are the Ships?

THE R.V. 'Atlantis' (Capt. A. D. Colburn) is in the Mediterranean Sea continuing to study the formation of deep and bottom waters due to winter cooling which promotes the sinking of high salinity surface water. This sinking may take place particularly in the northern Mediterranean where cold continental air from Europe and Asia is likely to modify the surface waters. A study of past data indicates that subsurface jet streams may exist which may escape observation unless a close network of hydrographic stations is made. The present program consists of standard oceanographic measurements of temperature, salinity and oxygen; together with observations of energy exchanges across the sea surface such as radiation, evaporation, humidity, and other meteorological factors. Direct observations of currents with the use of neutrally buoyant floats and parachute drogues, observations of bottom currents, and possible anchor stations will be made by cooperating vessels. Throughout the cruise a cooperative drift bottle program between Woods Hole and the Service Hydrographique of France will be carried out. The ship will spend approximately two months in the Mediterranean with two main areas of effort in the Adriatic and Ionian Seas and the waters about Crete and Rhodes.

It may be pointed out here that chief scientist A. R. Miller of our staff has done and is doing yeoman's work as a self appointed Ambassador of good will. For many years he has encouraged foreign scientists to take part in his cruises and also entertains and enlightens university professors and others in visiting ports.

At Monaco three French guest scientists and their equipment will come aboard. It is planned to rendezvous with the Yugoslavian research vessel 'Bios' near the Island of Corfu to combine efforts in the study of the Adriatic influence on Mediterranean circulation. A Greek hydrographer has been invited to join the ship's scientific staff while working in Greek waters. Further work is planned in cooperation with the Motor Vessel 'Aragonese' of the NATO Laboratory at La Spezia.

During the present cruise, 'Atlantis' #275, the ship will have touched at Ponta Delgade, Azores; Malaga, Spain; Monte Carlo; Split, Jugoslavia; Irakleion, Greece; Rhodes; Naples, Italy and Algiers. The 'Atlantis' will return to Woods Hole on or about April 27th.

Where are the Ships?

The R.V. 'Chain' (Captain E. H. Hiller) was in dry dock since returning from the Mediterranean in December. (See Oceanus VIII, 2). The ship will depart in early March, with Dr. Wm. S. Richardson as chief scientist, to set anchored buoys in the Gulf Stream and make simultaneous current measurements from the ship. One of the anchor stations (described in Oceanus VIII, 2) will be set out anchored on a wire rope which has a core of conducting cable so that the information obtained by the current meter can be telemetered to Woods Hole or to our airplane from the surface float. It this test is successful it will eventually not be necessary to haul the buoy line periodically.

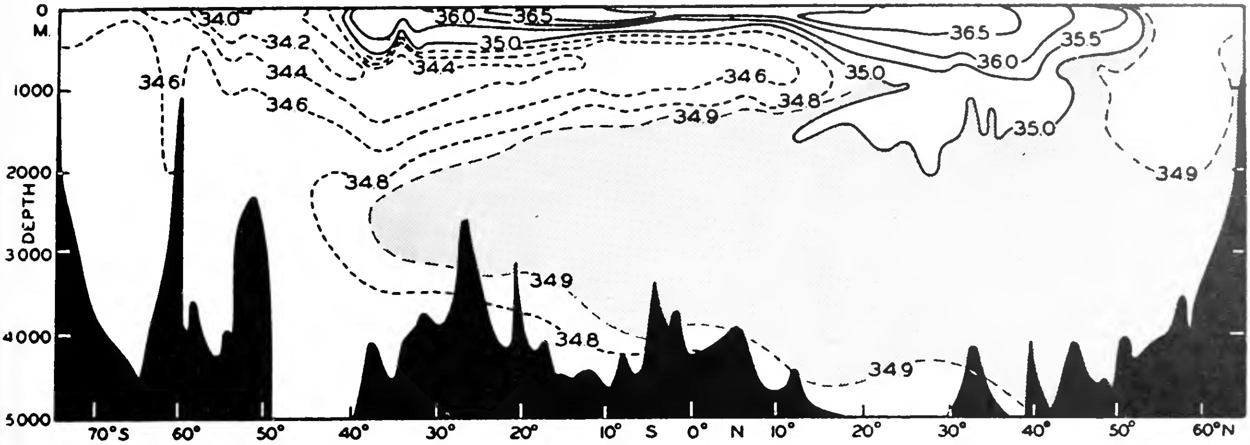
During the same cruise a new biological sampler will be tested as well as a temperature device towed at a depth of 200 meter which records continuously on shipboard. Some sediment cores also will be obtained.

Near the end of March the 'Chain' will depart to make a hydrographic section from Nova Scotia to Barbados in the continuing program to study the chemical and biological properties of the western north Atlantic. Dr. J. H. Ryther and Mr. C. S. Yentsch each will be chief scientist during two phases of the cruise.

The R.V. 'Crawford' (Capt. D. F. Casiles) made one short cruise in January to set radio-telemetering drift buoys. Three other short cruises for biological, physical and geo-chemical purposes were made in February and March. In April the ship will be in the shipyard for her annual overhaul.

Our R 4-D aircraft (Capt. N. Gingrass) made a three week aerial survey in the Caribbean Sea for Dr. John M. Zeigler's geological group. Studies were made of shoaling, wave motion and sediment movement around the Caribbean islands. During the flights the island's coast lines also were photographed extensively.

The Danish Icebreaker 'Erika Dan' has been chartered to investigate circulation during the winter months in northern areas. Painted a bright red for visibility among the ice, the ship is larger and more comfortable than any in our fleet.



About half the total volume of the Atlantic Ocean is made up of a large water mass known as North Atlantic Deep Water (after Wüst)

Is dense water forming during the winter in the northern North Atlantic, thus aiding in "overturning" the ocean? We have chartered a Danish ice-breaker to study an area where our own ships have never been able to go.

How Old is Deep Water?

By L. V. WORTHINGTON

A QUESTION of paramount interest is: How long does it take for the ocean to "turn over"? There is much conflicting evidence on this subject; estimates vary from one hundred to two thousand years.

Deep water is produced by the cooling of surface water at high latitudes in late winter. This cooling increases the density of the surface water to the point at which it is able to sink to the bottom and flow southward, filling the deep basins. In the Indian and Pacific Oceans all the deep and bottom water can be traced to the periphery of the Antarctic continent but in the Atlantic there is a large water mass, known as North Atlantic Deep Water which comprises about half the total volume of the ocean and which is clearly of North Atlantic origin.

Deep Water

The densest surface water in the Atlantic is in the Labrador sea and to date there is little information about late winter conditions in that area. None of the Institution's ships are capable of working the Labrador Sea in the winter time. My own belief is that no important contributions of deep water from this source have been made since the end of the last cold climatic fluctuation known as the "little ice age". This fluctuation lasted from the 16th to the 18th centuries and was followed by an abrupt turn to warmer conditions about the year 1820. During the "little ice age" the glaciers in the north Atlantic area reached their farthest point of advance since the Pleistocene.

