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SHELLBACK Expedition

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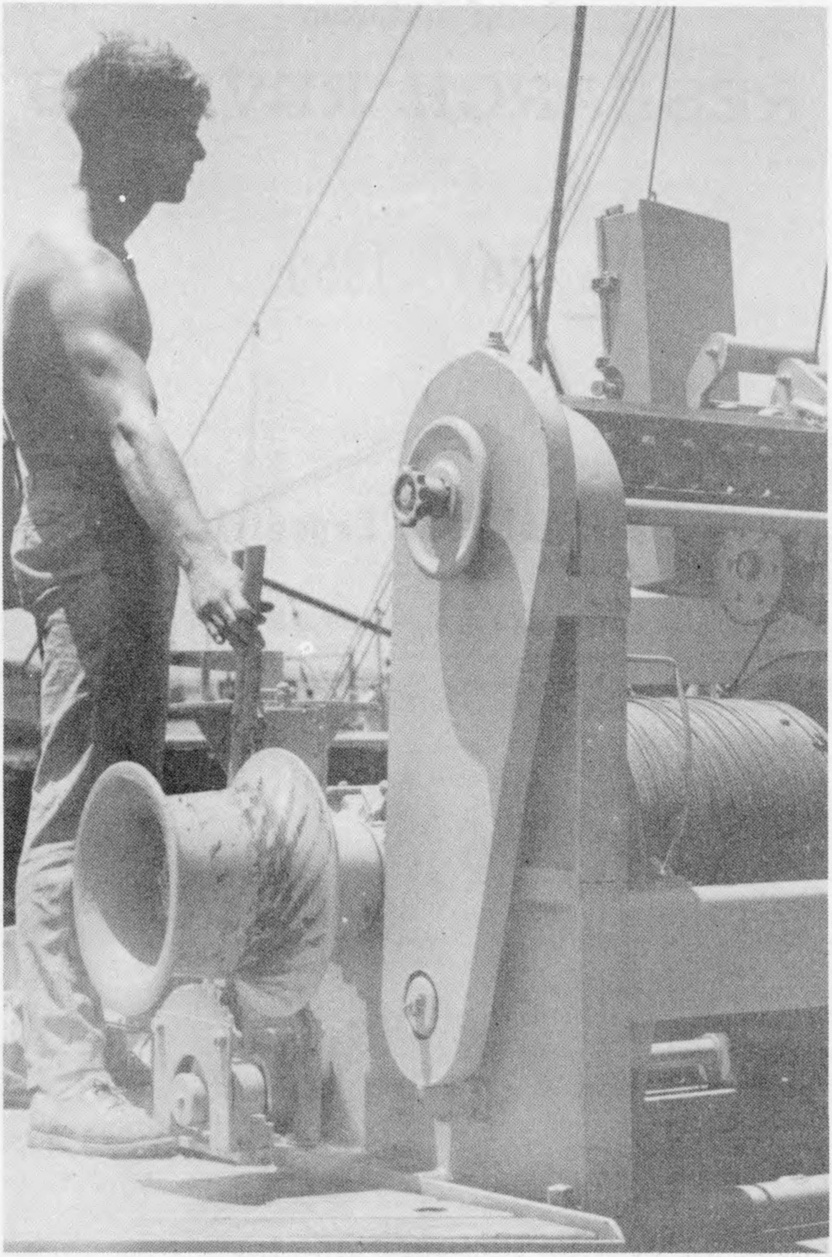

In the study of the oceans, man is largely dependent upon instruments that can be lowered to a predetermined depth to transmit information or bring back actual samples of the water or of the plants and creatures that live in the water. Thus the winch, which lowers these instruments on the end of a steel cable to the desired depth, is an integral part of an oceanographic vessel.

SHELLBACK Expedition

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...of the Geophysics Branch, ONR, participated in the SHELLBACK expedition as an oceanographer. He is working on his Ph. D. in this field at the University of California.

Since 1949 the Scripps Institution of Oceanography of the University of California has conducted, in cooperation with the Navy, a series of exploratory oceanographic cruises in the Pacific Ocean. Now, certainly the Pacific has been explored before. From the British CHALLENGER expedition (1873-76) to the Danish GALATHEA in 1951 and 1952 (Research Reviews, October 1952), various ships and scientists have studied the Pacific Ocean. But of necessity nearly all of these expeditions have had to sample sparsely. It has been the aim of the Scripps cruises, on the other hand, to study certain areas of the Pacific in some detail.

