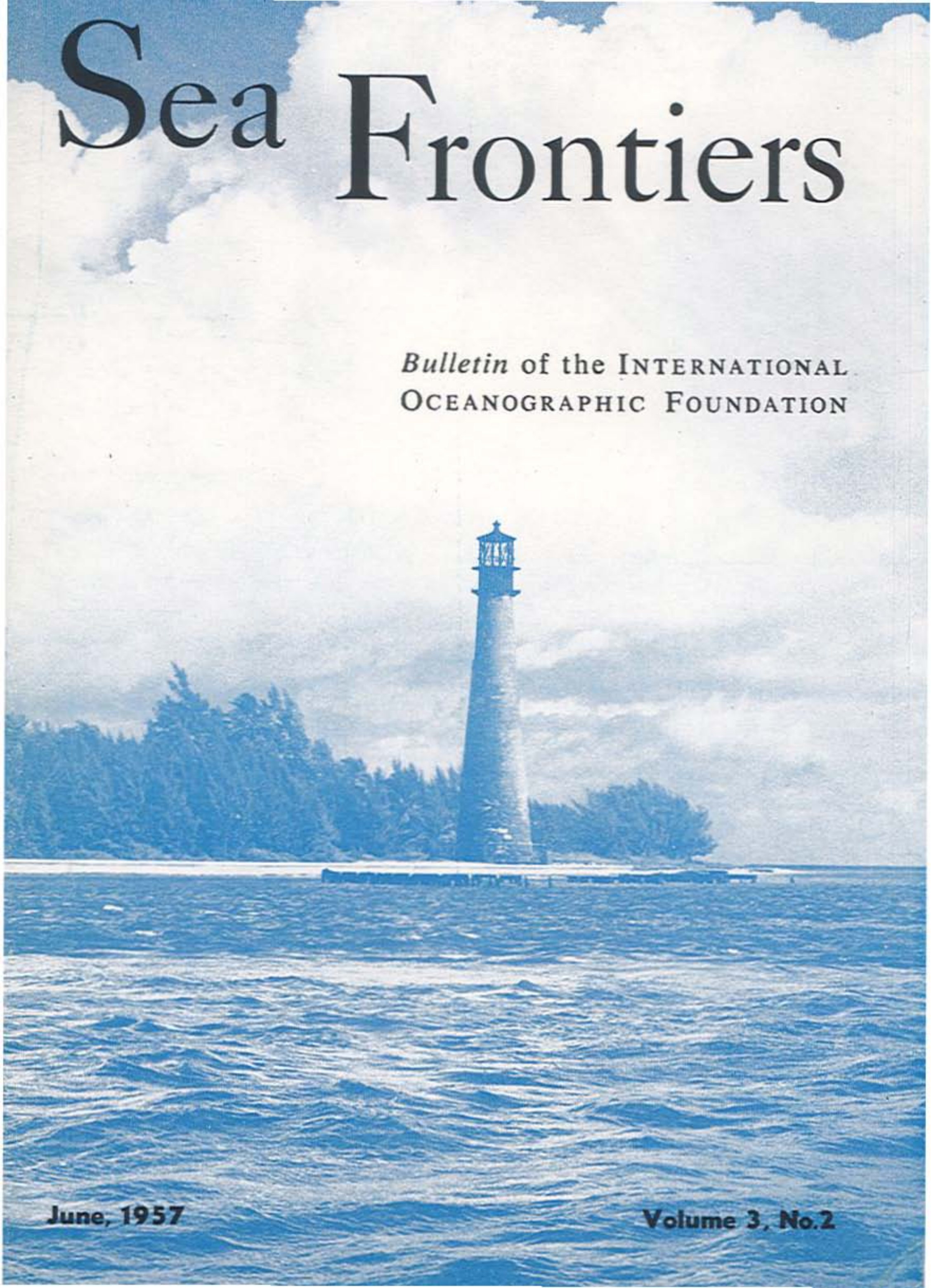
Sea Frontiers

Bulletin of the INTERNATIONAL OCEANOGRAPHIC FOUNDATION



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must play to abate it. Already certain water conversion experiments are being moved from inland laboratories to test sites along the seashore, where large-scale operations can determine if they are economical and feasible.

