TWO LEGS OF "OCEANOGRAPHER'S" GLOBAL CRUISE

By Dr. Timothy Joyner* and Robert C. Clark**

On Dec. 11, 1967, the globe-circling U. S. oceanographic survey vessel "Oceanographer" returned to her home port of Seattle, Wash., after an 8-month, 37,000-mile scientific expedition. Representatives of 17 foreign nations participated. The 303-foot, 3,800-ton, gleaming white "floating laboratory" belongs to the U. S. Coast and Geodetic Survey.

The authors, oceanographers, represented BCF on two legs of the cruise. As geochemists, their primary mission was to evaluate the chemical properties of the water masses in the Tasman Sea and the Southern Pacific Ocean. A secondary mission was to investigate the survival of Pacific salmon transplanted experimentally to the Southern Hemisphere in the early years of this century by the old Bureau of Fisheries, a precursor of the present Bureau of Commercial Fisheries.

Below are parts of the report on their trip, which ran from Sept. 10-Nov. 14--Ed.

o o • • o o

We flew to Sydney to join the Oceanographer. A highlight of our stay in Sydney was a visit to the Division of Fisheries and Oceanography, Commonwealth Scientific and Industrial Organization, in Cronulla, a suburb. The staff was gracious. Brian Newell, a marine chemist specializing in nutrient chemistry, briefed us on the history of fishery development in Australia:

Trawl Fisheries: These began in southeastern waters about 1915, the year following government-sponsored exploratory fishing. Years of high production were followed by a sharp decline. Steam trawlers were taken out of service in 1958-59. The fishery is currently stabilized at a low level of production; otter and Danish seine trawling predominate.

Tuna Fishery: In 1937, a cannery was established in Narooma, New South Wales, to exploit the occurrence of southern bluefin revealed by aerial surveys. The landings were insignificant. The actual development of the Australian tuna fishery followed the visit of 2 American tuna experts in 1954. In 1965, the use of gill nets, long lines and purse seines was introduced.

Crayfish: For many decades this was a small-scale operation centered on the southeast coast. In 1944, the western coast began to develop into what has since become Australia's most productive single fishery. The U. S. market for frozen crayfish developed in 1948-1953. The years 1954-62 saw the introduction of more powerful vessels, conservation methods designed to maximize the sustained yield, and better processing facilities.

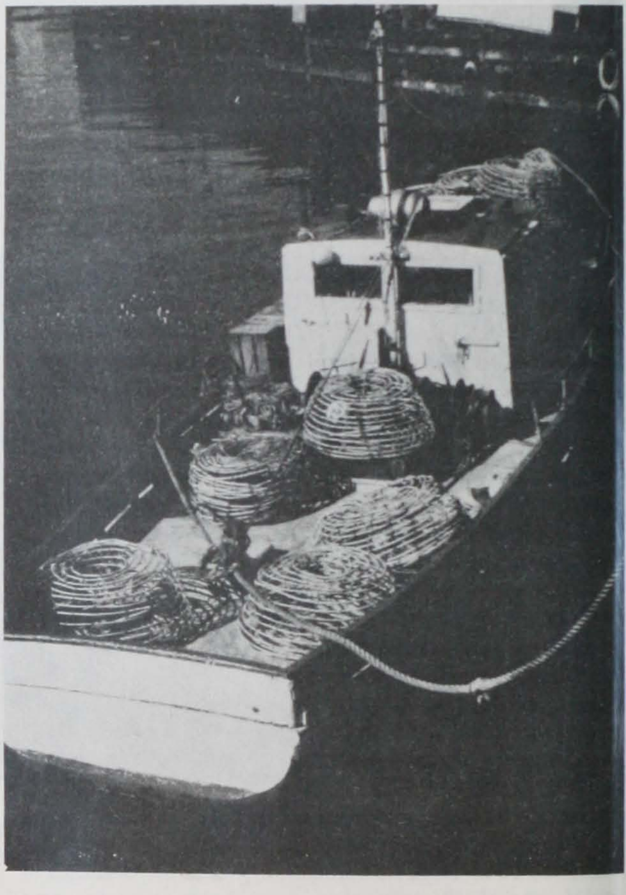


Fig. 1 - Cray fishing vessel with Maori-type pots in Wellington, New Zealand.

