

Thomas Washington (ship) concludes 37,886 mile east Pacific voyage

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Total amount of water flowing through the Drake Passage, between the Antarctic continent and South America, is estimated at 270 million tons per second.

A substantial amount of helium is injected into the deep ocean from the earth's interior.

The apparent "collision" of ocean and land off the shore of Peru and Chile has helped form the great Peru-Chile Trench.

These are but three of a number of scientific findings reported as Scripps Institution of Oceanography's research vessel, the Thomas Washington, docked at Scripps' Nimitz Marine Facility in San Diego to conclude a 37,886-mile expedition to the eastern Pacific Ocean.

The Piquero Expedition, as it was designated, was an eight-month, biological, geophysical, and physical scientific exploration of the deep ocean off the west coast of South America and on the continental shelf. Piquero is the common name in Peru for the Peruvian Booby, the dominant bird of the Peru (Humboldt) Current.

Dr. Bruce A. Taft, assistant professor of oceanography and expedition coordinator, joined the cruise as chief scientist at Callao, Peru, in late June and was aboard when the ship returned home August 11.

Scientists who led earlier legs were Dr. Rudolph H. Bieri, specialist in physics; Miss Tanya Atwater, graduate student in marine geophysics; Joseph L. Reid, research oceanographer; Dr. Edward M. Brinton, associate research biologist; Victor Vacquier, professor of geophysics; and Dr. John D. H. Strickland, research oceanographer.

Nearly 100 scientists and technicians from the United States, Chile, Peru, France and the United Kingdom participated in the expedition.

Scripps graduate students taking part, in addition to Miss Atwater, were Jed Hirota, James J. McCarthy, Michael Barnett, Michael Lees, Robherd Lange, Anthony Russo, Forrest E. Steber, Timothy Whorf, Jean M. Francheteau, John W. Hill, Frederick Woy, Elizabeth Venrick, Peter Hacker, James Jones and Francois Revel.

Capt. Noel Ferris and Terry Hansen shared the ship's master's duties.

In the Drake Passage work, five current-meter measurements were made from depths as great as 2 1/2 miles below the surface.

"These, with the measurements of water characteristics we studied, can be used to estimate the total amount of water flowing through the Passage from the Pacific to the Atlantic in the Antarctic Circumpolar Current," Reid said.

"The average daily speeds at the bottom of the Passage varied from 1/20th to 1/3rd of a mile per hour. The width of the Passage is about 300 miles and the average depth a little over two miles.

"The total transport of water through the Passage was estimated at about 270 million tons per second. This is about twice the values estimated previously, without current meters, and about three times the estimated transport of the Gulf Stream."

Dr. Bieri said that seawater contains small amounts of noble gases, such as helium, neon, argon, krypton, and xenon.

"The results from 140 samples collected en route to Antofogasta, Chile, in the east equatorial and southeast Pacific give conclusive evidence that a substantial amount of helium is also injected into the deep ocean from the interior of the earth," he said.

"This helium component probably derives from the decay of uranium and thorium in the earth's mantle and is then transported upward by some as yet unknown mechanism."

He said that of all the other areas searched so far - the North Atlantic, the Drake Passage, and the north and west equatorial Pacific - the deep samples collected in the vicinity of the East Pacific Rise showed the largest excess of helium.

The great Peru-Chile Trench, 26,454 feet deep, that extends from Ecuador to southern Chile along the coast, is believed to have been formed as the result of the apparent "collision" of the ocean and the land, Miss Atwater said.

The ship tracked back and forth across this trench and collected sedimentary and structural evidence of such a "collision" which she said is presumed to be occurring there between two great crustal plates of the seafloor.

"Northern Chile is also cut by very large faults, some of which cross the beach and disappear into the sea," she said.

"We made a detailed survey of the topography and sediments of the continental shelf near Antofogasta and followed the traces of these faults across the shelf to see where they went and whether they have moved in recent years."