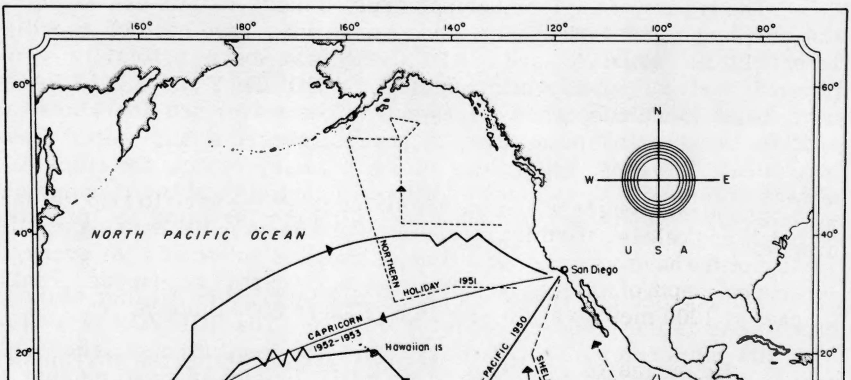
The tracks of the four Scripps cruises made to date are shown on the graph on p. 2. Essentially these expeditions have been of two different kinds. MIDPAC and CAPRICORN have been primarily geophysical and geological while NORTHERN HOLIDAY and SHELLBACK have been more concerned with what might be termed the classical studies in physical oceanography, that is, currents and water mass structure. However, regardless of the primary object, the ships are always crammed with as many additional scientists and their equipment for special projects as can be handled without disrupting the primary program.

The one Scripps vessel which has participated in all four of these expeditions is the research vessel HORIZON. The HORIZON is a 143-foot, 700-ton former ATA (auxiliary tug). The institution sails her with a crew of eighteen and has living accommodations for an equal number of scientists. This ratio (or a higher one) of scientists to crew is one which all private oceanographic vessels in this country try to maintain, since generally speaking the greater the ratio of scientists to crew, the less the "overhead" costs of an expedition.

The SHELLBACK cruise, in which the author participated, was not in any sense a single-institution operation. While the HORIZON was operating in the area shown on the chart, the U.S. Navy Electronics Laboratory's research vessel, the EPCE(R)857, was making measurements to the north, and the U.S. Fish and Wildlife Service, Pacific Oceanic Fisheries Investigation, which operates out of Hawaii, was making a series of stations to the west. Members of the oceanographic branch of NEL worked aboard the HORIZON, and several of the Scripps staff were aboard the EPCE(R). Also aboard the HORIZON were members of the Inter-American Tropical Tuna Commission and the U.S. Weather Bureau. In addition, one of the staff members from Scripps, with the assistance of the U. S. Air Force in Panama, made aerial reconnaissance studies over the operating area. The whole joint expedition was aptly dubbed Operation CO-OP.

The HORIZON left San Diego on May 17 and returned on August 27, 1952. During this period it steamed some 14,580 miles. Eight times it crossed the equator while sweeping back and forth across an area of four million square miles. Its speed of advance, however, was slow because the ship stopped 216 times (every sixty miles) for about two hours to make an oceanographic station. These stations were the real heart of the SHELLBACK cruise, and it might be well to discuss in some detail what measurements were made and what is expected from them.

The essential piece of equipment is a Nansen bottle and its rack of deep sea reversing thermometers. Some 10 to 15 such bottles are spaced along a wire and lowered in an open position down to a depth of about 1500 meters. After the bottles have reached the desired depths, a "messenger" (a small brass weight) is slid down the wire until it hits a lever on the first bottle. It reverses the bottle and thermometer rack and closes the valve on the bottle; in this way a liter sample of water from that depth is trapped inside. As the bottle is reversed it releases



The HORIZON

a second messenger which in turn slides down the wire to trip the second bottle and release the third messenger; and so on until, barring misfires, all bottles have been tripped and water samples collected. At every other station, depth of water permitting, two such "casts" were made, a shallow cast at 1000 meters and a second at 1000 to 3000 meters.

By means of a delicate capillary system within the thermometer, turning the thermometers upside down cuts off the thread of mercury so that the thermometers can be brought to the surface still showing in situ temperatures. These thermometers are accurate to plus or minus .02 degrees centigrade.

For this accuracy to be attained, corrections must be made for the difference between the expansion coefficients of glass and mercury. However, because of this difference in expansion, it is possible to calculate the pressure and hence the depth from the difference in apparent temperatures of two thermometers attached to the same bottle—one in which the thermometer stem is protected from the outside water pressure and one in which it is not. This method of determining depth, which is good to about plus or minus five meters, is considered more accurate than simply measuring the amount of the wire out and correcting for the observed wire angle.

Water from the Nansen bottles was analyzed to determine its content of dissolved salt, oxygen, phosphate, and silicate ions. A network of closely spaced stations such as those made on SHELLBACK allows one to construct charts showing a three-dimensional distribution of salinity, temperature, oxygen, etc. It is then possible, using the temperature and salinity data, to construct charts showing density structure and, from this, to calculate the average current system and water transport. From analysis of the distribution of variables such as these, oceanographers gain insight into some of the large-scale dynamic processes of the ocean. Charts of this type are analogous in some respects to the preliminary mapping that geologists must do before they can begin to study possible causal relationships.

Supplementing the oceanographic stations, an even tighter network of temperature observations in the top layer of the ocean was provided by the bathythermograph, which was used about once every two hours as the ship traveled between stations. This instrument gives a continuous trace of temperature versus depth in the upper 900 feet, where the most rapid changes in temperature take place.