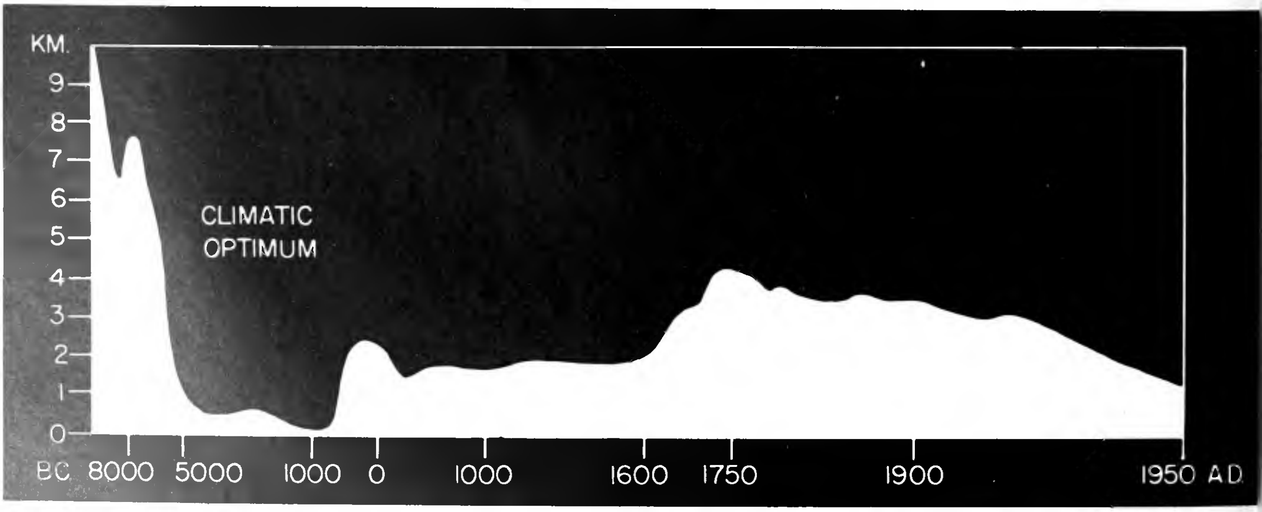
The formation of deep water is quite controversial and it may be that appreciable quantities of this water are produced each winter. In an effort to find out, or more likely, to make a beginning in our understanding, we have arranged with the Office of Naval Research to charter an ice-breaker, the M/S 'Erika Dan' from J. Laritzen, shipowners in Copenhagen, Denmark. The 'Erika Dan' has already been used for oceanographic research on a Belgian cruise to Antarctica.

We hope to accomplish a survey of the Labrador Sea before, during and after extreme winter conditions which should prevail in March. We shall measure temperature, salinity, oxygen and phosphates from the surface to the bottom at about 200 stations. In addition to this hydrographic survey we intend to measure the deep currents off the south coast of Greenland. Recent cruises of the German research vessel 'Anton Dohrn' have indicated that there is a considerable overflow of extremely cold water from the Norwegian Sea between Greenland and Iceland. This water occupies the very bottom layers of the Labrador Basin. We are fortunate in having Dr. J. Swallow of the (British) National Institute of Oceanography with us on the cruise and hope to compare current measurements made with his floats with those made by the Richardson current meter.[1]

1. See: "Swallow floats", Oceanus, Vol. VI, 2, and: "Current measurements from moored buoys", Oceanus, Vol. VIII, 2.

2. See: "Radio-active Isotope Studies", Oceanus, Vol. VIII, 1.

The glacier variations in Norway over the last 12,000 years clearly show the advent of the "little ice-age" in the 1600's and a gradually increasing warmer climate since the early 1800's.

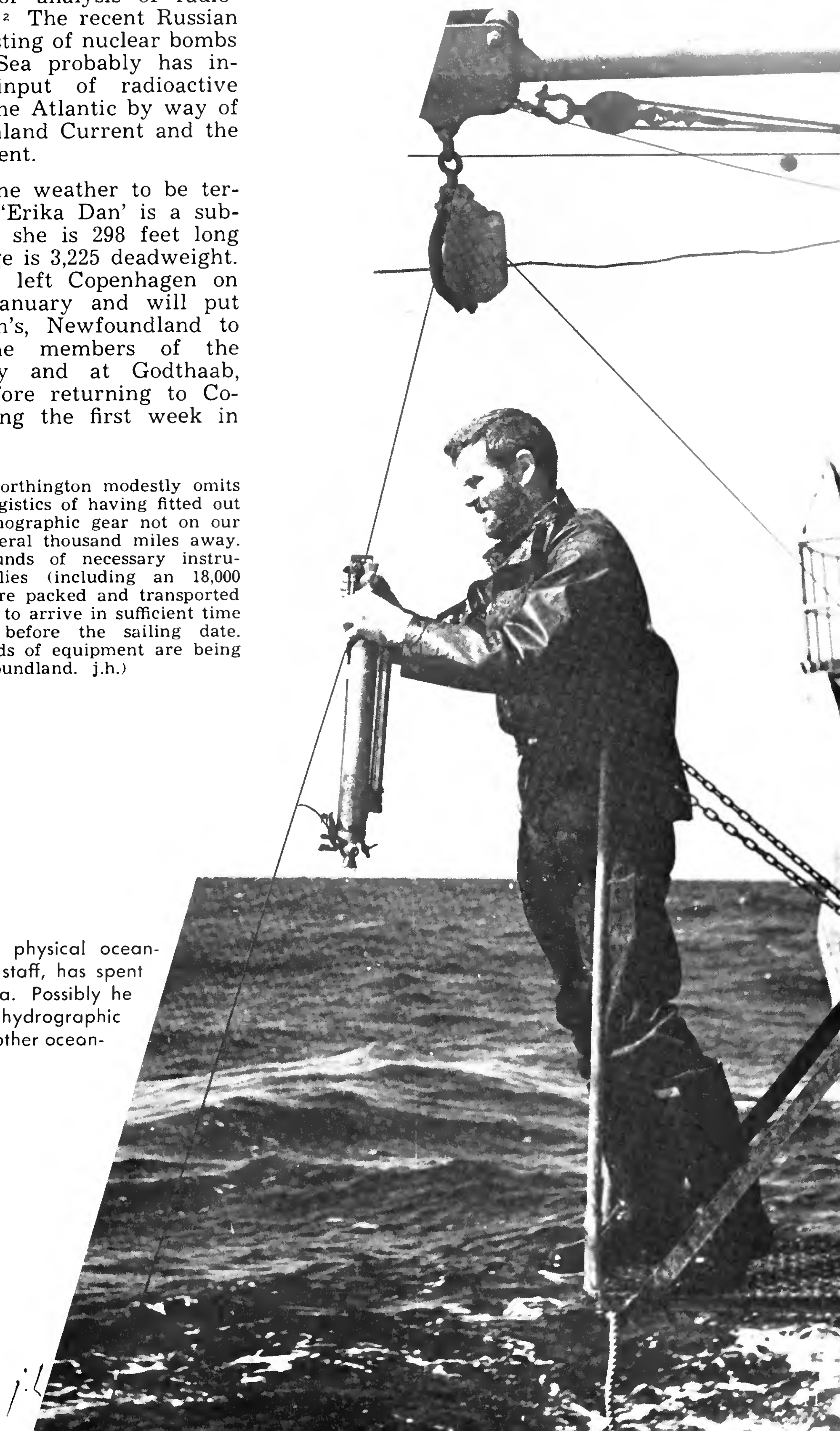


FROM: O. LIESTÖL IN AHLMANN (195

We shall also collect large volume water samples for Dr. V. T. Bowen of our staff for analysis of radioactive isotopes.[2] The recent Russian atmospheric testing of nuclear bombs in the Polar Sea probably has increased the input of radioactive material into the Atlantic by way of the East Greenland Current and the Labrador Current.