To scientists in general and oceanographers in particular the prospect is exhilarating. The *New York Times*, in a recent editorial, takes this optimistic view: "Ever since Malthus, the prophets of doom have forecast the decimation of the world's people by starvation. They could not have foreseen the possibilities of atomic power or of the inexhaustible sea."

Science Goes Deep

By G. Houot
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A glance at the history of submarine diving shows that the number of inventors concerned with it during the past centuries has been very large. Although many of the diving machines were highly fantastic, nevertheless some were remarkably well conceived. Solutions to the technical problems and the desire of man to penetrate deeply into an unknown world have not been lacking but, until recently, the mechanical and industrial means were not available for the construction of the necessary apparatus.

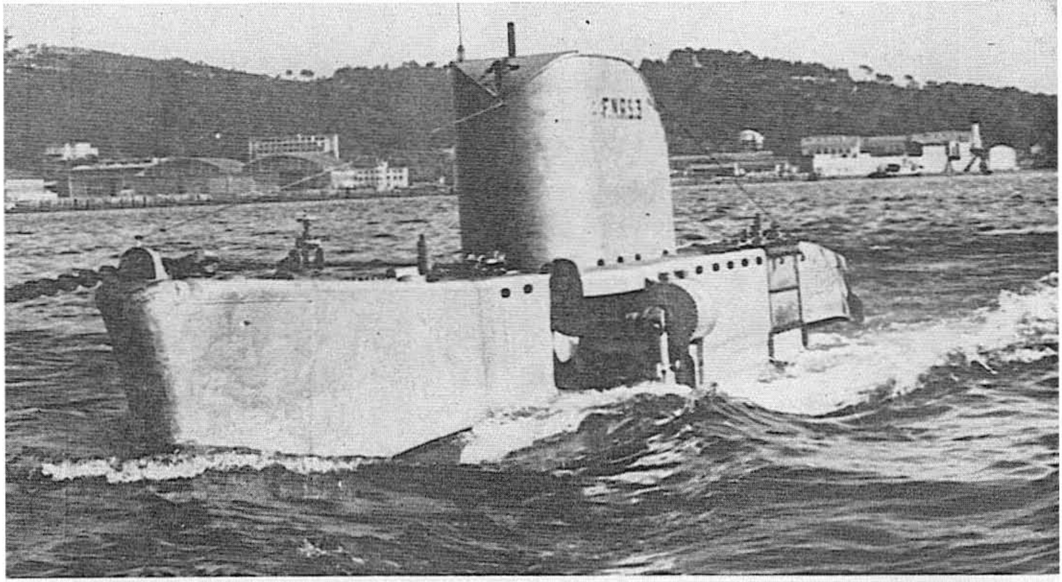
From Beebe to Piccard

It was not until 1934 that the American William Beebe and Oris Barton succeeded in descending to 3,028 feet in a sphere suspended from a cable. Some years later, the Swiss professor Auguste Piccard, of the University of Brussels, in collaboration with Professor Cosyns, and with the financial contribution of the F.N.R.S., the Belgian National Fund for Scientific Research, succeeded in making the first diving machine capable of reaching a depth of 12,000 feet without any form of suspension. This he christened the Bathyscaphe.

A Second Attempt

The difficulties encountered and the eventual failure of this first attempt did not discourage him. A new undertaking was planned, this time with collaboration between the Belgian F.N.R.S. and the French Navy. This enterprise has resulted in the construction of *F.N.R.S. III*, the first apparatus adequately planned for a scientific exploration of great depths.