Miss Atwater said four earth scientists from the University of Chile were aboard when she was. They stood watches, learned the basic principles of marine geophysics, and took cores for their own studies of erosion and sedimentation.

Before the ship arrived at Antofogasta, the scientists surveyed the Easter Island Fracture Zone, and east-west area of rough underwater mountains west of northern Chile. A previously unknown, planed-off, mountain top, or guyot, some 600 feet below the sea surface, was discovered during the survey.

The ship also stopped at the uninhabited Isla San Felix, at the eastern end of the Easter Island Fracture Zone. "This island is a mile wide and some five miles long, and we tramped all over it in two hours," Miss Atwater said, "collecting rocks, soil, plants, and birds."

James Lewis, representing the Smithsonian Institution, was a cruise guest. His interest lay in making a survey of marine birds, counting, shooting, and stuffing them as the ship sailed along.

Westward from Callao, the scientists prepared maps (1) of surface nutrients required for plant growth (nitrate, phosphate, and silicate), (2) of the size of the plant crop, and (3) of surface temperature and salinity in upwelling regions of the Peru Current.

"Some of these mapping operations were carried out in cooperation with the Peruvian research vessel SNP-1, which mapped, at the same time, the distribution of anchoveta for comparison with Scripps maps of upwelled water," Dr. R. W. Eppley reported for Dr. Strickland, who returned to San Diego during this leg of the cruise because of illness.

Dr. Eppley, an associate research biologist, said these operations were "very successful."

He reported that in certain areas, the nutrient-rich, upwelled water appeared to remain several days at the surface before plant, or phytoplankton, growth commenced.

"We examined some possible reasons for this restricted plant growth," he said, "especially the possibility of intensive grazing of the plants by animals (zooplankton)."

"We took many zooplankton samples for this purpose and for additional studies of grazing pressure in regions of active plant growth. We also measured the growth rate of the plants and their ability to grow with urea as a source of nitrogen."

In an area some 1,000 to 1,500 miles west of Lima and 500 miles to the north and south, the track of this leg of the expedition crossed the Nazca Ridge, a southwest-northeast underwater ridge, followed latitude 22 south to roughly 101 degrees west longitude, and then zigzagged northward.

"This track was laid out for investigating the direction of magnetic anomalies from which the history of the ocean floor can be reconstructed," Professor Vacquier said.

"We found the magnetic field in this area more complex than was believed, and results will have to come from future analysis of the data.

"Heat flow through the ocean floor was measured at 45 stations. Higher heat flow than normal occurs in patches throughout the area; this is new information. Unfortunately, the number of measurements was insufficient for defining the shapes of the anomalous areas.

"All we can say is that there must have been volcanism there during the last two million years or so. This appears to be verified by small samples of fresh olivine basalt brought up by free-fall sample grabbers belonging to the Kennecott Copper Co., whose representative was a guest during the cruise."

From February to April, the distribution and abundance of plankton off the west coast of South America and in the subtropical waters to the west were studied. These areas proved to be extremely contrasting in the amount of crops they support.

"The ship made four crossings of the Peru-Chile Current, each time steaming westward far enough to enter the South Pacific Central water mass, found to be the most barren large body of water yet studied in the Pacific, and as far as we know, anywhere," Dr. Brinton said.

He reported that the intensely fertile part of the northerly Peru-Chile Current was found to be scarcely 100 miles wide off Chile, but it broadens to more than 200 miles off southern Peru.

Using sampling devices that catch plankton at finely spaced distance and depth intervals, the scientists made more than 5,000 collections of these small organisms, plant and animal, which are the basic life resource in the sea.

"In the Peru-Chile Current, production of life in the surface waters is so great that, upon its dying, sinking and decomposing, oxygen is almost completely depleted from a layer beneath the surface," Dr. Brinton said. "This would appear to place an uninhabitable layer next to layers extremely rich in life.

