THE NEW WORLD OF THE OCEANS

by Daniel Behrman

As the ocean thrusts itself into our affairs, it creates situations that demand new political and juridical answers. Its present and future uses are incompatible with the old assumption that beyond the three-mile limit it belongs to no one. For all intents and purposes other than navigation, the assumption is as anachronistic as the shore batteries upon whose range the limit was based. At least seven nations have claimed jurisdiction over fishing rights 200 miles off their shores.

Under the Convention on the Continental Shelf, adopted by a United Nations conference in 1958 at Geneva, all coastal nations now have a clear title to the bottom resources of their continental shelves down to a depth of 200 metres (656 feet), a boundary that can run as far out to sea as 250 miles, depending on the hazards of submarine geography. It is as if a continent larger than Africa were added to their area.

Within it, states the Convention, they own "the mineral and other non-living resources of the seabed and subsoil together with living organisms belonging to sedentary species, that is to say, organisms which, at the harvestable stage, either are immobile on or under the seabed or are unable to move, except in constant physical contact with the seabed or the subsoil."

Certain "organisms" slip through this legal barbed-wire entanglement. In international disputes since the adoption of the convention, marine biologists have been drafted as experts to determine whether lobsters and king crabs swim or crawl. If the animals swim, then the lawyers must consider them as fish and anyone can catch them ; if they crawl, they belong to the owner of the continental shelf.

Ownership of the shelf is not all that clear, either. In 1958, the Geneva Convention's framers expected that twenty years would go by before anything worthwhile could be mined beyond the depth boundary of 200 metres that they had drawn.

Oil drillers are already capable of surpassing it; the miners of phosphorite and manganese nodules are waiting in the wings. They can make use of a purposely opened loophole in the convention's definition of the continental shelf as "the seabed and subsoil of the submarine areas adjacent to the coast ... to a depth of 200 metres, or beyond that limit, to whether the depth of the superjacent waters admits of the exploitation of the natural resources of the said area."

In other words, exploitation of the natural resources is nine points of the law. Dr. Kenneth O. Emery, a geologist from Woods Hole Oceanographic Institution, Cape Cod, U.S.A., is among those who note that "exploitation" is not defined in the convention.

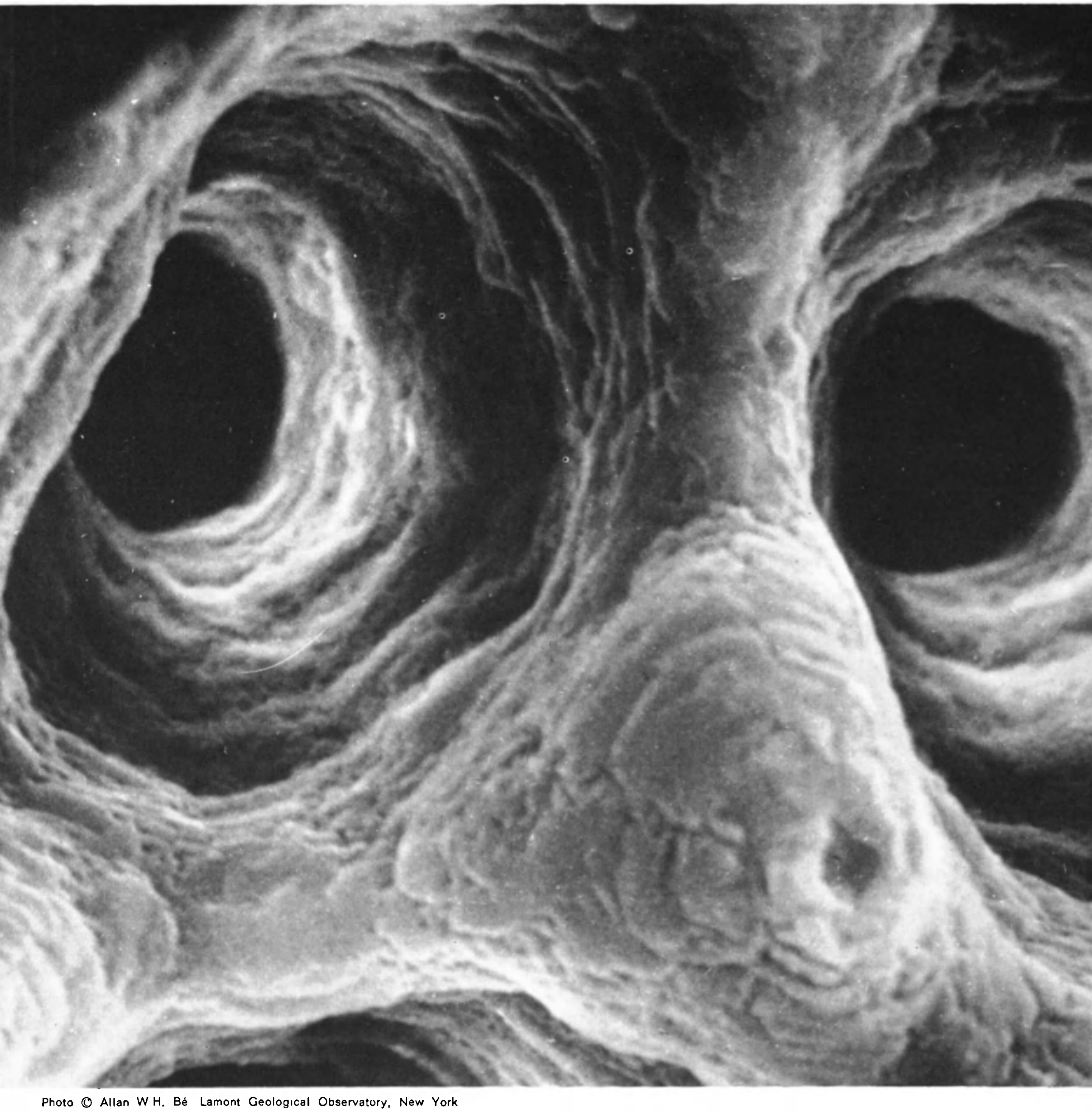
He has asked several provocative questions that cannot as yet be answered: "Does the recovery of a few manganese nodules as curios constitute exploitation? How many tons of nodules per year per unit area constitutes exploitation? Is profit on a free and open market required, or will large governmental subsidies substitute for profit? Manganese nodules with their content of cobalt, copper and nickel are the chief deep-sea resources that

CONTINUED ON PAGE 6

DANIEL BEHRMAN *writes on science for Unesco's Press Division. While on leave from Unesco, he authored "The New World of the Oceans", to be published this month by Little, Brown and Co. in Boston. The above article is taken from the chapter "The United Oceans" and is reprinted by permission of the author who holds the copyright, and the publisher. Mr. Behrman, an American ex-newspaperman, has written extensively on Unesco field projects.*

Photo © Science Service, Paris

This hollow-eyed face, right, is actually a greatly enlarged view of the pores and spine base of a species of zooplankton. As all sea life depends on this mass of minute drifting plant and animal organisms, analysing the microscopic life in the oceans has become an increasingly important part of the science of oceanography. Scientists foresee the day when "prairies" of the deep will be harvested, with stocks of fish being herded and grazed as a farmer herds cattle. Left, artist's impression of future submarine "reapers" clearing a forest of seaweed which obstructs fishing operations.



No flags on the sea floor

generally receive mention, but does the recovery of a few million dollars worth of these metals per year warrant assignment of sovereignty to huge areas of the earth?"

There are other questions. What is the status of the country with a deep trench near its coast that separates it from what would normally be its continental shelf? Norway was in such a position when drilling rights were apportioned in the North Sea, but Great Britain allowed her to extend her claim across the trench.