We expect the weather to be terrible, but the 'Erika Dan' is a substantial vessel, she is 298 feet long and her tonnage is 3,225 deadweight. We shall have left Copenhagen on the 20th of January and will put in at St. John's, Newfoundland to exchange some members of the scientific party and at Godthaab, Greenland, before returning to Copenhagen during the first week in May.

(Ed. note: Mr. Worthington modestly omits to mention the logistics of having fitted out a ship with oceanographic gear not on our own pier but several thousand miles away. About 35,000 pounds of necessary instruments and supplies (including an 18,000 pound winch) were packed and transported to Denmark so as to arrive in sufficient time to be installed before the sailing date. About 4,000 pounds of equipment are being shipped to Newfoundland. j.h.)



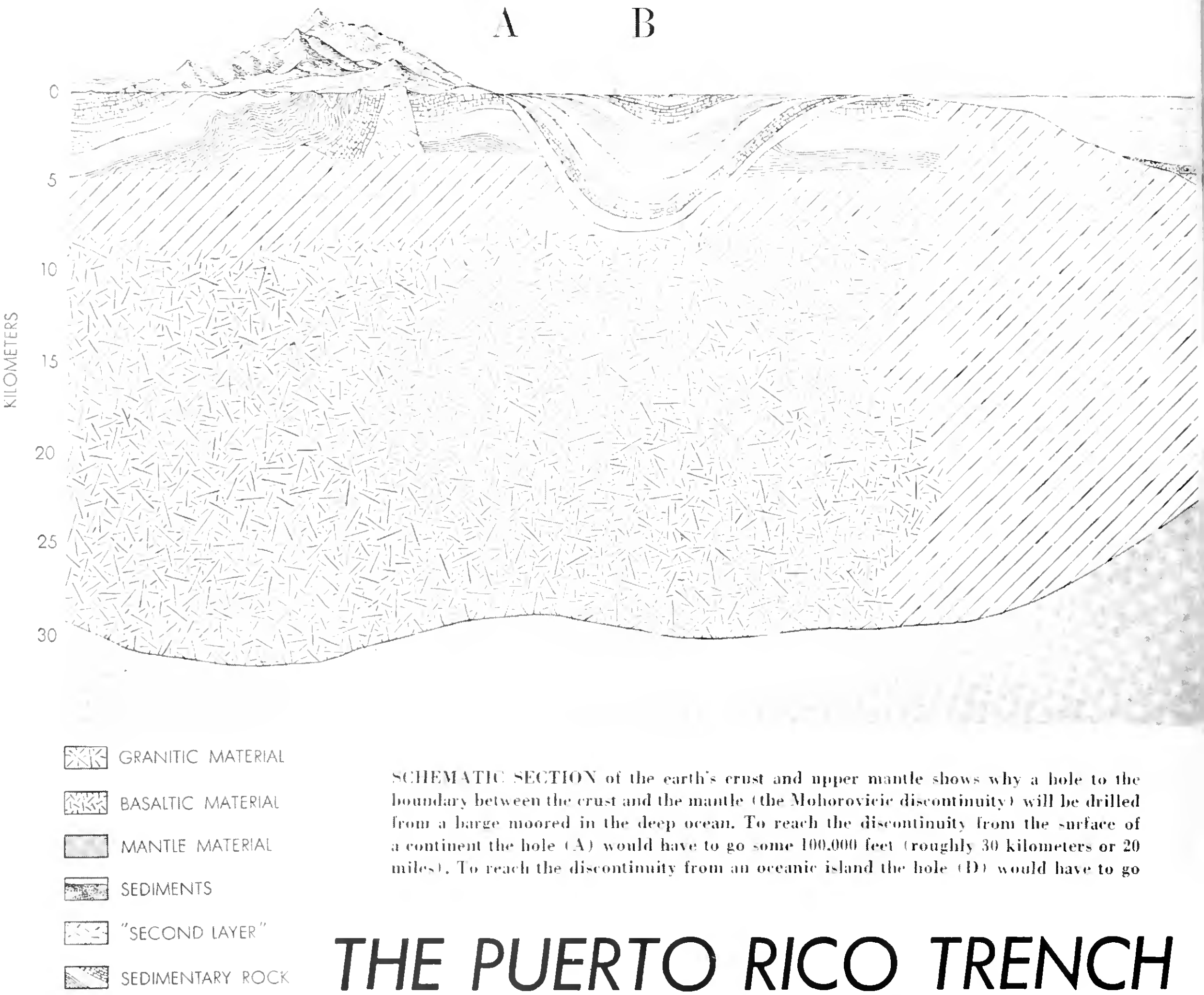
Mr. Worthington, physical oceanographer on our staff, has spent many years at sea. Possibly he has made more hydrographic stations than any other oceanographer.

Giant tree in the middle of the Main Street in Freetown, Sierra Leone. The size of men working at the base of the tree gives some indication of its size. The tree reputedly was already of notable size in the 1400's when the Portuguese landed.

We do get ashore

PRIOR to about 1957 most of our cruises were made in the north-western north Atlantic and in the Caribbean Sea. Bermuda and other "tropical paradises" were frequently visited. Since then during and since the IGY our ships have visited many other ports on both sides of the north and south Atlantic, the Red Sea and the Indian Ocean, whereas some Mediterranean ports have become quite well known.

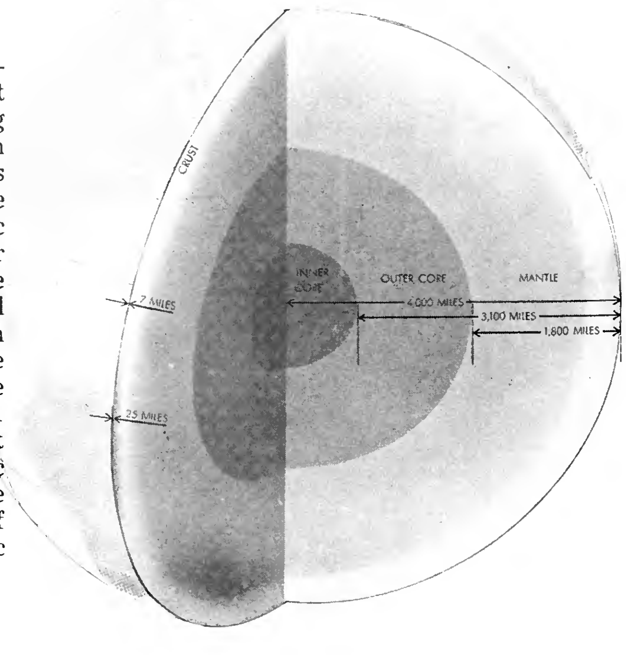
The beautifully landscaped terraces of the Azores are cultivated from the top of the extinct volcanoes to the edge of the seacliffs sprayed by wind-blown seasalts.