The Bathyscaphe is made essentially of two parts, the sphere and the float. The sphere is the brain of the apparatus. It is this which carries the two passengers, the pilot and the observer. In order to withstand the very great pressures which exist in great depths, it was made of special high



THE FRENCH BATHYSCAPE, *while being towed. She has a superficial resemblance to a submarine. The visible part is actually the float. The diving sphere is suspended beneath it.*

strength steel. It is 6 feet in inside diameter and about 4 inches in thickness with a weight of 11¼ tons. The steel door has an opening about 15 inches in diameter and two portholes, of which one serves for observation. These portholes are made of tapered plexiglass plugs, 6 inches thick and 4 inches in internal diameter.

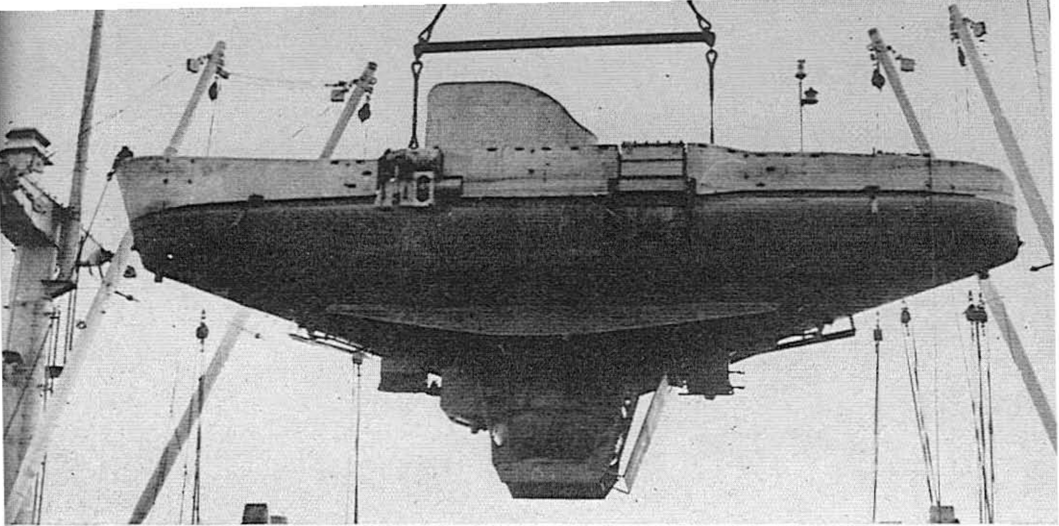
Six Ton Cabin

The sphere, immersed in water, weighs 6 tons. If it were set loose in the sea, it would inevitably sink without hope of recovery. The whole principle of the apparatus lies in its attachment to a buoyant unit, the "float," which retains considerable buoyancy at any depth. Sphere and float are permanently joined. The float must be large enough to counteract the weight of the sphere and to bring it back to the surface, no matter what happens. Unfortunately there is no solid material with great buoyancy and the compressibility of gases makes them useless. So we turned to liquids and, naturally, to the lightest of them, gasoline.

Maneuvered by Ballast

The float is nothing but an enormous reservoir, divided into compartments on the inside in order to reduce accidental loss. It contains about 10,000 gallons of gasoline. This liquid has the additional property of not mixing with water. A permanent passage between the inside and outside of the float provides continuous communication between the gasoline and the sea water. Thus. the steel sides of the reservoir are not subjected to strain in diving and, in contrast to the sphere, are made of thin, light material.

The whole operation of the machine is a simple application of the Archimedes principle. In order to make the Bathyscaphe sink it is made



THE DIVING CHAMBER *can be seen below the boat shaped hull of the float.* F.N.R.S. III *is capable of descending to a depth of several miles beneath the surface.*

heavier and in order to regain the surface it is lightened. This is accomplished by means of ballast. The initial excess weight is provided by filling a reservoir with water. At the surface this is normally empty. Immediately before diving, it is opened to the sea. To simplify construction, this reservoir, of about 27 cubic foot capacity, is used as a shaft or "lock," giving access to the sphere. The latter is always under water.