In the Pacific Ocean, the long arm of American law reached over waters 10,000 feet deep to prosecute an ingenious group that had tried to put a man-made island on Cortes Bank, 110 miles off San Diego, to reap a crop of abalone and lobster. To start their island, they decided to sink an old troopship on the bank, but their plans went awry and the ship was wrecked in 35 feet of water. They were charged with creating a hazard to navigation on the continental shelf off California.

THE convention's least controversial provisions are already becoming obsolescent. It declared as a matter of course that the legal status of the seas above the shelf remains unaffected. Serious doubts are now being expressed about allowing freedom on the top of the sea.

Dr. John P. Craven, chief scientist of the Navy Special Projects Office in Washington, does not see how fishing and shipping could continue in areas where divers are working for long periods at a stretch:

"They are in a precarious position with respect to man-made perils. They cannot tolerate explosive detonation in their near vicinity; they cannot tolerate extensive pollution; they cannot tolerate interference by trawls or dragnets."

Such prospects are plausible in the context of a legal vacuum. There is a growing sentiment that the vacuum cannot be allowed to exist much longer if we are not to repeat in the ocean the same grievous mistakes that have left us in our present predicament on land.

In July 1966, President Johnson said what many are thinking: "Under no circumstances, we believe, must we ever allow the prospects of rich harvests and mineral wealth to create a new form of colonial competition among the maritime nations. We must be careful to avoid a race to grab and to hold the lands under the high seas. We must ensure that the deep seas and the ocean bottoms are, and remain, the legacy of all human beings."

In several quarters, the President has been taken literally. Senator Claiborne Pell, of Rhode Island (a state, as he has said, with 156 of its 1,214 square miles under water and a shoreline of 384 miles) introduced into the U.S. Senate, in September 1967, a short resolution aimed at achieving "a reasonable legal order for the extranational world ocean."

The resolution speaks of an "urgent need" for an international agreement to keep the deep-sea floor and its resources free for use by all nations. The agreement would also ban the stationing on the ocean bottom of "unproven types of nuclear or other kinds of mass destruction weapons."

Pell asked that the U.S. State Department take steps leading to an ocean space treaty that would allay any fear that the United States and the Soviet Union "might attempt to carve up the oceans of the world into co-dominions much as the Spanish and Portuguese sought to do with the New World in their agreement at Tordesillas, signed on June 7, 1494."

Just about this time, Malta, a state even smaller than Rhode Island, dropped a similar idea into the United Nations General Assembly. In August 1967, Malta requested that the Assembly's agenda be modified to include an item on "the reservation exclusively for peaceful purposes of the seabed and of the ocean floor, underlying the seas beyond the limits of present

CONTINUED ON PAGE 8

THE UNDERWATER LANDSCAPE OF OUR PLANET

Beneath the enveloping mantle of the oceans lies most of the geography of our planet, a landscape as seamed and rugged as any on earth. Until recently, man knew even less about the submerged 70 per cent of the earth's surface than he knew about the near side of the moon. Today with the aid of new electronic instruments man has mapped the ups and downs of much of the sea bottom. One striking result is this map of the Atlantic Ocean floor (detail of a larger map) reproduced here by special permission of the National Geographic Society, Washington (U.S.A.).
Map shows how the Continental Shelf, a vast underwater platform, juts out from the coasts of North America, Greenland, Iceland, Europe and Africa. Deep gorges and canyons, crevasses and valleys mark the greatest depths. Winding down the middle of the ocean from Iceland towards the equator is the Mid-Atlantic Ridge, an immense oceanic "spinal cord", criss-crossed by deep fractures and flanked by chains of high mountain ranges. Key to figures shown: -12,000, depth in feet below sea level; *(14,000)*, height above the 16,000-foot average depth in the abyssal plains; 9,000, height in feet above sea level on islands and continents.


ICELAND
Reykjavík
SURTSEY
Godthåb
-7800
-2160
REYKJANES RIDGE
FAEROE ISLANDS
LOUSY BANK
-6450
-594
CONTINENTAL SLOPE
ROCKALL
-1740
(14260)
-9510
-10500
MID-OCEAN CANYON
-462
(15538)
BRITISH
ISLES
-306
(15694)
ISLAND OF NEWFOUNDLAND
-14760
-15420
-168
FLEMISH CAP
-4500
(11500)
BISCAY ABYSSAL PLAIN
MIQUELON ISLANDS
-42
GRAND BANKS
-330
-15420
-15400
MILNE SEAMOUNT
-336
(15664)
RIFT VALLEY
-17280
-17700
LAURENTIAN CONE
-15300
-15900
IBERIAN PENINSULA
AZORES
Pico
7615
(23615)
Lisbon
SOHM ABYSSAL PLAIN
-17400
OCEANOGRAPHER FRACTURE ZONE
-16680
CORNER SEAMOUNTS
AMPERE SEAMOUNT
-132
(15868)
-4500
-870
-12000
MID-ATLANTIC RIDGE
6106
MADEIRA ISLANDS
-9342
-960
(15040)
Jebel Toubkal
13665
ATLAS
-18300
-17820
-15000
-1470
(14530)
-12600
-12000
CANARY ISLANDS
12198
(28198)
-13200
-18624
-16200
-6978
(9022)
-13500
-12844
-17060
CAPE VERDE ISLANDS
KRYLOV SEAMOUNT
-4260
9281
(25281)
BERANN
-17753
Dakar
GAMBIA ABYSSAL PLAIN
-15748
-15994
-8333

270,000,000,000 tons of heavy water

national jurisdiction, and the use of their resources in the interests of mankind."

In an accompanying memorandum, Malta suggested that the "net financial benefits" that would come from use of the sea floor should be used "primarily to promote the development of poor countries." An international agency could be created to assume jurisdiction over the ocean floor as a trustee for all countries.

One of the main proponents of such a solution has been Dr. Francis T. Christy, Jr., of Reseach for the Future, Inc. in Washington, a non-profit corporation financed by the Ford Foundation. Christy discounts the feasibility of simply extending each country's continental shelf as it is exploited.

Under such a "national lake" approach, the French and the British could lay claim to vast areas of the Pacific, Atlantic and Indian Oceans because of their island holdings (the Geneva Convention gives islands the same rights as the mainland). The Soviet Union, with its comparatively small coastline, would be short-changed and, Christy remarks, no ocean regime can be set up without its agreement.

The second possibility he mentions is that of the "flag nation". Anyone could operate on the ocean floor under the protection of his own country but competition and conflict would inevitably call for supra-national rules anyway. Christy concludes that the answer is an international authority that could collect royalties from the the seabed miners in the deep ocean, and in return guarantee their exclusive rights to a deposit.

THE U.N. General Assembly started to discuss Malta's idea in November 1967. Dr. Arvid Pardo, the Maltese delegate, provided more details about the international agency that his government had in mind. The ocean floor, he believed, could not very well become the responsibility of the U.N. in its present form: "It is hardly likely that those countries that have already developed a technical capability to exploit the ocean floor would agree to an international regime if it were administered by a body where small countries, such as mine, had the same voting power as the United States or the Soviet Union."

Pardo suggested a new agency that could finance itself by income from rental of the ocean floor. If the agency were created in 1970, its gross income could reach $6,000 million a year by 1975, a sum that could be transfused into the underdeveloped world. Two months later, the General Assembly adopted its resolution setting up a committee of thirty-five countries to study the item in view of future action.

Malta's suggestion kicked up a curious storm in the United States. Strong reactions were heard in the halls of Congress against the idea of turning the sea floor over to the United Nations (which Pardo specifically said he did not have in mind). Florida seems to have led the attack.

One of the state's congressmen, Representative Paul G. Rogers, proposed an eastward ho! alternative. He urged that the United States should occupy the sea floor out to the Mid-Atlantic Ridge by 1980. "The sea bottoms off the United States present an opportunity to expand our national borders in the same manner we did as we crossed the West in the early days."