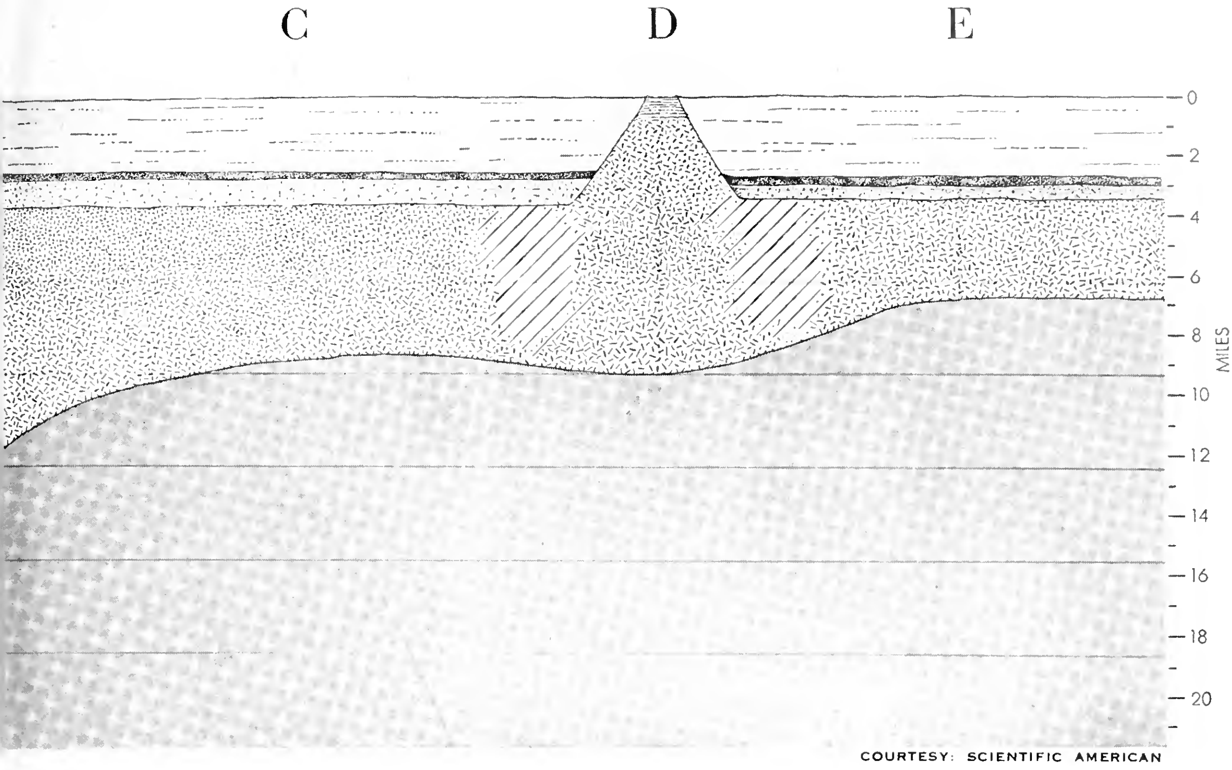


SCHEMATIC SECTION of the earth's crust and upper mantle shows why a hole to the boundary between the crust and the mantle (the Mohorovicic discontinuity) will be drilled from a barge moored in the deep ocean. To reach the discontinuity from the surface of a continent the hole (A) would have to go some 100,000 feet (roughly 30 kilometers or 20 miles). To reach the discontinuity from an oceanic island the hole (D) would have to go

THE PUERTO RICO TRENCH

ONE of the most exciting discoveries in oceanography in the last fifteen years has been the finding that the crust of the earth is much thinner under the ocean than it is under the continents and that there is an absence of the lighter granitic type rock which is prominent under the continents. This has led to the "Mohole Project" designed to drill through the crust of the earth from a barge at sea. To find the best place to do this drilling several sites were investigated. In the spring of 1961 preliminary drilling was carried out from the barge 'Cuss I' in the Pacific Ocean near Guadalupe Island. The drills went through 180 meters of sediments and entered into basaltic rocks.





some 50,000 feet (roughly 15 kilometers or nine miles). To reach the discontinuity from the surface of the deep ocean the hole (E) would have to go only some 32,000 feet (roughly 10 kilometers or six miles), the upper 11,000 feet of which would be water. A hole (C) might also be drilled in somewhat shallower water to obtain a cross section of oceanic sediments. The depth of the deepest well yet drilled on dry land (B) is 25,000 feet. The crust beneath the soft oceanic sediments is divided into two layers, the upper of which is called the second layer. The diagonal lines in the diagram indicate the regions in crust of least certain composition.

A Geophysical Laboratory

"Project Mohole" had its beginning many years ago through the seagoing experiments of our geophysicists and their colleagues of the Lamont Geological Observatory.