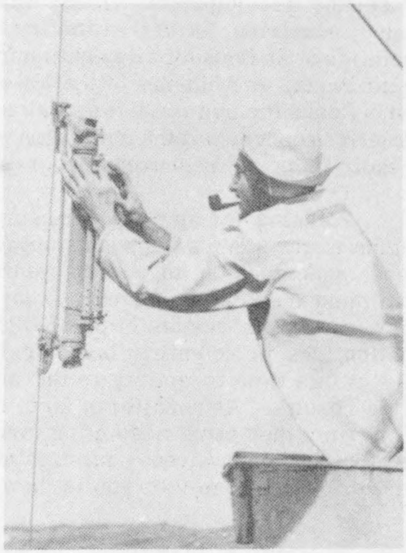
The method described of computing the ocean current structure from an analysis of the density gradients is not entirely satisfactory. The distance between stations, plus the several simplifying assumptions that have to be made in the calculations, mean that the current structure derived at best is only an average one, and that short period variations in time and in space are apt to be masked.

Therefore, another method was used on SHELLBACK to give a more instantaneous picture of the surface currents. Measurements as a function of the electrical voltage of the water were made every twenty miles. These voltage measurements can be related to the velocity of the surface waters but require assumptions as to the ratio of current width to depth. The truth of the matter is that no completely satisfactory method of measuring currents has been devised.

Along with the study of the water masses and ocean current characteristics, there is considerable interest in studying how life within the ocean is affected by changes in these factors. At each station two nets were lowered to sample the biological life. One, which was towed at a depth of 300 meters for twenty minutes, had a mouth one meter in diameter and a recording mechanism that measured the amount of water filtered during the tow. Observations of this type give a measure of variations in the total amount and in different types of plankton (floating-organisms). The other net used regularly was a small one with a 17-centimeter mouth, and with mesh openings of less than a tenth of a millimeter. This net, which was towed vertically through the upper 50 meters, collected even smaller organisms loosely classified by marine biologists as microplankton.

An additional 12 net hauls were made at a depth of about 4000 feet using a large net (with a mouth area of somewhat less than 100 square feet). Tows at this depth with large nets have been made but rarely in the past, and major interest in these hauls was in new or seldom collected species and in the occasional finding at these relatively great depths, of species thought to be indigenous to the surface waters.

On 37 stations water samples were drawn and treated with radioactive carbon. Some time later the sample was filtered and the amount of "carbon uptake" by the residual plankton was measured. These techniques are still in the experimental stage, but it is hoped that they will furnish a quantitative means of measuring plant productivity in the ocean.



Preparing to lower a sampling bottle to obtain data on temperature and salinity at great depths. (Photograph, courtesy of Scripps Institution of Oceanography)

Although, as stated earlier, the primary purpose of SHELLBACK was the study of currents and water masses, both geological and meteorological study programs went along simultaneously. The Weather Bureau personnel made regular surface and upper-air pilot balloon and radiosonde observations, which served two general purposes. They were coded and sent out over the Weather Bureau circuits to be added to the daily weather maps, but, of more lasting importance, they provide a series of upper air sections through the intertropical convergence in an area where few if any such sections exist.

Although no stops were made for coring or dredging the bottom, the ship's two echo sounders were kept running to give a continuous trace of the ocean floor. Occasionally when an unusual feature like a large seamount was passed over, the ship would turn and retrace its tracks, cutting the feature from several angles so that a general contour chart could be drawn. The amount of new information that marine geologists have gathered during and since the war about the morphology of the ocean basins is staggering and will be treated as a separate article at some future time in Research Reviews.

In oceanography, as in all sciences, the feeling of surprise about a new discovery is usually tempered by the long analysis and study that brings it forth. But there are dramatic exceptions. On SHELLBACK one quiet afternoon the echo sounder was etching a steady trace at 2300 fathoms when the pen began to rise, slowly at first, then more swiftly until, before it began to sink, it had traced the profile of a 12,000-foot mountain—a mountain that comes to within 268 fathoms of the surface, a mountain that no one had ever known about before, and which would still be unknown if the path of the HORIZON had been some twenty miles away in either direction.

The ship was gone from San Diego 103 days. During that time it stopped four times to take on fuel and provisions and to exchange passengers. Open house was held aboard the HORIZON at its stop in Lima, Peru. More than 200 guests came aboard at various times to inspect the vessel and its equipment. They represented the Navy, the fisheries and Guano industries, as well as the University of San Marcus and scientific societies. At Ecuador a delegation from the ship paid a visit to President Gallo Plaza, an alumnus of the University of California. Both in Peru and in Costa Rica informal discussions were held with government representatives concerning the Institution's oceanographic work and its relation to their fisheries resources program.

Planning for an oceanographic expedition of this kind, of course, begins many months before its departure, and analysis of the observations made goes on for several years after the ship returns home. As is almost inevitable in such a study, more questions were raised than answered. The results of SHELLBACK will be appearing as individual publications in scientific periodicals for the next few years. It is not fair at this time to anticipate the authors with any preliminary review of the results. As a matter of fact, those conclusions that appear obvious at the time they were made often turn out to be not very obvious after all. As somebody answered a question about results on the day the ship returned, "All I can tell you is how many tons of data I've collected."