In October 1967, Florida's governor, Claude Kirk, went down in the underwater research vessel *Aluminaut* and planted the flags of his state and the United States on the bottom, eight miles off Miami, at a depth of 1,000 feet. When he came up, he explained to the press: "I didn't make a fanfare about this thing because we would have had eighteen senators and the federal government protesting. Well, it's too late now. You should dismiss the question of boundaries when talking about the ocean bottom. It is only a question of possession. That's the way the Spaniards did it. They just said 'it's mine' and took it. The United States should do the same."

Eighty-six members of Parliament for all British parties do not see things his way. In May 1968, they tabled a motion in the House of Commons that asked, as Pell had done in the U.S. Senate and Malta in the U.N. General Assembly, for a treaty to conserve the sea floor as "the common heritage of mankind."

Elsewhere, it has been hinted that the strongest backers of the Malta plan were large companies with a stake in the sea. Their support was attributed to their business sense, not to a sudden infatuation with the U.N.

Yvonne Rebeyrol, who covers oceanography for *Le Monde* in Paris, wrote: "They [industrial firms] are the most eager of all to see a settlement of the legal problems raised by the exploitation of the resources of the ocean bottom. In fact, they cannot start to invest heavily on the bottom until they are certain they will not be evicted by someone else who, for example, could claim prior discovery or rights under a national law."

The debate among parliamentarians, economists, jurists and diplomats shows that the land world is becoming aware of the built-in internationality of the ocean. The oceanographers are involved in dozens of international organizations, the oldest being the International Council for the Exploration of the Sea that dates back to 1901, when it was founded in Copenhagen by countries of north-western Europe.

Dr. Arthur Maxwell, associate director of Woods Hole, has gone so far as to say that "the oceanographers have arrived at a position where they are actively considering a public order of the sea quite independently from the efforts taking place in international law circles."

Maxwell, who is equally at ease at sea or in a U.N. working group, traces the first major co-operative effort in oceanography back to the International Geophysical Year, which ran through 1957 and 1958. It was based on enlightened self-interest: "While the motivation of the organizers of this effort was co-operation on a world-wide basis, its acceptance among the oceanographic community was at least in part an economic necessity. Support for oceanography had been fluctuating widely and this international programme provided a salvation."

The scientists then convinced their foreign ministries to support an Intergovernmental Oceanographic Commission, which came into being under Unesco's wing in 1960, with the late Anton Bruun, a Danish deep-sea biologist, as its first chairman.

ONE of the Commission's earliest moves was to turn all its members' guns against a proposed international research vessel. The oceanographers knew what they were doing. Instead of one ship performing international research, they have since had dozens—their own. The Commission offers them a way to combine their resources, represented by land laboratories as well as by ships.

Such resources are not the monopoly of a single country. The United States, it is generally agreed, spends more than anyone else on the ocean. Its federal marine science and technology budget has been growing lustily: $333 million in the 1966 fiscal year; $409 million in 1967; $447 million in 1968.

The proposal for fiscal year 1969 was $516 million, an increase of 15 per cent, but still only 3 per cent of the $17,000 million that the federal government devotes to research and development. In 1967, the United States had 125 oceanographic ships.

In a report to the U.N., the U.S.S.R. has stated that its annual expenditures on oceanography run to $20 million and that it operates 110 vessels. Comparisons are difficult to establish and are always being made. In the United States, there is a tendency to speak in public about "catching up with the Russians" whenever funds are being sought. American oceanographers who visited the U.S.S.R. have told me that their Soviet colleagues tend to use the same argument for the same purpose.

There is certainly a similarity in attitudes about the sea. The following quotation must sound familiar to Western readers: "More than 40 chemical elements have been discovered in sea water. There are more than 10 billion tons of gold, four billion tons of uranium and 270 billion tons of heavy water [the author uses "billion" in the U.S. sense, 1,000 millions] to say nothing of the fact that the sea contains 97 per cent of our planet's wealth in water. The ocean is a storehouse holding all the minerals of the globe. If they were gathered and spread evenly over the earth's surface, they would form a layer more than 200 metres thick."

It is from an article entitled "Seven Seas," by A. Grinevitch, in *Yuni Technik* (Young Technician), a popular Soviet science magazine aimed at young readers. The issue also contains articles on the polar seas, whaling, ships of the year 2000 and a piece by Jacques Cousteau, who starts by telling *Yuni Technik's* audience: "Mystery *is* a challenge I cannot resist."

There is a difference between the usual Western presentation of the subject and the Russian approach: Grinevitch talks of six seas (those of the physicists, the biologist, the geologist, etc.), and adds a "poet's sea." A Soviet captain describes an area in the Mediterranean: "A handful of amber beads is scattered over the blue Aegean. Garlands of yellow pebbles fill the waters between the Greek and Turkish shores; their many rows cross the sea, and along the southernmost strand of the necklace of islands, there hangs the mysterious amulet of Crete."

To learn more about Soviet oceanography, I called on an old acquaintance, Dr. Konstantin N. Fedorov, a physical oceanographer from Leningrad who worked for the Institute of Oceanology of the U.S.S.R. Academy of Sciences. He now doubles in brass as head of Unesco's oceanography office and secretary of the Intergovernmental Oceanographic Commission (and manages to do valid scientific work during his weekends). No interpreter was needed: Fedorov's English is as fluent as his Russian, and his French is not far behind.

He thought that American and Soviet oceanographic efforts are now running parallel, though at their very origin they stemmed from different sources: the practical needs of the seaman and the fisherman in the United States, and basic scientific curiosity in the U.S.S.R. "During the eighteenth and nineteenth centuries, attempts were often made to study the ocean as part of Russia's major geographic exploratory efforts. The great Russian scientist-explorers were always assured the active support of the Academy of Sciences. Ever since its creation by Peter the Great, the academy has never been a passive club of academicians."

A major stimulus to Soviet oceanography was the early exploration of the Arctic. "Little is known outside Russia of the dramatic history of the Arctic seas. They were our only free route to the Pacific: to Japan, to the Aleutians, and to Alaska, our source of furs and gold. Beginning in the seventeenth century, Russian explorers went east along the Arctic coast in summer. This economic drive was the basis of our present efforts in Arctic meteorology and oceanography. On the northern route, the U.S.S.R. runs one of the few existing oceanographic services in the world. It serves shipping bound from Archangel and Murmansk to Vladivostok."

Fedorov himself came into oceanography through meteorology. In 1947, he graduated from a technical college in his native Leningrad with the diploma of meteorological observer. "Our diplomas are narrowly specialized, true, but they are based on a very broad education. The technical college also offered a course in descriptive and physical oceanography. It interested me, and I chose it for my higher education and more advanced work for my Ph.D."

His first expedition took him to the Baltic and the Barents Seas. Later, he worked in the Black Sea and the Pacific, and in 1959, he was chief scientist aboard the *Akademik Vavilov* when she made the first Soviet research expedition to the Mediterranean. Following that trip, he went to England to study at Liverpool University and the Imperial College of Science and Technology in London on a Unesco fellowship.

FEDOROV has also sailed on an American ship, Woods Hole's *Atlantis II*, during the International Indian Ocean Expedition in 1965. This cruise—his idea of a vacation from his office in Paris—gave him an opportunity to work with Henry Stommel, an American oceanographer, on the study of differences in temperature and salinity over depth ranges of only a few feet—the new field of micro-oceanography.