Electromagnetic Safety Controls

In order to lighten the apparatus, iron shot contained in vertical hoppers are released. These are held solidly in place when magnetized by an electromagnet. Breaking the current allows them to flow out. This principle guarantees safety, since any electrical breakdown causes the discharge of the ballast. The weight of the ballast, over 4 tons, may seem considerable. It is needed because the volume of the gasoline becomes less and its density increases in the course of a dive, due to increased pressure and reduced temperature. The loss of buoyancy is thus relatively large in the course of deep dives and the 4 tons are not excessive for providing a return from depths of 12,000 feet.

For reasons of safety, there is also supplementary ballast, to be used in the case of accidents, especially a leakage of gasoline. This is also secured by electromagnets so that an electrical breakdown will cause nothing worse than a premature return to the surface.

Auxiliary Equipment

The machine has numerous accessories, some of which are used in piloting, others in observation. The more important ones are listed below:

Air purifying apparatus. These are cylinders of oxygen and cartridges of soda lime.

The gauges which show the quantity of iron shot in the hoppers.

The gauges of gasoline and water level, which make it possible to maintain the proper pressure equilibrium.

The detectors of water leaks.

Pressure gauges indicating depth.

Temperature gauges for both gasoline and sea water.

The compass.

The depth sounder. This makes possible a gentle approach to the bottom and landing without shock.

Apparatus for communicating with the outside world; radiotelephone on the surface, ultrasonic equipment during the dive.

All this material is in the sphere and is operated along with the electromagnets by a set of storage batteries.

Self-propelled

On the outside there are two propulsion motors which provide horizontal movement, during the dive and at the bottom of the sea. There is also a group of six searchlights of 1,000 watts each, illuminating all the area visible from the porthole. They are served by a second battery of accumulators situated outside the sphere, simply immersed in oil and open to the sea pressure. More specialized scientific equipment has also been added:

An electronic flash and two automatic photographic instruments controlled from within the sphere. These were made by Professor H. Edgerton of the Massachusetts Institute of Technology.

Apparatus for moving pictures.

Bottles for obtaining water samples controlled by electromagnets.

An apparatus for automatically and continuously recording the temperature of the sea in course of being perfected.

Diving Below 12,000 Feet

By diving to 12,150 feet on February 15, 1954, the Bathyscaphe *F.N.R.S. III* ended its trial period. Shortly afterwards, an agreement between the National Center for Scientific Research and the Navy settled the problems of scientific and routine operation. An administrative committee, under the distinguished presidency of M. Fage, a member of the Institute, was created to decide the program of work.

Since its construction, *F.N.R.S. III* has made forty-eight dives. This figure speaks well for its safety. The various trips made to Dakar, to Paris for the exposition at the Salon Nautique, and to Lisbon recently, are proof of its durability. Of course, it is far from perfect and our grandchildren will doubtless smile when they see it, but it is the first machine of a series of offspring which will continue to grow in the immense achievement of opening the door to the great deeps.

A New Oceanographic Tool

It is obvious from its description that the Bathyscaphe is a marvelous instrument for oceanographic work. Up till now, eighteen dives have been made with biologists and they have already produced important though fragmentary results.

Critics of the Bathyscaphe may say

that the results are insignificant. This would be both incorrect and unjust. A new machine and a new technique, no matter how perfect, cannot be expected to revolutionize a complete science overnight. Think of the years which were needed to make possible submarine photography in great depths, or even to develop an instrument as intrinsically simple as a bottom sampler. Scarcely two years have passed since the testing was finished and the Bathyscaphe ready to go to work.