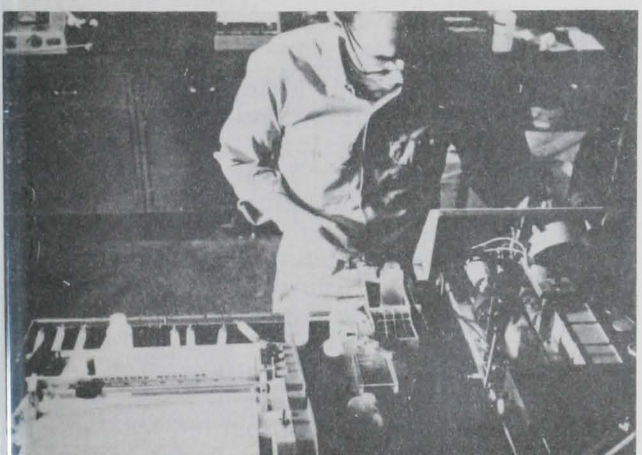
*Project Leader, Marine Geochemistry Project, BCF Biological Laboratory, Seattle, Wash. 98102.
**Oceanographer, BCF Biological Laboratory, Seattle, Wash. 98102.

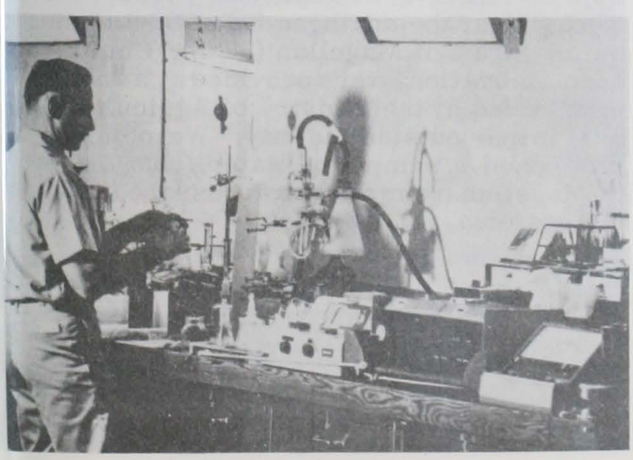
Prawns: In 1947, deep-sea prawning started off the east coast of New South Wales. The fishery is based on off-shore spawning. Since 1962, an extensive prawn fishery has developed off Western Australia.

Molluscs: Oysters (Crassostrea commercialis) are produced in all states except South Australia. In the estuaries of New South Wales and, to a lesser extent, Queensland, oyster culture is being developed. Oyster production has not kept pace with domestic demand, and imports are still necessary. In the Botany Bay estuaries, where raft culture of oysters is being developed, the range of water temperatures is from 24° C. in the summer to 16° C. in the winter.

Sydney to Wellington

Our objective for this leg of the cruise was to evaluate the chemical properties of the water masses contributing to the circulation patterns of the Tasman Sea. Instrumentation, reagents, and laboratory ware were installed in the ship's oceanographic laboratory to provide capability for the following kinds of chemical processing and analysis at sea: Atomic absorption and emission flame photometry for analysis of alkai and alkaline earth elements; Spectrophotometric analysis of Cu, Zn, Fe and carbohydrates; pH measurement; Selective preconcentration of heavy-metal trace elements from sea water.





Figs. 2A & 2B - BCF geochemistry on OSS Oceanographer.

Shipboard facilities and the cooperation of the scientific staff, officers, and crew were excellent.

Sampling data, preconcentration processing and analyses were performed at sea. Heavy-metal concentrates were returned to Seattle for analysis.

In Wellington, we had the good fortune to contact Ron Little, Supervisory Fishery Scientist for the Marine Department. He is a Californian, a former BCF employee, and is in charge of his department's current effort to evaluate the extent of the Quinnat (chinook) salmon resource on South Island. These fish were planted in New Zealand near the turn of the century from eggs of Sacramento River (California) chinook stock. These fish have survived in a number of streams and rivers of the southeastern, southern, and southwestern coasts of South Island. The government has built a fish trap on the Glenariffe tributary of the Rakaia River to evaluate the extent of the incoming and outgoing migrations. At present, virtually nothing is known of the populations of Quinnat salmon in New Zealand streams.