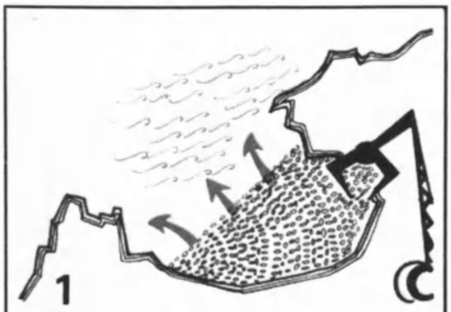
He knew of Stommel from his writings. "His works were among the first scientific books that I studied in English. Practically every research oceanographer in the Soviet Union reads English. Later, I met Stommel at a meeting of our Commission's scientific advisory group in Moscow. He is one of those scientists—I only know a few—like Lev Zenkevich, the father of marine biology in the Soviet Union, or Roger Revelle, or Vsevolod Zenkovich, the coastal geomorphologist, or Walter Munk—who have both stature and unlimited human qualities." Stommel and Fedorov published a joint paper on their research.

Fedorov saw no difference between *Atlantis II* and Soviet vessels in the organization of work at sea and the spirit in which it was carried out. "On both American and Soviet ships, many crewmen participate voluntarily in scientific observations: bird-watching or surface fish-catching. When one of our ships is on station at night, sailors lower a lamp into the water and catch fish. It's a sport, of course, but they don't eat the fish They give them to the scientists for their collections. I think that, like *Atlantis II*, we get the type of sailor

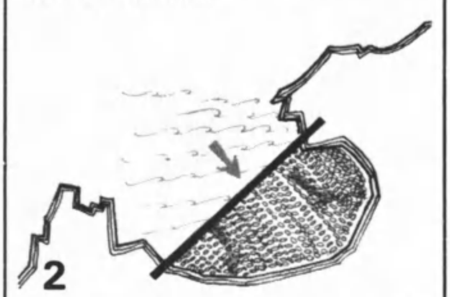
CONTINUED ON PAGE 12

MINING SEAFLOOR URANIUM

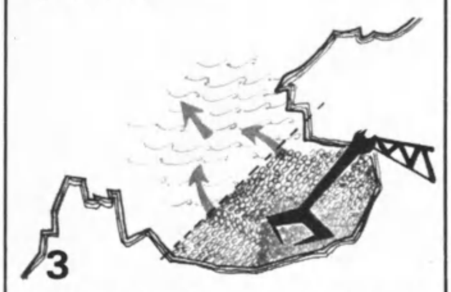
Century after century, water washing off the land has deposited in the oceans every mineral known to man. Scientists are now devising new ways to "mine" the ocean's uranium which totals four billion tons. Drawings below explain the functioning of a huge "uranium trap" to be set up on the coast of North Wales.



Nodules of titanium hydroxide, a "magnet" for uranium, are placed on the beach at low tide.

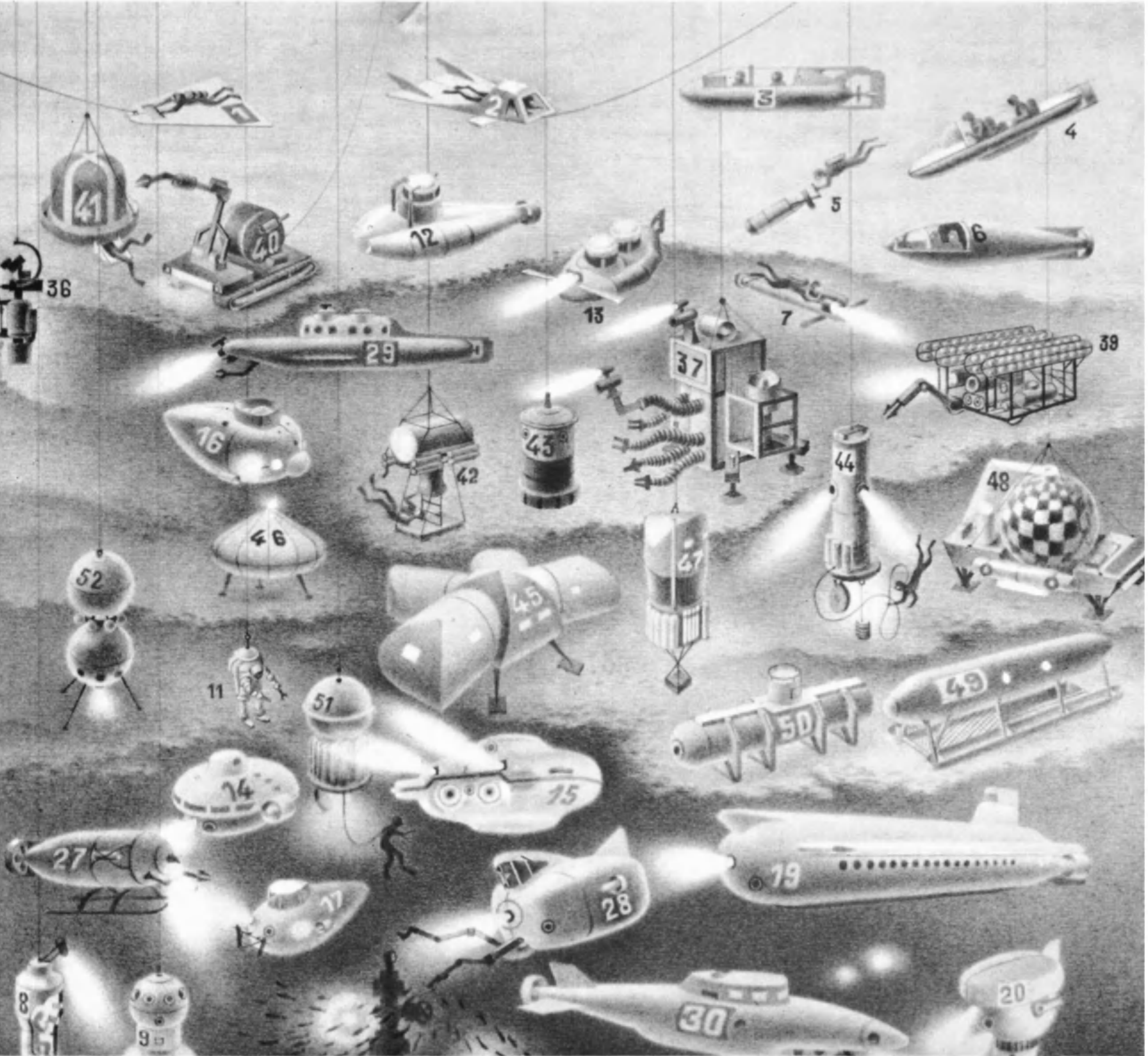


The rising tide covers the nodules. A barrage is placed across the bay to trap the seawater.



Two days later the barrage is removed. Nodules, on which uranium has combined with the titanium hydroxide, are recovered at low tide.