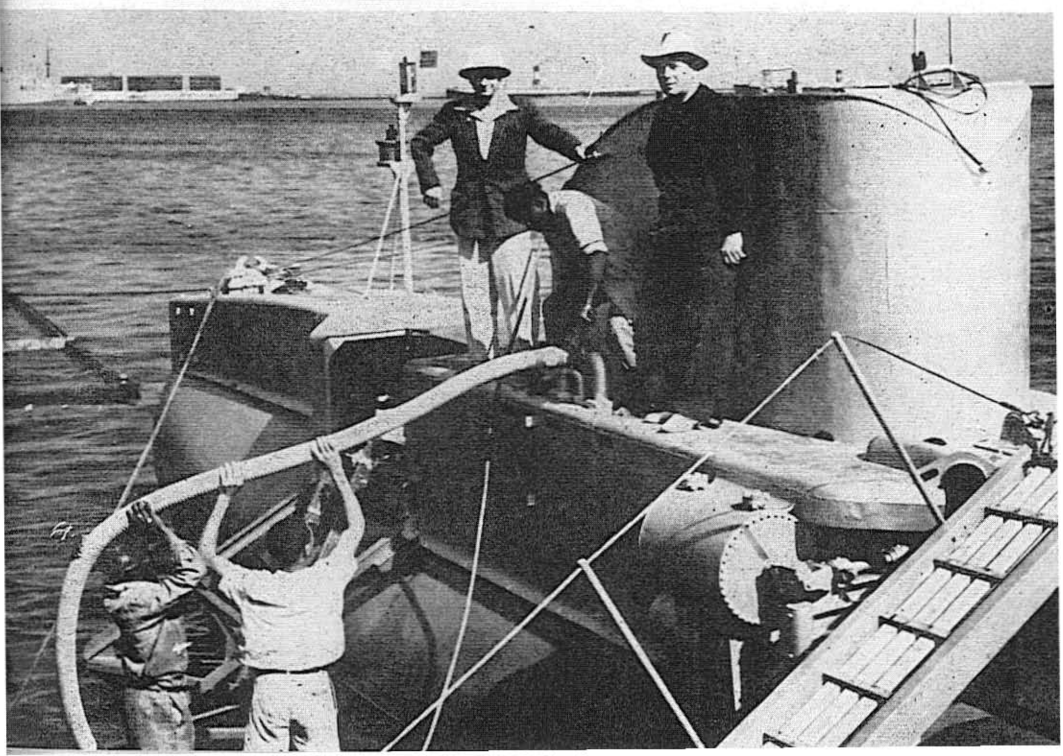
Two Years of Discovery

Let us review, very objectively, the results obtained in the course of two years of research. Luck did not favor the first users of the Bathyscaphe. After the first biological dives made near Dakar by Prof. Th. Monod, a dozen consecutive dives were completed in the Mediterranean. But the Mediterranean is one of the least suitable seas for the Bathyscaphe. Forbes, a century ago, tried trawling in its depths and found them so barren that he concluded that all deep seas are lacking in animal life.

Mediterranean Depths Almost Empty

Even if all the deep waters of the Mediterranean are not as barren as Forbes thought, they are very poorly populated. The French oceanographic vessel *Calypso* has made thousands of deepwater photographs in the Mediterranean, with the Edgerton camera. The published photographs are the exceptional ones, with something to show, but the vast majority showed nothing except mud in which are hidden infrequent specimens of *Abra longicallus, Dentalium agile, Siphonodentalium quinquangulare* and several other common deep bottom molluscs. One reason for this sparsity is,