The Glenariffe trap is located in the foothills of the eastern slopes of the Southern Alps, about 80 miles from Christchurch, South Island.

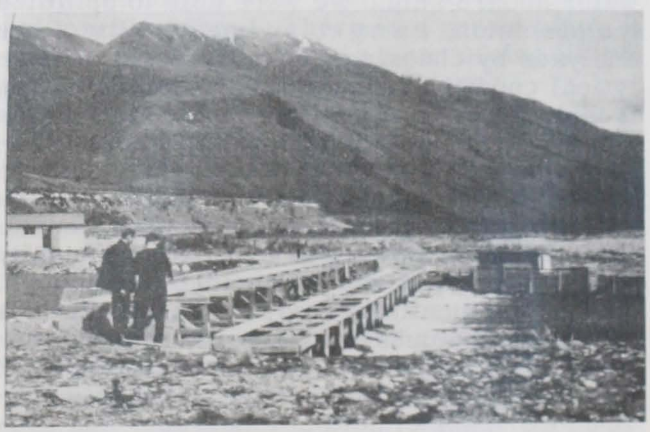


Fig. 3 - Salmon trap in Rakaia River, South Island, New Zealand.

The bed of the river is a maze of braided channels which continually shift, creating serious hazards for egg survival. Spring flooding and predation by birds are additional obstacles to survival of the newly hatched fry. The returning adults appear to be predominantly 3-year-olds and average 6-10 pounds in weight. The young migrate early, at about 3 months, when they are only a few inches long. Little is known of their ocean behavior. There is a convergence of tropical with cold water off the east coast of South Island, so it is likely that their ocean movements are confined to the Southern Shelf region. Ron Little is anxious to try some additional transplanting experiments and may ask BCF for a shipment of chinook eggs in 1968. The relations between the Marine Department and sports fishing interests are not always as cordial as they might be. There has been a surprising amount of opposition by sportsmen to any sort of government control over the salmon stocks.

Wellington to Valparaiso

This leg of the cruise was primarily geological--with emphasis on elucidation of various characteristics of the sea bottom-topography, strength of materials, sedimentology, minerology, and gravitational and magnetic phenomena.

The chemical analyses of sea water begun on the Sydney-Wellington leg were continued.

With the assistance of the superb facilities of the ship's oceanographic laboratory, we were able to collect, process, and analyze samples almost continuously along the entire track from Australia to Chile. The cruise demonstrated the feasibility of operating an integrated instrumental system for elemental analysis of sea water aboard ship. We were able to optimize the precision, range, and sensitivity of our analyses by choosing, for a given set of analytical conditions, the most applicable of the techniques of molecular absorption, flame emission, and atomic absorption spectrophometry.

Working alongside the geologists on the Wellington-Valparaiso leg gave us the opportunity to become acquainted with their techniques. The experience suggested possible adaptations of these techniques to provide information useful in assessing water mass and (possibly) fish distribution in the North Pacific. Closely contoured maps of bottom topography and geomorphology, prepared with the help of high-resolution echo sounding, should be most helpful in predicting flow patterns along the floor of the shelf areas. Coring techniques could be adapted to study distribution and relative age of hard parts of fish found in the upper sediment layers. This would prove useful in working out the history of the geographic distribution of fish populations (as in the case of the California sardine).

Supplementary Work

In addition to our oceanographic work during the cruise, the time spent in Australia, New Zealand, and Chile gave us the opportunity to do two other things: We extended our investigations to include terrestrial and coastal waters in which both mixing and separation processes bring about the distinctive chemistry that constitutes a significant feature of the near-shore environment. And, to a limited extent, we communicated with fishery officials and observed some facets of fishery-based activities.

Chile

The Division of Fisheries of the Chilean Ministry of Agriculture had assigned Senora Irma Vila, P., a biologist, to assist us as a guide, interpreter, and informant. Arrangements were made for us to visit and obtain water samples from the Strait of Magellan, the shellfish culture stations on the Island of Chiloe in the Gulf of Ancud, and Lake Llanquihue near Puerto Montt.