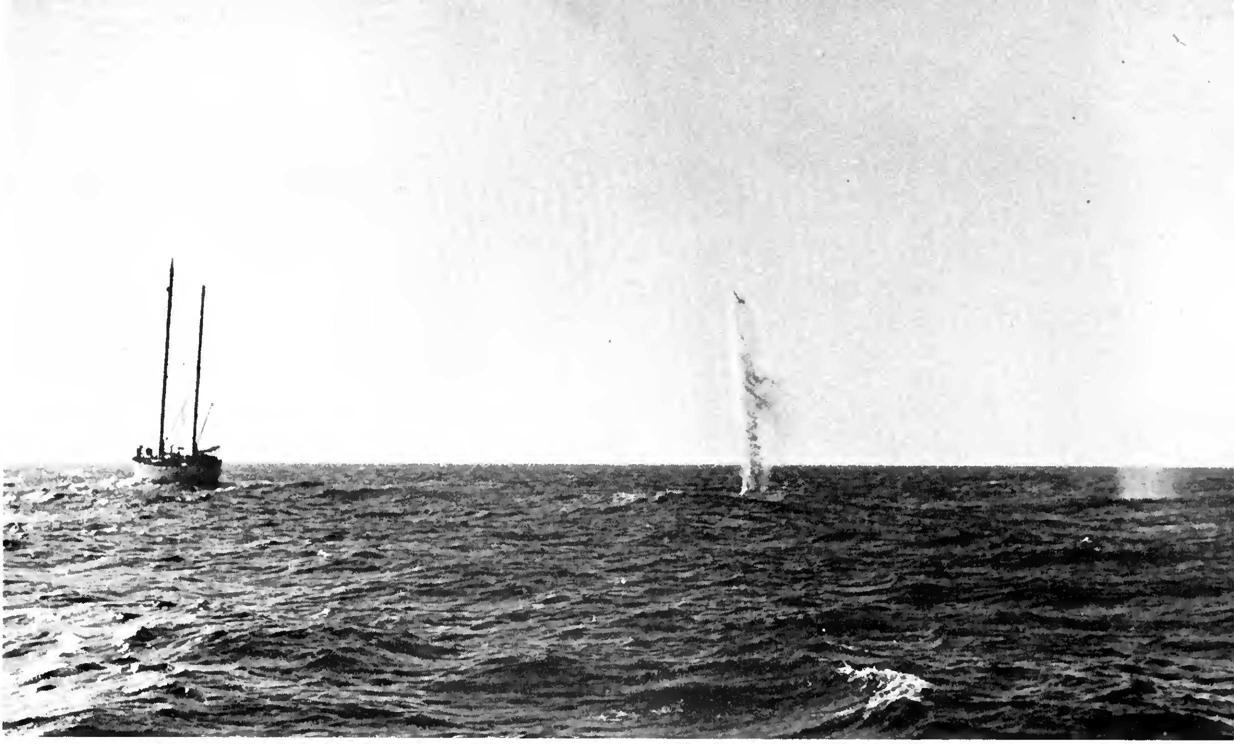
by Dr. J. B. Hersey

THE Mohole site survey goes back in recent oceanographic history farther than many recent participants realize. The Earth's thin crust beneath the oceans which we now seek to pierce by drilling has been measured by the seismic refraction method since 1949. This method depends on setting of explosions and measuring the passage of seismic waves through the crust of the Earth along paths like those shown in the accompanying diagram. By this method the Moho was first reached in deep-sea in 1949 on 'Atlantis' cruise 154 and 'Caryn' cruise 5. The first profile (a set of observations along a track thirty or more miles in length) was between Hatteras and Bermuda, but the second, third, and fourth were made in and north of the Puerto Rico Trench. Thus, unwittingly, on March 14, 15, and 16, 1949 we started the Mohole site survey.

We were working with USS 'O'Hare' (DD889), Lcdr. Fitzgerald commanding. The 'O'Hare' had been shooting depth charges on a pre-arranged schedule throughout the 14th and half the 15th while the 'Atlantis' and 'Caryn', both rolling continually in a heavy Atlantic swell, received the seismic waves on our hydrophones. Lcdr. Fitzgerald knowing that our scheduled working time was running out called me on the 'Caryn' by radio proposing a conference that evening on board the 'O'Hare'. "Come on over for dinner" he said, "and bring the rest of the scientific party with you. I should be near you about 1630". He was then ninety miles away (but making 30 knots). We hadn't seen a ship in days. We knew we were somewhere roughly 120 miles north of Puerto Rico, and several miles north of the north wall of the Puerto Rico Trench. Where we were the water was three miles deep. Over the Trench it is over four and a half miles deep. At that point we had some idea of the shape of the Trench, but we knew little more than these geophysical deductions and the undeniable fact that 'Caryn' had been rolling without ceasing for days and days and days.

Back in San Juan scientists scattered from the ship, sometimes without telling the cook that we wouldn't be on board for lunch or supper. There had been the inevitable blowup by Fred, the cook, and the friendly suggestion from John Pike, the Captain, that we **could** let Fred know when we'd be out for a meal. So here we were 120 miles at sea with a bona fide invitation to dinner. I saw Fred heading for the galley to prepare for supper. I told him I'd be out for dinner as would the four other scientists. He looked at me with infinite scorn salted with a who-are-you-trying-to-kid emphasis, but he said: "Thank you very much, Doc, I certainly appreciate your telling me". At 1625 I was on deck again unusually well-scrubbed when Fred passed me. He paused, and in some astonishment said "Dammit, Doc, I believe you **are** going out to dinner". At that juncture someone called out that the destroyer was in sight. We were transferred via whaleboat and passed a pleasant evening (plus conference) aboard 'O'Hare'. (The wardroom afforded hamburger that night, while Fred managed fillet mignon on the 'Caryn' —— ah — well.)

THE DOUGHTY CREW. On board the 'Caryn' in 1949 are, from left to right: standing, W. Dow, the late H. Johnson, G. H. Volkmann, J. B. Hersey, the late M. Pollak. Kneeling: S. W. Bergstrom, Mr. Sandoz, a Canadian visitor, and O. E. Hunt.



SHOOTING CHARGES of TNT, the R.V. 'Atlantis' moves away from the R.V. 'Bear' at the start of a thirty mile long refraction profile.

Depth of the Moho

At any rate, following the conference we completed a successful shoot from which the first measurements of the depth to the Moho in this region were made. We found the Mohorovicic discontinuity at a depth of 11.47 kilometers below the sea surface. The water depth was 5.30 kilometers so that the Moho was only 6.17 kilometers below the seafloor as contrasted to a depth of 30 or more kilometers below the continents.

Following this first look, our friends at Lamont Geological Observatory under the leadership of Maurice Ewing and our own geophysics group led by C. B. Officer have returned several times to the Puerto Rico Trench and environs to develop a rather detailed picture of the structure of the crust there. It is probably the best known region under the deep-sea, since it has been studied not only by seismic waves, but also by numerous and repeated gravity measurements and observations of the magnetic field. From this work a group at Lamont (Talwani, Worzel, and Ewing) deduced a structure section showing an especially thin place in the crust which almost immediately was an attractive, possible drilling site as the Mohole project developed. Accordingly J. Nafe, from Lamont in 1959, led a co-operative group from his observatory, from Woods Hole, from the Hudson Laboratories, and from Texas A and M to make a careful seismic check of this region.