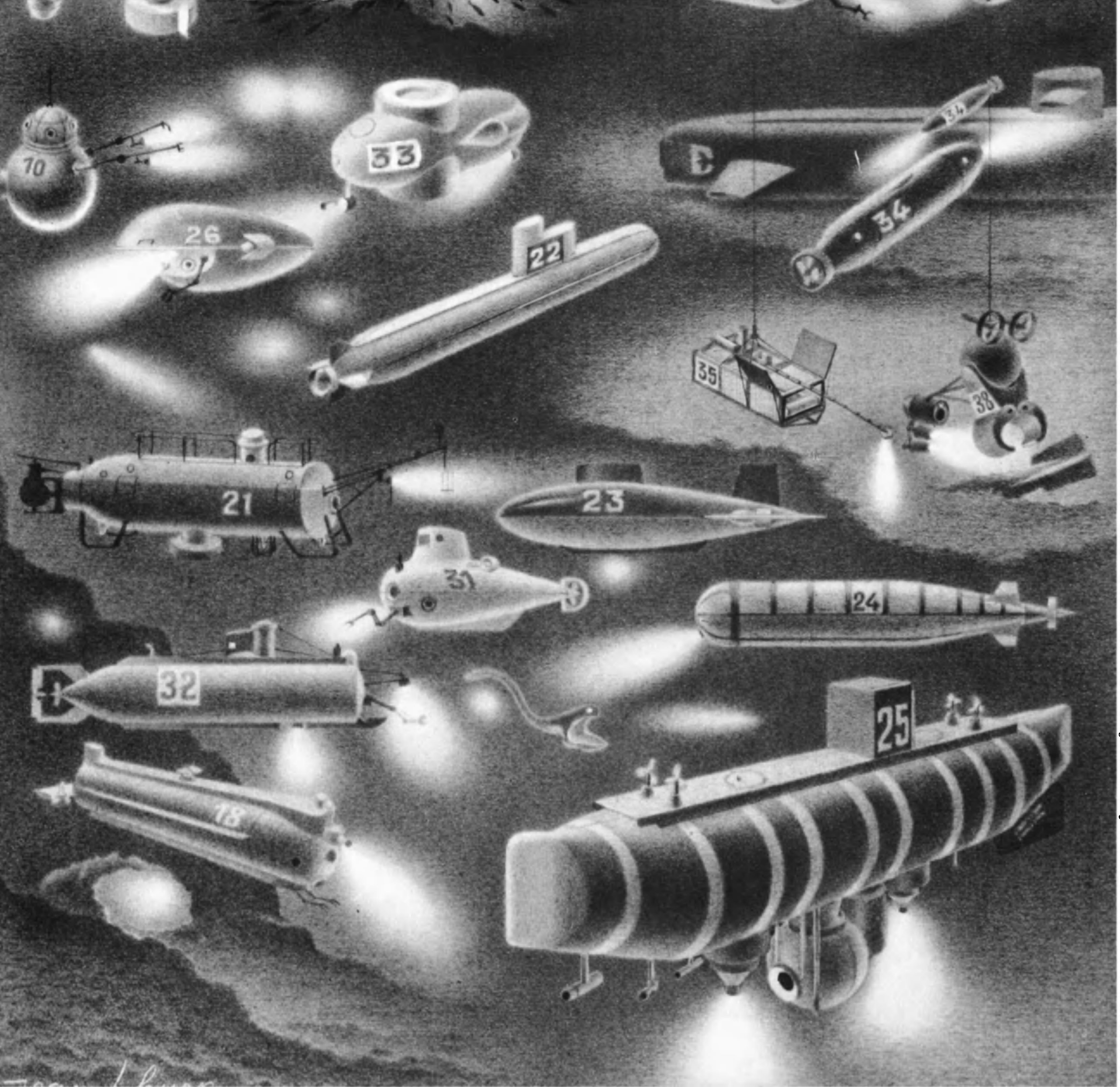
Photos © Science Service, Paris



For aquanauts of inner space

To explore the ocean depths—the still mysterious "inner space" of our planet—scientists and engineers have designed and built a formidable array of vehicles, from underwater gliders to deep-diving submersibles. On this double page we show a broad selection of these unique devices of oceanographic research. These vehicles have been built by Belgium, France, Italy, Japan, U.K., U.S.A., U.S.S.R. and Switzerland. The maximum operating depth of each vessel shown here is given in metres, abbreviated m.

1. *Manta* underwater sled, 30 m.
2. Sub-aquatic glider, 30 m.
3-4. Two-man submarines, 30 m.
5. *GRS* marine scooter, 30 m.
6. *X-engine,* 2 men, 30 m.
7. One-man *DSV* scooter, 30 m.
8. One-man diving turret, 600 m.
9. One-man *Galeazzi* diving turret, 600 m.
10. *Barton* sphere with manipulating arms, one man, 1,400 m.
11. *J.S. Peress* heavy diving suit, 200 m.
12. *American Submarine 600,* 2 men, 200 m.
13. *American Submarine 300,* 2 men, 100 m.
14. *Pisces* vehicle with mechanical arms, 2 men, 1,500 m.
15. *Diving saucer* with mechanical arms, 2 men, 300 m.
16. *Benthos V* observation vehicle, 2 men, 200 m.



From "Pétrole-Progrès". Drawing Jean Lhuer. Photo Friedlander

17. *Star II* research vehicle, 2 men, 200 m.
18. *Aluminaut* deep submersible, 5-6 men, 5,000 m.
19. Piccard *Mesoscaph,* 40 passengers, 800 m.
20. *Deep Jeep* observation vehicle, 2 men, 600 m.
21. *Kuroshio II* fisheries research vehicle, 4 men, 200 m.
22. *Dolphin* acoustic and oceanographic research vehicle
23. *Deep Quest*, exploration vehicle, 4 men, 2,000 m.
24. *Moray TV 1 A,* deep research vehicle, 2 men, 2,000 m.
25. *Bathyscaph Trieste I,* deep research vehicle, 2 men, 12,000 m.
26. *Deep Star 4000,* research vehicle, 3 men, 1,300 m.
27. *General Mills* submersible (designed but not built)
28. *Beaver* submersible to service underwater oil wellheads, 2 men, 200 m.
29. *Perry Cubmarine* with mechanical arms, 2 men, 200 m.
30. *Star III* observation vehicle, 2 men, 600 m.
31. *Alvin,* first operational scientific research submarine, 2 men, 2,000 m.
32. *Yomuri,* fisheries research vehicle with manipulators, 6 men, 300 m.
33. *DOWB* research and deep ocean engineering vehicle, 2 men, 2,200 m.
34. *DSSP* submarine rescue vehicle, 1,000 m.
35. Underwater photographic device, towed observation robot, 1,500 m.
36. *Mobot,* for oil drilling; hears, sees, swims, turns screws and handles tools, 100 m.
37. *Unamo,* multi-task robot with auxiliary engines, 100 m.
38. *Solaris,* robot for locating and retrieving objects, 1,500 m.
39. *Télénaut,* cable-controlled research vehicle, with mechanical arms, 1,000 m.
40. *GMI-RUM* cable-controlled, tracked vehicle for collecting seabed samples, 3,000 m.

41-42. Inflatable diving bells for aqualung divers; *Sea Igloo* (50 m.), *SPID* (100 m.).

43-44. *Galeazzi* turret and *Sea Diver* bell, equipped with air lock, bases for aqualung divers, 150 m.

45. *Etoile de Mer (Pré-continent 2),* seabed base for aqualung divers, 30 m.
46. Diving saucer garage *(Pré-continent 2),* 30 m.
47. Underwater cabin *(Pré-continent 2),* two men, 50 m.

48, 49, 50. Seabed bases for aqualung divers; *Pré-continent 3* (60 m.), *Sealab I* and *II* (80 m.)

51-52. *Ocean System* and *Purisima* diving bells with air-locks, 150 m.

Photo Bibliothèque Nationale, Paris

According to legend, Alexander the Great, in the 3rd century B.C., was lowered into the sea in a glass barrel "to see what was there and to defy the whale" (from a 15th century manuscript, below). Leonardo da Vinci designed submarines and diving gear and is said to have made a descent in a diving bell. Above, a 17th century one-man diving bell, ballasted by a large lead ball. Water penetrated the bell to the point where it equalized the air pressure.

Mobile houseboat for

who doesn't go to sea just for the money."

I asked Fedorov a question that keeps popping up: why are Soviet research ships so big. The largest is the veteran *Ob*, displacing 12,000 tons, and several newer vessels run to 6,000 tons, three times the size of *Atlantis II*. "There are several reasons. The boundaries of the U.S.S.R. are such that our ships cannot keep returning to Soviet ports. It is not profitable for them to pay for supplies in foreign ports. Fuel, for example, is much cheaper at home. So voyages must be long. A large ship offers more comfort for the scientific team and much more of a cultural life for both the scientists and the crew."