Water From Strait of Magellan

On November 2, accompanied by Senora Vila, we were flown by Lan-Chile Airlines to Punta Arenas, a clean, busy, free-port city of 35,000 at the southern tip of South America on the Strait of Magellan (53°S). Comfortable accommodations were provided at a "hosteria" maintained by the Ministry of Agriculture several miles outside the city. We obtained and processed a sample of water from the Strait of Magellan from a beach across the road from the hosteria.

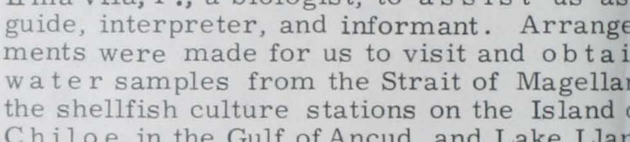


Fig. 4 - Strait of Magellan--obtaining a water sample.

Before leaving Punta Arenas, we visited Senor Guillermo Roehrs, president of the sport fishing club, owner of a hardware and fishing tackle shop, a long-time resident, and a fishing enthusiast. He is well known and respected by Chilean fish and game authorities and appeared to be familiar with the taxonomy of the sport fishes of the area, including the salmonids. He assured us that the fish called salmon by the local sportsmen were not of the genus Onchorhyncus--but were sea-run trout Salvelinus fontenalis and Salmo trutta, the former commonly reaching 10 kilos. These sea-run trout have silvery scales and bright red flesh and are eagerly sought by sportsmen. These trout are caught in substantial numbers in Seno Otway and Seno Skyring, two wide fjords with narrow openings to the Pacific Ocean and interconnected by a narrow channel. Local maps show that many small, year-round streams flow into these protected, salt-water inlets, which appear to be well suited as an environment for salmonid fishes. The sea temperatures range from 6^{o}-12^{o} C. year round.

Fig. 5 - Fish market at Angelmo, Chile. Dried fish, sea-urchins, clams, abalone, conger eel, dried mussels.

We left Punta Arenas on November 3 for Puerto Montt. On November 4, we visited the fish market at Angelmo, the fishing and shipping port for Puerto Montt. We were struck by the predominance of shellfish in the fish market. Several kinds of mussels, smoked and hung on strings, were evident everywhere in large numbers. Also displayed were clams, oysters, huge barnacles, abalones, and sea urchins. Most of the fish displayed (eels, mackerel, and groundfish) were caught by handline fishermen working from oar-propelled open boats close inshore. There were very few motorized fishing vessels evident. A large number of small sailboats, 15 to 75 feet long, were beached at low tide, some had auxiliary power. They are not generally used for fishing but for carrying cargo to the island of Chiloe, a few miles across the gulf. We saw women gathering kelp at low tide and were told that it is sold and used for food. There is little transport and storage of fishery products of this region; most is sold fresh or smoked in local markets.

On November 5, we traveled by bus and ferry to Castro, on the island of Chiloe, where we obtained a water sample at the head of the Fiordo Castro which opens into the Gulf of Ancud.

Oyster Culture at Pullinque

On November 6, we traveled by bus to Ancud, at the northern end of Chiloe. Here we were met by a boat from the oyster-culture station at Pullinque, in the Golfito (Little Gulf) de Quetalmahue, about 10 kilometers by water from Ancud. This station encompasses farm buildings and waterfront acreage with a small boat pier; it appears to be a model of progressive, scientific management. The barn has been converted into a well-equipped wood-working and machine shop. There is a power plant, a small laboratory building containing diving gear and a wet-lab, and a residence.

In the culture operation, mussel shells are strung on strings, spaced about 6" apart with spacers of polyethylene tubing. These strings are suspended from rails fastened horizontally to stakes which are pounded into the shallow bottom of the bay. The spat attach to the mussel shells, especially to the concave side which faces downward, and are thus protected from sedimentary fallout by the "umbrella" action of the mussel shell. Dr. Sergio Basulto d.C., Chief, Section of Biological Studies of the Division of Fisheries, has studied oyster culture in Aomori, Japan. The methods used at

Fig. 6 - Oyster culture at Pullinque, Island of Chiloe, Chile.