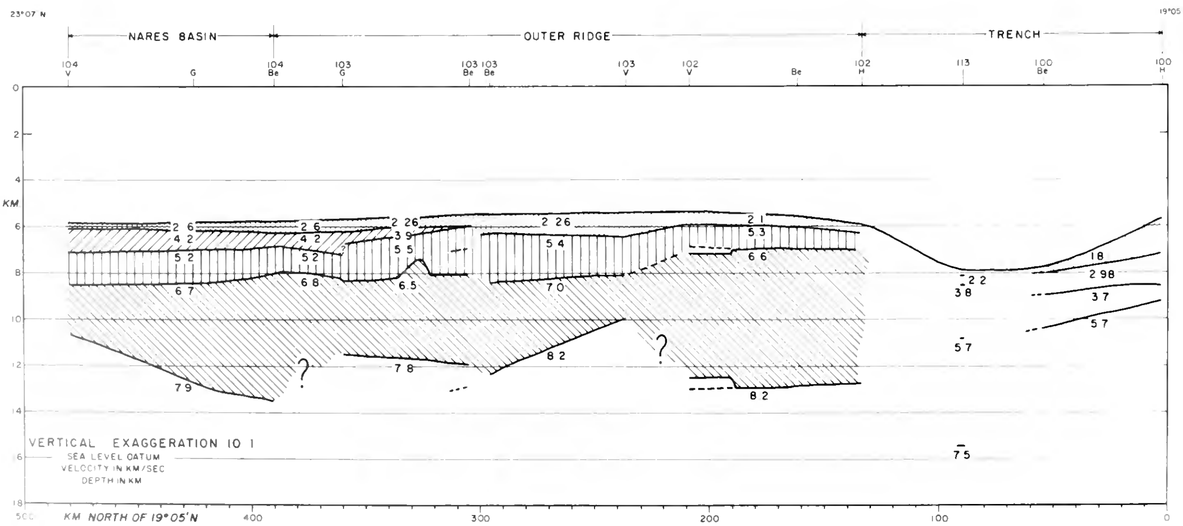
Trench

Elizabeth T. Bunce and D. A. Fahlquist undertook a large share of analysis from this field effort which resulted, in 1960 in a structural section which also shows a thin place in the crust. About this same time E. E. Hays, as chief scientist on 'Chain' cruise 11 in the Caribbean was playing host to H. E. Edgerton from MIT, who was most anxious to find out whether his cameras could take good pictures on the floor of the Puerto Rico Trench where the depth is roughly 4.5 nautical miles. One day while trying to do this they drifted over the north wall of the Trench. The photographic results were most exciting; here were large rocks and many smaller broken fragments. They and the geologists present tried hard to dredge some of these rocks, but without success. Back in Woods Hole after the cruise the seismic and photographic evidence fitted better than the accuracy of either observations warranted. Miss Bunce and Mr. Fahlquist pointed out that if their layer boundaries were extended to the north wall the top of their deepest crustal layer corresponded with the depth at which Edgerton and Hays' deepest photographs were taken. Perhaps those huge blocks of rock were part of the deepest part of the Earth's crust. It would be exciting and fun to know more about this!

(continued)

DR. HERSEY is a geophysicist at the Institution where he has specialized in submarine geophysics and hydroacoustics since 1946. His degrees are in physics: A.B. and M.S., Princeton University 1934 and 1935, and Ph.D., Lehigh University 1943. Since 1957 he has served part time as Associate Professor of Oceandgraphy at MIT.

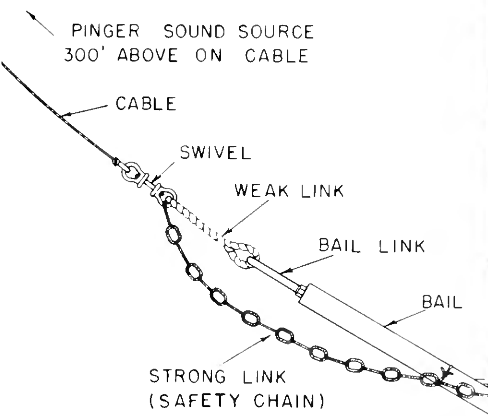
CRUSTAL STRUCTURE SECTION — Puerto Rico Trench along longitude 66°30′ W to Nares Basin. This view was presented at IUGG, Helsinki 1960, by E. T. Bunce and D. A. Fahlquist and since then has been re-interpreted and will be presented at the 1962 meetings of the American Geophysical Union.

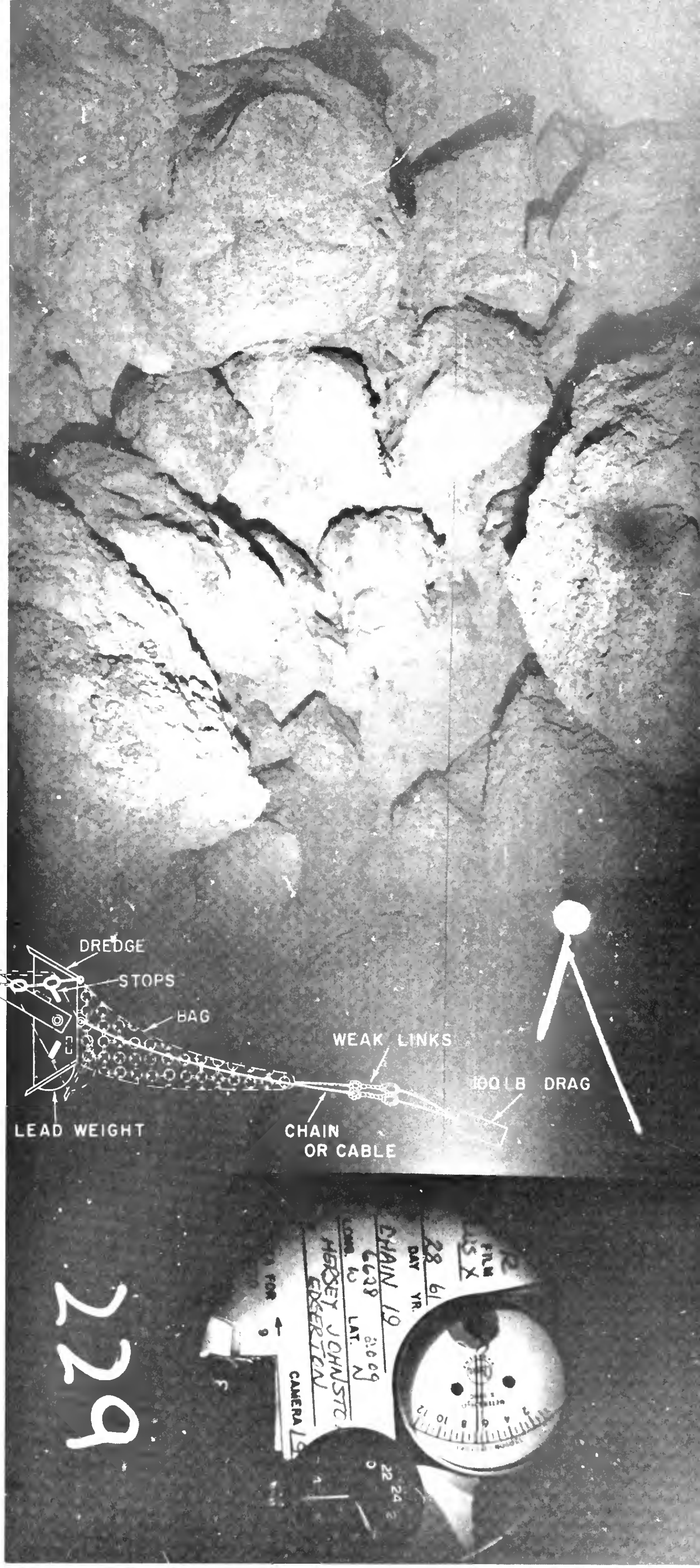


Trench

The first exciting evidence of the rock outcrop on the north wall of the Puerto Rico Trench came from a series of bottom photographs made on 'Chain' cruise #11. The photo shown here was made on 'Chain' cruise #19 in 1961.

Nalwalk's rock dredge which obtained some rocks is superimposed on the bottom photograph.





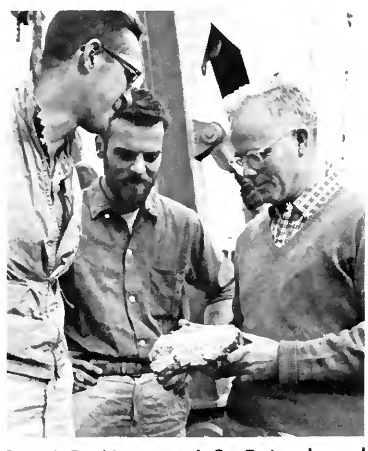
HERSEY · JOHNSTON · EDGERTON

We planned a return to the Puerto Rico Trench in June 1961. It simply wasn't possible for all those concerned and interested to be there. But we managed a quorum. I just pulled rank. H. E. Edgerton and Elizabeth T. Bunce were not likely to be left at the post; they were aboard. J. S. Reitzel, who had contributed to 'Chain' cruise 11 was very much on hand. The rest of our party were largely innocent of the past, but already intent on the future.