Fedorov confirmed what I heard from American visitors to the Soviet Union who were struck by a solid emphasis on details in oceanographic work. "We're very pedantic in scientific work. When we make observations, we bring along not only great scientists but a host of intermediate characters. They take a student by the ear and they give him a smack if he is careless. This is an absolute must, from the point of view of methodology. You must enforce standards of observation when you deal with a changing environment—otherwise, your measurements will change more than the environment."

Marine science in the U.S.S.R., he explained, has three main bases: the Academy of Sciences, responsible for basic research in the world ocean; the All-Union Institute of Fisheries and Oceanography; and the Hydrometeorological Service, which provides forecasts for fisheries and shipping.

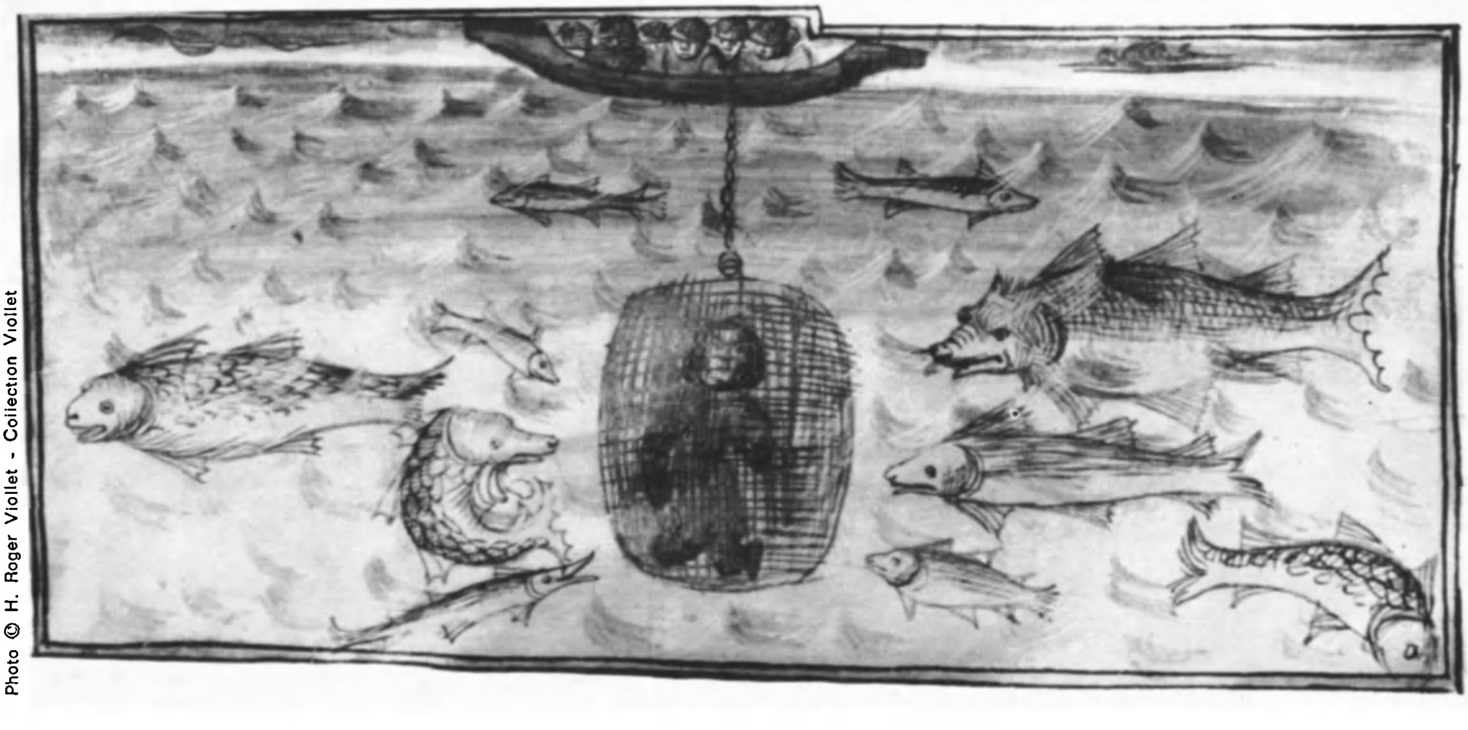


Photo © H. Roger Viollet - Collection Viollet

deep-sea divers

They are co-ordinated by a State Committee of Science and Technology under the Soviet Council of Ministers.

Fedorov, who never neglects a chance to score a point in the long and usually friendly debate that we have had over the years, reminded me that the U.S.S.R. brought the ocean into national affairs as early as 1921, when Lenin issued a decree establishing a "Floating Marine Science Institute" at Murmansk aboard a research vessel, the *Perseus*.

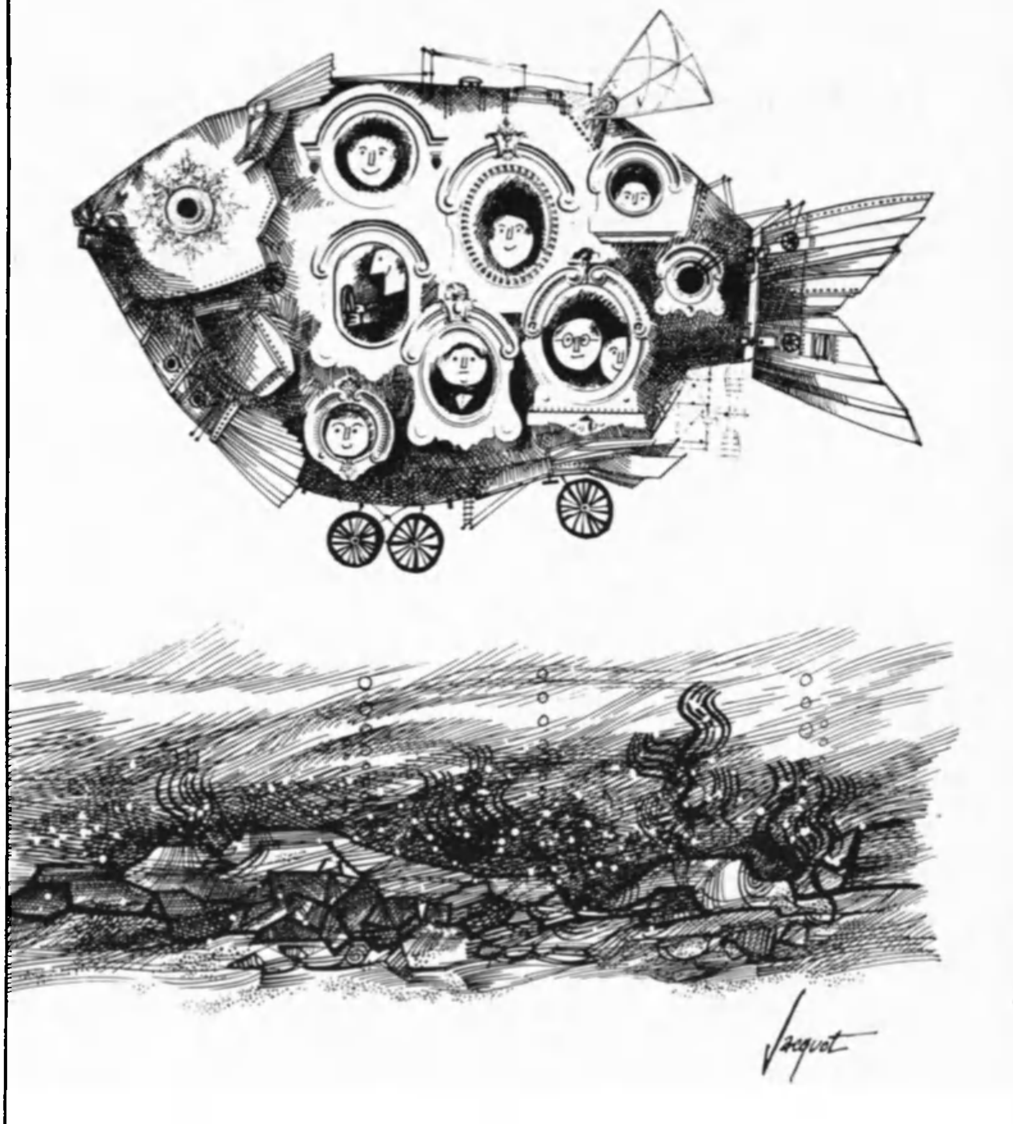
Behind the Soviet Union and the United States, money spent on oceanography falls off sharply, but there is no corresponding dip in quality. *Discovery* in Great Britain, *Meteor* in the Federal Republic of Germany, *Jean Charcot* in France are every bit the equal of American and Soviet ships, and laboratories are at the same level. Unlike space—a rich man's game—oceanography can be played by the moderately well-off.