"On leg V, this almost anaerobic layer, in which the amount of oxygen is less than two percent than that at the surface, or only 0.1 milliliter of oxygen per liter of water, was traced westward to 102 degrees West off southern Peru, or 1,500 miles offshore.

"Plankton was sampled above, through and beneath this layer, with a view to understanding how it is tolerated by a large variety of species which were found to daily migrate up and down through it."

He reported that a preliminary scanning of samples indicates that a localized group of species, an endemic fauna, is adapted to this area, while many of the familiar widely ranging tropical and subtropical species are absent from it. Because of the fertility of the Peru area, this localized fauna is extremely rich in numbers of animals, he added.

On Leg V, scientists studied a peculiar mid-ocean fauna that lives in a narrow belt, straddling the boundary between the tropics and the central water mass, near 20 degrees South. These species were discovered in this area in 1958 during Scripps' Downwind Expedition. They are anomalous in that they maintain themselves here in a current that has been presumed to be flowing to the west, though the center of abundance of these particular kinds of animals is on the western side of the ocean, downstream.

"Analysis of the details of the distribution of these species in relation to the measured currents and the presence of nutrients such as nitrates and phosphates found to be high to the north of the zone of interest and almost totally lacking in surface waters to the south of the zone - should help to explain how this peculiar fauna has adapted to live in so restricted a place in the open ocean," Dr. Brinton said.

On Leg 8, after the ship's departure from Callao for San Diego, the vessel steamed northward offshore of the coastal waters of Peru and Ecuador. In the vicinity of the equator a detailed survey was made of a sharp transition zone between cold water brought northward by the Peru Current and the warm tropical waters lying north of the equator in the eastern Pacific. The description of this boundary, which is sometimes referred to as the Equatorial Front, is of considerable importance to acquiring an understanding of the currents between the Galapagos Islands and the coast of Ecuador, according to Dr. Taft.

In addition, the transition zone also marks the northern limit of the range of many Peru Current species to the north and the southern limit of many tropical species. The observed temperature change across this frontal zone was 42.5 degrees Fahrenheit in only 30 miles.

The final leg of the expedition was devoted to the study of the Equatorial Undercurrent, a subsurface current flowing eastward along the equator. At the surface the water flows westward and in the eastern Pacific there is a transition between westward and eastward flow at about 131 feet.

Previous measurements on two Scripps expeditions - the Dolphin in the spring of 1958 and Swansong in the fall of 1961 - showed the water transport of the Undercurrent differed by about a factor of two. The Piquero measurements were designed to see whether the strong flow measured in 1958 or the weaker flow measured in 1961 was present during the summer of 1969. Both the speed and the transport of water of the Undercurrent were found to be very similar to the previous measurements made in the fall of 1961 and therefore were considerably less than that found in 1958. For example, the maximum speed of the Undercurrent was two knots on Piquero whereas at the same location on Dolphin the speed was three knots.

"It now appears," Dr. Taft said, "that there was either a strong seasonal cycle in the strength of the Undercurrent, or that 1958 was an anomalous year and the Undercurrent was much stronger than usual. It is

perhaps worth noting that in 1958 the ocean was unusually warm off California and it may also be true that the Undercurrent, as well as the other currents in the tropics, deviated greatly from their average strength."

The Galapagos Islands form a barrier to the eastward flow of the Undercurrent and the fate of the Undercurrent water east of the islands is not well understood. Measurements west of the islands on Piquero seemed to show that the Undercurrent had a northward component and swung around the north end of the island group rather than to the south.

"The Undercurrent at times is probably the strongest current in the tropical Pacific, and if its flow can vary within one year (or from one year to the next) by a factor of two, then there must be a corresponding large adjustment in the whole tropical circulation," Dr. Taft said. "It will not be until a number of surveys of the kind carried out on Piquero are completed that we can hope to document how the whole system works.