Serpentinite rock

First we concentrated on learning the shape of the north wall of the trench where the seismic results applied and the photographs had been taken. This locality proved to have the steepest slopes, and several camera lowerings showed it to contain loose rock slides and apparent outcrops. This was quite enough. We concentrated on dredging, thereafter, but were successful only part of the time. A J. Nalwalk, guessing at the size of the boulders to be coped with, estimated that we should try to avoid the big ones (since they were too large to handle with our gear), and designed a dredge that had a small mouth and a special bail that would permit the dredge to ride up over the big ones without becoming permanently stuck. As far as we know his scheme worked well, the dredge, held on bottom by a sound pinger, seemed always to be able to collect rocks when they were available and did not hang up. They were in four out of ten dredge hauls. Three of the four successful hauls were made on a steep slope where it seems likely that both the layers designated as 5.2 km/sec and 6.5 km/sec crop out. The excitement attending the rock dredging was intense and further was heightened by the fact that the rich hauls seemed to come on deck after one o'clock in the morning. (There was always a crowd.) The depth of the three deeper hauls could be considerably greater than 7 kilometers (± 22,000 feet), but the difficulties of interpreting echo soundings over a steeply sloping bottom make exact measurements quite impossible with the instruments now available. Only reasonable limits can be stated. Nevertheless, crystalline rock, called serpentinite, was taken at a depth greater than 7 km; thus on the basis of available evidence this serpentinite probably came from the outcrop of the layer which has a seismic wave velocity of 6.5 km / sec. This is the bottom-most layer of the Earth's crust beneath the oceans. Prof. H. H. Hess of Princeton had previously suggested that this layer is serpentinite, altered from the Earth's mantle, a dense rock layer enveloping the Earth's nickel-iron core. Thus our evidence and his hypothesis seem in agreement. So far as oceanographers are concerned the weak links are in the extrapolation of the seismic results to the north wall, and in the depth measurements of the rock samples and photographs.

All of these uncertainties are ours to correct. We are making plans now to do so and to return to the Puerto Rico Trench later this year to make more seismic measurements, rock dredging and photography. We intend to locate our observations and samples much more precisely geographically and in depth by using improved radio and hydroacoustic navigational aids.



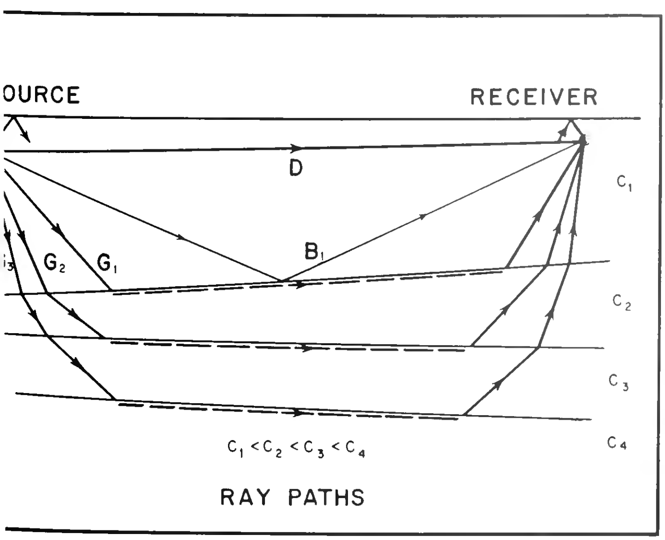
Dr. J. B. Hersey, J. S. Reitzel and A. J. Nalwalk survey one of the dredged rocks on board the 'Chain'.

LEE DAVIS

Watching the behavior of an underwater camera on the Woods Hole Precision Recorder, Dr. E. Hays rests his pencil on the trace of the ocean bottom. To the left of this is a trace made by the camera and at far left a trace made by a sound pinger attached to the camera. Talking to the man on the winch, Dr. Hays is keeping the camera at a proper distance above the bottom.

"Over the side!" S. W. Bergstrom and J. L. Worzel hoist a depth charge during the 1949 'Atlantis-Caryn' cruise to the Puerto Rico Trench.

Ray diagram showing the paths taken by seismic waves set off by exploding charges of TNT from one moving ship and received by another vessel hove-to on "silent-ship."



A New Marine Bacterium

By R. R. GUILLARD and S. W. WATSON

An accidental discovery of a new bacterium in the sea again raises the question of the formation of manganese nodules.*

A BACTERIUM not heretofore known from the sea has rudely forced itself upon us. We tentatively refer to it as a species of the extraordinary genus *HYPHOMICROBIUM* a genus remarkable because its members are capable of branching, budding, and forming motile stages. Most bacteria simply divide more or less in half and let it go at that.

Through the usual perversity of Nature, our *HYPHOMICROBIUM*, sp. was found and isolated, not when we were looking for bacteria, but by procedures carefully designed to destroy bacteria in algal cultures. It occurred as a contaminant in a culture of diatoms isolated from the Sargasso Sea. To free the diatoms from bacteria, they were suspended for a time in an antibiotic mixture, and then individual cells were fished out with a micro-pipette under a stereoscopic microscope. As a rule, some of the diatom cultures that develop from the single cells turn out to be bacteria free. In this case, however, the *HYPHOMICROBIUM* survived the antibiotic treatment and remained undetected in the diatom culture for a considerable time, during which the diatoms were described with some conviction as "bacteria-free". To test for the presence of bacteria we routinely transfer samples of the diatom cultures to broths high in nutrients upon which bacteria normally thrive. Our *HYPHOMICROBIUM*, sp. escaped detection simply because it was killed by these broths. It grew detectably only when the diatoms were given a dilute organic supplement — for their own growth, incidentally, not for the purpose of detecting bacteria.

We are naturally interested in the nutrition of such a fastidious organism. We can grow *HYPHOMICROBIUM* fairly well on low concentrations of certain protein digests or serum, but by far the best "broth" is a culture of algae, diatoms preferably. This bacterium grows more slowly than most others found in sea water or occurring as contaminants in algal cultures. When it grows on agar surfaces it forms tiny colorless colonies that are easily overrun by more robust bacteria. It is not surprising that the species heretofore has escaped notice in the sea.

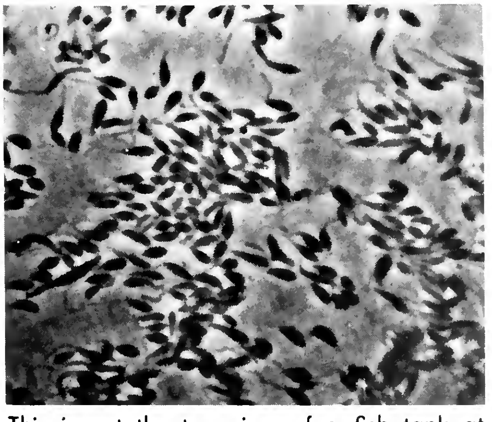
We reason that the newly found bacterium survived the treatment with antibiotics precisely because it does grow so slowly. Antibiotics tend to kill bacteria most efficiently when the cells divide. The time that algal cultures are exposed to antibiotics has been empirically adjusted to kill rapidly growing bacteria, which are the common ones in algal cultures, and hence was exactly wrong for killing the slow-growing *HYPHOMICROBIUM*. There may be another reason that bacteria-free diatom cells could not be picked out easily. The *HYPHOMICROBIUM* cells may have attached themselves to the diatoms by their stalks. At any rate, a second antibiotic treatment with a longer time of exposure did permit isolation of the diatoms free of the *HYPHOMICROBIUM*, sp. — and of other bacteria, too, we fervently hope!