TOTAL British expenditure on oceanography is less than $8 million a year, funded through a Natural Environment Research Council, which also finances activities in conservation, marine biology and Antarctic exploration.

The National Institute of Oceanography at Wormley in Surrey must get along on an annual budget of $1,800,000 that includes operation of the 2,800-ton *Discovery*. Frills are few and far between at the institute's laboratory, where offices are spartan and secretaries a collector's item.

There is no scrimping on the ship: she is fitted out as a small liner, on the theory that scientists get more work done when they live well. British oceanographers whom I met shuddered, when they recalled the steel decks of American vessels and the ordeal of going to breakfast without a cup of morning tea served in one's cabin by a cheery steward. *Discovery*'s size and comfort are considered an economy: she can work throughout the North Atlantic winter, and nothing costs more than a ship in port.

The Federal Republic of Germany is on pretty much the same tack as the British. The Ministry of Scientific Research pays the bills for the new $4-million *Meteor*, a magnificent 2,740-ton ship equipped with a dozen laboratories to work in all branches of oceanography. The German Research Society enabled her to carry out a notable cruise that studied both the geology and the inhabitants of seamounts in the North-East Atlantic, particularly the Great Meteor Seamount, a peak rising from a depth of 15,000 feet up to 900 feet and



A Sunday drive in the family fish, a humorous view of submarine travel tomorrow by the French cartoonist, Pierre Jacquot.

discovered by the first *Meteor* in 1938.

The cruise was led by another marine internationalist, Professor Günter Dietrich, head of the Institute of Oceanography at Kiel University. Dietrich was elected president of the International Association for the Physical Sciences of the Ocean in 1967 and he stuffs the *Meteor* with foreign scientists (on the seamount cruise, he had sixteen aboard from France, Great Britain, Norway, Portugal and Spain).

He once told a writer for *Science*: "When we were at the zero point of our existence in 1945, there was one commander who came as supervisor for oceanography from the British navy to our country. He did not come as a conqueror who drove the oceanographers in all directions... He gave them chances to work in Hamburg and Kiel... If oceanography revived in the Federal Republic of Germany, it was by his help. This was Dr. J.N.C. Carruthers of the National Institute of Oceanography."

A French government survey has counted 500 Frenchmen working in oceanography at no fewer than 100 laboratories. The statistic sums up the brilliant individualism that characterizes the French. While their country devotes but $26 million a year to all forms of marine science, they are present everywhere: whether in diving and underwater living, deep-sea tide measurements, biological studies in the deepest ocean with the bathyscaph *Archimède*, or the use of manned floating islands.

A National Centre for the Exploitation of the Ocean has been set up by the French government to harmonize these commendable, if somewhat disjointed, efforts. The centre operates the *Jean Charcot*, a new 2,200-ton ship, and is establishing a large oceanographic laboratory at Brest. As priorities, it has chosen the development of marine protein concentrates for food, aquaculture, the mapping of the continental shelf, deep-diving techniques, the prevention and cure of pollution, and air-sea interaction research.

It has contracted with Cousteau's Centre for Advanced Marine Studies at Marseilles for a new diving saucer that will take a pilot and two scientists

CONTINUED ON NEXT PAGE

The Mediterranean — ideal site for polar studies

down to 10,000 feet. Also under construction in co-operation with the French Petroleum Institute is a 230-ton submarine that is really a mobile houseboat for divers, rendering them independent of a surface ship and attendant risks of bad weather.

A new floating island will replace the first version that has been in the water since 1963 as a house sitting on top of 210 feet of pipe, with 160 feet below the waterline (it cannot be flipped; once it is down, it stays vertical even when it is towed). It has spent most of its working life anchored between Nice and Corsica, staying for as long as two years at a stretch.

Its main user has been the laboratory of Professor Henri Lacombe, who started the first modern course in physical oceanography in France in 1948. Members of Lacombe's staff, based at the Paris Museum of Natural History, take turns living on the buoy to run an ocean data station. They try to correlate what happens in the sea with the atmospheric records kept by meteorologists less than a hundred miles away.

"That is the advantage of working on air-sea interaction in the Mediterranean," Lacombe said. "It is caged by a network of land stations." To study these processes on a smaller scale, he is also creating a sample ocean 130 feet long, 10 feet wide and 3 feet deep, to be used with a wind tunnel. Professor Alexandre Favre, director of the Institut de Mécanique Statistique de la Turbulence at Marseilles, is in charge of this work.

Lacombe considers the whole Mediterranean as a miniature ocean where processes can be studied with greater ease and accessibility. He and Dr. Paul Tchernia, his assistant director, put the finishing touches to the solution of the ancient riddle of why the Mediterranean doesn't overflow despite the current that rushes into the Straits of Gibraltar from the Atlantic.

The presence of an opposing undercurrent in the straits had long been known (and put to use during World War II by Italian submarines that rode it silently out into the Atlantic past British listening posts), but the Mediterranean's water budget was still uncertain. Using measurements obtained by ships of five nationalities, in a one-month survey of the straits, Lacombe and Tchernia concluded that about 31,600 cubic kilometres of water enter the Mediterranean from the Atlantic every year and only 30,000 slip out below. The missing five per cent represents evaporation by Mediterranean sunshine.

Despite the sun, Lacombe also finds the Mediterranean an ideal place to study the formation of deep water under "polar" conditions normally found only off the Greenland ice cap and Antarctica. During a cold European winter, the Mediterranean off the Riviera behaves almost like the Labrador Sea: surface water chilled by cold winds grows denser as it cools, then sinks to mix with underlying water and thus contributes to the formation of bottom water. What happens to it after that is of importance not only to physical oceanographers but to researchers in marine pollution who wish to know the fate of dangerous wastes buried in the deep.

Movements of bottom water are influenced by "sills" in the seabed, another feature that the Mediterranean offers in abundance for convenient examination. Lacombe told me of a study of the process of deep water formation in the north-west Mediterranean that he hopes to carry out with the participation of American, British and French vessels. Very detailed observations are to be made with new techniques to follow "mini-features" of temperature or salinity characteristics and to try to get at the underlying processes.

Lacombe served as chairman of the Intergovernmental Oceanographic Commission from 1965 to 1967. He manages to remain active in teaching and research, yet finds time for international affairs. It is something of an act of faith. He once wrote: "Will man be able to see the ocean's unity as an image of the need for a unity of efforts, a sharing by nations of their capacity for discovery so they can first explore and then exploit an area that is intrinsically almost entirely international and open to all—open to hopes but also to ambitions?"