FLOTATION IS PROVIDED *by filling the float reservoirs with gasoline.*

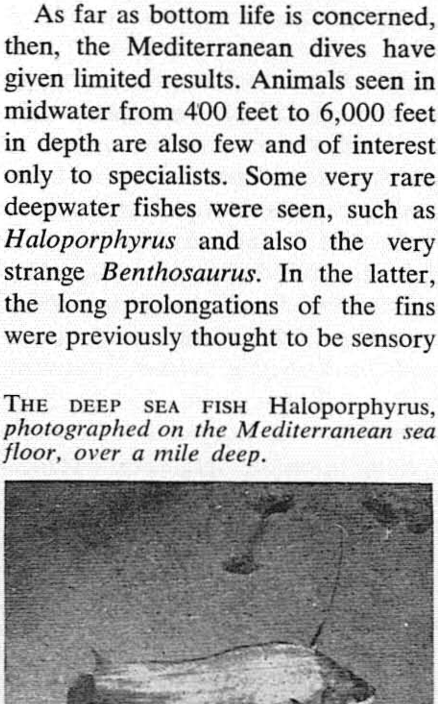


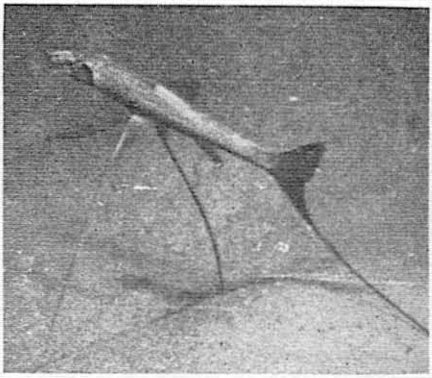
of course, the fact that the Mediterranean is over 14,000 feet deep in places and has no connection with the ocean except the Straits of Gibraltar. The Straits are very narrow, seven miles across, with a shallow sill of about 1,000 feet depth. This lack of communication with the ocean results in very poor circulation of the deep Mediterranean waters. The plankton is also less dense than that of the nearby Atlantic. Scarcity of deepwater animal life in the Mediterranean is basically a question of lack of plankton food, both from actual insufficiency and also because of poor distribution.

Fish Walks on Tentacles

As far as bottom life is concerned, then, the Mediterranean dives have given limited results. Animals seen in midwater from 400 feet to 6,000 feet in depth are also few and of interest only to specialists. Some very rare deepwater fishes were seen, such as *Haloporphyrus* and also the very strange *Benthosaurus*. In the latter, the long prolongations of the fins were previously thought to be sensory organs, but it now seems that they are used for support.

THE DEEP SEA FISH Haloporphyrus, *photographed on the Mediterranean sea floor, over a mile deep.*





THREE POINT LANDING *is apparently the purpose of the long rod-like extensions of the fins of* Benthosaurus, *as photographed from the Bathyscaphe at about 7,000 feet depth. Previously it was thought that the antenna-like projections were sensory organs. Its first photograph taken on the sea floor shows that the fish walks on them.*

At the time of the two first test dives, when unfortunately no biologist was on board, a fair number of dogfish were seen, some about 6 feet long. Doubtless the visit of the Bathyscaphe had alarmed them, because they were never again seen. For plankton studies, the Mediterranean dives brought valuable lessons in the vertical distribution and in the natural appearance of various free living creatures.

Sea Snowstorms

G. Houot and P. Willm gave particular attention to what they called "snow." During a dive, on arrival in the darker depths, the searchlights, shining from above down, brought into view an immense number of small particles, apparently stationary in the water and with a decided resemblance to snowflakes.

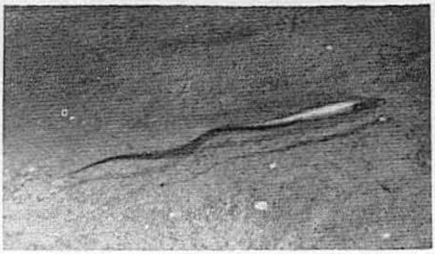
It seems that the particles consist principally of small planktonic Acanthids, but with some clumps of Coccolithophorides and even flakes of dead organic material derived from the dead bodies of plankton. The thickness of the "snowfall" varied in relation to the depth.

Success off Portugal

To increase the scientific production of the Bathyscaphe the French National Center of Scientific Research has supported a research cruise in the Atlantic on the Portuguese coast, where relatively great depths are found near the shore. Thanks to the help of the Portuguese authorities, we made six dives, of which five were a complete success; three were in the the canyon of Setubal, south of Lisbon, from 1,800 to 5,000 feet in depth. Two were outside a canyon on the Atlantic slope immediately to the north of the mouth of the Tagus. This cruise has given results of considerable interest and rich populations of bottom living animals were found.