As yet we do not know if organisms like *HYPHOMICROBIUM*, sp. are common in the sea but we do know they occur there. Such bacteria also are found in fresh waters; in fact, they must relish distilled water, because they occasionally are seen on electron micrographs of entirely different subject matter, much to the astonishment of the electron microscopist. They grow in the wash bottles, as nearly as can be determined. This meager evidence suggests that the fresh-water species also thrive on low concentration of nutrients.

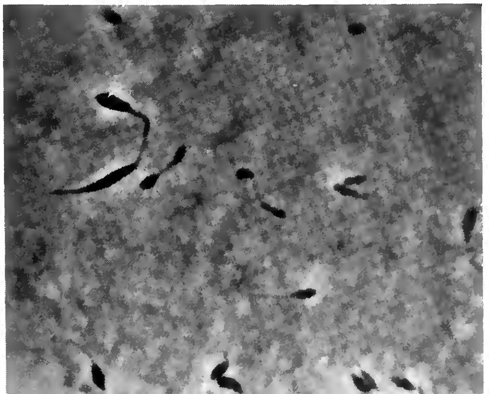
*See: "Manganese nodules", Oceanus VI, 2.

It is certainly premature even to guess what may be the role of *HYPHOMICROBIUM*, in the biological and chemical cycles in the sea. If bacteria are indeed responsible for the formation of manganese nodules on the sea bottom,* then the species involved might well be expected to have properties similar to those of our *HYPHOMICROBIUM*, sp. and capable of growing and reproducing while attached. But will our species grow at the low temperatures found at the bottom of the sea? We have not found out yet.

We can also speculate that our species can live parasitically within or attached to algal cells. When we examine diatom cultures that we know contain the bacteria, we see fewer than we suspect are present. We hope someone will be interested in investigating this possibility of a parasitic mode of life.



This is not the top view of a fish tank at feeding time, but a view through the phase-contrast microscope of stalked marine bacteria in culture. The photo below shows buds developing on some of the stalks. 1200x enlarged.



WATSON

Stalked mico-organisms of various types may be more widespread and more important than is generally thought. Dr. H. W. Jannasch, who is to join our staff, has identified large numbers of another stalked bacterium (*CAULOBACTER* sp.) in sea water. A whole new class of marine micro-organisms (the Krassilnikoviae) has been named as recently as 1959, and we read of great numbers of a taxonomically indeterminate organism (*CYANOTHECA* sp.) from South African fresh waters. Many of these abundant organisms will undoubtedly be difficult to culture and study but success should enable us to deduce something about their ecological roles as well as to find any useful or interesting physiological idiosyncracies they may have.

Electron Micrograph of a stalk bacterium that became attached to a plastic film suspended in the sea. Magnification: 20,000x.

Book Review

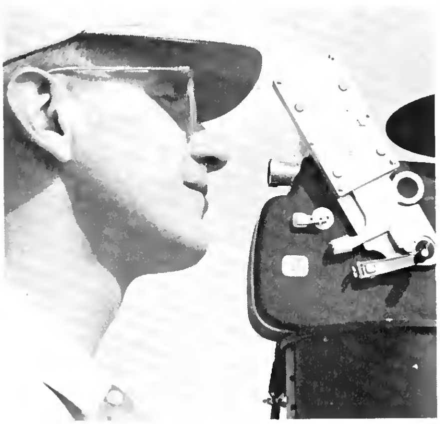
BY C. O'D. ISELIN

Introduction to Physical Oceanography
by W. S. von Arx
Addison-Wesley Publishing Company, Inc.
1962

WHEN I first saw the new book of my great friend, Bill von Arx, and turned over the beautifully printed and illustrated pages, I was concerned by the fact that the title might be considered misleading. It is far from being an elementary text book and to have called it "Introduction to Physical Oceanography" bothered me at first.

Each oceanographer has a somewhat different idea about which aspects of the subject are the more important. Since I consider myself primarily a physical oceanographer, it upset me at first in scanning the pages that he seemed to have arrived at a somewhat different interpretation of the subject than I had.

A rainy day enabled me to read the book from one end to the other, although I must admit that I started in the back and proceeded towards the beginning, just as I normally read Time Magazine. When you do this it is soon abundantly clear that everything up to the final chapter is indeed an introduction. For someone who every two years attempts to teach physical oceanography the book is indeed a magnificent introduction. If the students could digest the book before the first lecture, the teacher should really be able to take off — I look forward to my next attempt. In short, Bill von Arx has set the stage in a very effective manner and the title of his excellent book is entirely appropriate.



Dr. W. S. von Arx, author of the new textbook

To those who wish that the final chapter, which most of the book is leading up to, were somewhat longer, in other words, to those of us who may end the book with a feeling that he has not quite adequately covered the subject of physical oceanography, I would recommend reading Henry Stommel's essay on the Gulf Stream,* after having mastered Bill von Arx's "introduction". They complement each other admirably.

What neither book in my opinion adequately admits is that when one approaches a coastline which is well watered, the question of the cause of ocean currents has perhaps not been fairly dealt with.

Henry B. Bigelow's profound insight in the causes of coastal currents, at least along a well rained on coast, deserves more mention than it has yet received in text books about physical oceanography. Also the convincing observation by B. H. Ketchum that the continental shelf in effect is an infinitely wide estuary should receive more attention.

It has become popular of recent years to think of physical oceanography as dealing primarily with the water beyond the 100 fathom curve. Students should be taught that the margins of the sea are perhaps equally important. This gives me a chance to slant my lectures next spring so as to fill this gap.

*Stommel, H. "The Gulf Stream, a physical and dynamical description". University of California Press, 1958.

Printed by Leyden Press, Inc., Plymouth, Mass.

Associates' News

Dinner meetings announced.

THIS spring there will be three Dinner meetings for the Associates. The guest speaker will be Dr. John C. Lilly, author of the recently published book "Man and Dolphin". Dr. Lilly who is Director of the Communications Research Institute at St. Thomas, V. I. will show motion pictures and describe his studies of the bottle-nosed dophin.

Associates are requested to supply the names of other interested persons to be invited to the dinners. Formal invitations will be mailed directly.

The dates are: April 30, Wilmington; May 1, New York and May 3, Boston.

THE ASSOCIATES of the Woods Hole Oceanographic Institution are a group of individuals, corporations and other organizations who, because of their love for the sea and interest in science and education, support and encourage the research and related activities of the Institution.

Membership dues in the Associates are as follows:

Member	$50
Contributing Member	$100
Patron	$500
Life Member	$1,000
Corporate Member	$1,000
Sustaining Corporate Member	$5,000 or more.

All contributions and dues are tax deductible to the extent provided by law.

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Features

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