As chairman of the Commission, Lacombe was busy with legal matters. The status of buoys drifting or anchored in mid-ocean is a subject for discussion; so is freedom of research itself, which was set back, many feel, by the convention on the continental shelf. Under the convention, the country owning the shelf must give permission for research there, and scientists are complaining that it can take longer to get a permit than to do the work.

Lacombe sees two distinct viewpoints here: "The Americans and the British prefer to look at an issue case by case before trying to frame rules; the Soviets, and to some extent, the French and the Latin countries, want to study all aspects at once and move immediately to a convention."

The Commission has sixty member countries, but no budget of its own, no building and no bureaucracy. Administrative housekeeping arrangements are provided by Unesco at a cost of $50,000 to $80,000 a year, as compared to the $10 million to $20 million a year that the Commission's members have devoted to international co-operative expeditions.

The most recent of these expeditions is a study of the Kuroshio (its name means "black water" in Japanese), the western Pacific's equivalent of the Gulf Stream. It has been carried out by eight countries and thirty-six vessels, with Japan making the greatest contribution. In 1963 and 1964, an international co-operative investigation of the tropical Atlantic was conducted by the same number of nations using thirteen ships.

The Commission's largest single effort has been the International Indian Ocean Expedition from 1959 to 1965 that launched an armada of forty research vessels under fourteen flags, with nine more countries participating in shore operations.

On the oceanographers' charts, the Indian Ocean was one of the last great blanks; even data from commercial shipping had dwindled since the opening of the Suez Canal.

It was also the site of the kind of natural experiment that every physical oceanographer dreams of performing. To see the effect of the wind on the circulation of the sea, he would dearly love to switch it on and off. In the Indian Ocean, he has the seasonal reversal of the winds with the monsoons. Geologists wanted to learn if their ridge system continued into the Indian Ocean; biologists were interested in the actual productivity of an ocean that accounts for 25 per cent of the area of the sea but only 5 per cent of its fish catch.

No single nation could mount such an undertaking. The major oceanographic powers sent ships, but so did Australia, India, Indonesia, Pakistan, Portugal, South Africa and Thailand. The expedition was started by the Scientific Committee on Oceanic Research (SCOR) of the International Council of Scientific Unions, an organization that groups scientists in their professional capacities, not as delegates of governments.

Later on, the expedition was co-sponsored by SCOR and Unesco, while the Intergovernmental Oceanographic Commission took over its co-ordination. Its implications for weather and fisheries became the respective concerns of two U.N. agencies: the World Meteorological Organization, and the Food and Agriculture Organization.

Tangible results were produced by the free-roaming ships. The great wind experiment was a success. During the south-west summer monsoon, Soviet, British and American ships investigated the Somali Current along the coasts of Arabia and Africa. It races north at speeds up to seven knots—almost twice as fast as the Gulf Stream.

The Somali Current turns sharply away from the Arabian coast. To replace it, cold water—55 degrees F., the coldest surface water anyone has ever found so close to the equator—rises and brings up nutrients. It is roughly the same upwelling situation that feeds the anchovies off Peru.

It would be comforting to write that a scientific expedition has found fish for the protein-hungry populations on the shores of the Arabian Sea. It would be misleading: the 150,000 tons of fish that are now being taken off the Arabian coast go into the holds of modern Japanese and Soviet trawlers. Antiquated local dhows are unable to work this new offshore fishery.

In the short run, therefore, the expedition has failed to achieve one of its stated purposes: to bring food out of the ocean for Asia. In the long run, the prospects may not be as gloomy. The expedition has given a salutary jolt to marine science in the region, mainly in India, which now has a National Institute of Oceanography of its own at New Delhi.

OTHER results of the expedition are being charted. Scripps Institution has brought out an atlas of the fishery oceanography of the Arabian Sea; Soviet scientists are responsible for a biological atlas of the entire Indian Ocean; Americans at the University of Hawaii are compiling physical and meteorological atlases.

Another heritage of the expedition is an International Meteorological Centre at Bombay that is getting an insight into the vagaries of the monsoon, upon which Indian agriculture depends. The end of the expedition has seen the start of permanent research in the Indian Ocean.

Scientific co-operation on the high seas is now focusing on areas that can be covered more intensively. The latest studies conducted by the Intergovernmental Oceanographic Commission are aimed at the Caribbean and the Mediterranean, two seas that have already been explored but now need to be understood.

What is heartening about both studies is that they give smaller countries a chance to join in oceanography. The investigation of the Caribbean was proposed by the Netherlands; research in the Mediterranean is bringing together countries of North Africa and the Near East under arrangements that permit them to carry out scientific investigations in the same waters.

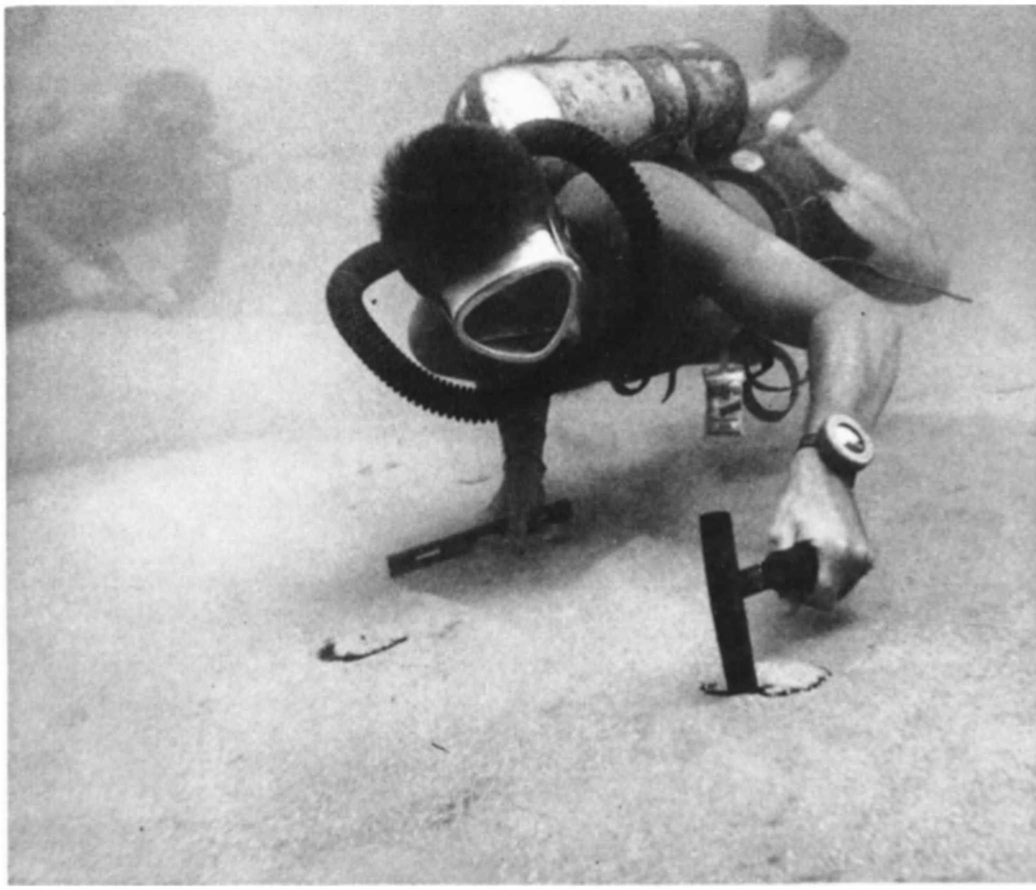


Photo above shows an undersea geologist gathering samples from the seabed as clues to locating fossil-bearing oil beds. One day man may mine the sea floor for cobalt, copper and nickel, using huge vacuum cleaners to suck the minerals up into surface ships, or submarine earth movers to scrape them into submarine mine hoists.