Undersea Gardens

We were astonished by the unsuspected variety and number of certain bottom living populations. At 5,000 feet in the Setubal canyon we dropped down upon a bed of varicolored sea anenomes forming a colony 6 feet square. The variety of colors was entrancing, going from whites and yellows of the gorgonians to the violet of the *Kophobelemnon stelliferum* and including the red plumes of *Bathypenna elegens* and



THIS STRANGE FISH, *looking like an eel, is called* Halosaurus. *It was photographed on the deep sea floor off the coast of Portugal, during one of the descents of the Bathyscaphe.*

the brown bouquets of the cerianthid tentacles. In the midst of the mud plain, decorated with these multicolored "flowers," large violet aristeid shrimp, 9 inches long, swam by, while on the bottom, were crawling sea cucumbers, zoroasterid starfish and the like.

The fishes included numerous specimens of *Halosaurus johnsonianus,* which looks a little like an eel. It glides near the bottom with its body at diving angle, its snout in the sediment, and its tail rhythmically undulating. We have seen also the *Macruridae Trachyrhynchus scabrus* and especially the strange *Hymenocephalus longifilis,* whose pectoral and pelvic fins have the first ray threadlike and elongated, which the creature seems to drag some distance from the bottom. The similar threadlike ray of the dorsal fin is not dragged behind the fish, as was thought, but is recurved to the front, projecting well beyond the snout.

Deep Sea Lilies

Among other interesting creatures were sea lilies of the genus *Rhizocrinus* at 7,000 feet, growing erect above the mud on their foot long stalks. This gives the lie to the theory that the stalk is used to support the head on the surface of a liquid mud, covering the deep sea floor. Such a substrate has never been seen from the Bathyscaphe.

A 2,000 foot dive showed the very curious attitude of the shrimp *Nephrops,* lying in wait in a kind of burrow, from which only the head end and pinchers projected.

Observations were also made on creatures in the waters above the bottom. It was possible to distinguish some general features of the vertical distribution of these organisms. All the dives were made between morning and midday. There consistently appeared three distinct zones. There was a well populated surface zone extending down to 400 feet, with the maximum usually from the surface to 150 feet. Another zone ran from 400 feet to about 1,200 feet and was lacking in both small and large plankton. In the zone from 1,200 feet to 2,500 feet, the plankton again became rich and abounded with Narcomedusan jellyfish *Solmissus* and little hatchet fishes or mycotophids. Incidentally, we have never seen their so-called luminous organs emit the slightest gleam. Perhaps the poverty of the layer between 400 and 1,200 feet may be due to the fact that, in day time, a large number of pelagic animals seek refuge in deep water, mostly from 1,200 to 2,500 feet. They only come to the surface at night.

Beyond 2,500 feet the free swimming life thins out, especially about 3,500 feet, but it always shows a small maximum in the 500 feet immediately over the bottom. Plankton is distinctly richer in the canyon, where strong currents have been seen near the bottom, than it is over the Atlantic slope outside.

Future Oceanography and the Bathyscaphe

It is impossible to give here a good idea of all that we have been able to see, since the report on biological operations for the Portugal expedition alone covers forty pages. We hope that this article will give to readers in other countries than our own, some idea of the immense possibilities for oceanographic research which the Bathyscaphe opens up. Even in its present imperfect state, *F.N.R.S. III* has already permitted us to watch the natural behavior of the animals of great depths, alive and in their natural habitat. Only Beebe and Barton have hitherto seen this and then only down to about 3,000 feet. Thanks to the Bathyscaphe, the voyage of a biologist to the great deeps is now a practical reality and not an exceptional feat of daring. Tomorrow a new and larger Bathyscaphe, drawing from the experience of *F.N.R.S. III* and better equipped will go down to the greatest depths known. Tomorrow this world of the abyss which *F.N.R.S. III* has opened up will be almost as easily studied as a meadow or a pool of water left by the receding tide.