Pullinque are based on Japanese techniques modified for conditions in Chile. The temperature of the water in the Golfito de Quetalmahue was 14.2^{o} C. when we took our sample there. The annual range is narrow, as the climate is quite uniform. Salinity at the oyster station averages about 26-27 with a range of 20-29 parts per thousand. The oysters, classified Ostrea chilensis, tasted somewhat strong, similar to Australian rock oysters. The government makes seed available to private individuals to encourage development of private oyster farms. We were told that it is the same with the mussel culture (in which Spanish techniques are being used).

We went to Puerto Montt on November 7. We took a short bus ride to Puerto Varas on Lake Llanquihue, where we obtained a water sample. The lake collects drainage from the western slopes of the Andes. It is the largest and southernmost in Chile's famed Lake District.

Salmon Eggs from U. S.

On November 8, we went to the Rio Blanco Fish Hatchery, Chile's oldest (1905), about 80 km. from Santiago, 9,000 feet up in the Andes, and not far from Portillo. It was at this hatchery that the salmon eggs transported from the United States early in the century were hatched. The hatchery is one of four in the country. It is used principally for the culture of brown trout, which are planted in lakes to stimulate the sport fishery. Rio Blanco, in a beautiful setting similar to the High Sierras of California, is a clean and well-run hatchery. The troughs and concrete ponds are scrubbed, the egg baskets well picked, and the trout food is well prepared and nicely pelletized. It appears to be very well managed.

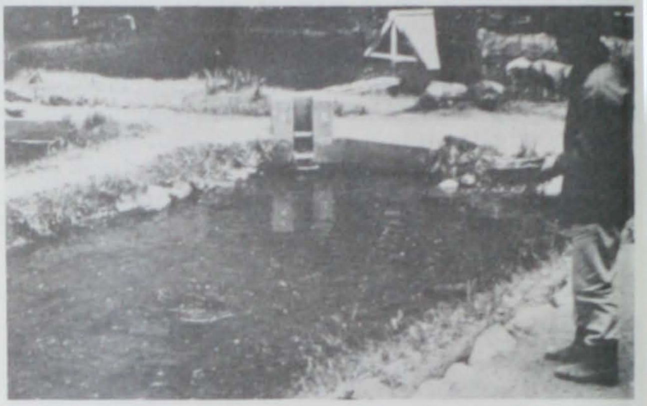


Fig. 7 - Earthern rearing pond, Rio Blanco hatchery, Chile.

Observations on Visit to Chile

1. There do not seem to be any Pacific salmon surviving in Chile from early-century transplant experiments. However, the southern third of the country (Aysen and Magallanes) should have potential as a favorable environment for the culture of salmonid fishes, including Pacific salmon.

2. The Centolla crab industry of southern Chile appears to be capable of sustaining an enlarged fishery. Exploratory fishing investigations are sorely needed to define the magnitude and extent of this resource. The present fleet of boats engaged in this fishery is inadequate for anything more than marginal operations close inshore and in favorable weather.

3. The deeply indented coastline of Aysen and Magallanes is washed by the cold, nutrient-rich waters of the Humboldt current. It would appear well-suited for shellfish culture, pisciculture, and small-boat, inshore fisheries. However, lack of adequate transport, shore facilities, local markets and, above all, of people oriented toward the sea and maritime

trades, impose severe restrictions on developing these potential marine resources.

4. The culture of trout as game fish is a well-established, well-managed, successful operation. Four trout hatcheries are operated by the government for stocking lakes and streams in the central part of the country. There seems to be a good measure of rapport between the sports fishing organizations and the Ministry of Agriculture's Division of Fisheries.

Dr. Basulto is now eager to undertake an attempt to transplant Pacific salmon to the Aysen-Magallanes region. The Division of Fisheries is particularly interested in sending some scientists and technicians to the U. S. Pacific Northwest for observation and training in salmon culture techniques. The Division also is interested in getting the assistance of some American salmon hatchery men for locating and planning their transplant experiments.

UNDERSEA WARFARE

Underwater gadgets of the future should resist attack by sea organisms better than their predecessors. Thanks to research stimulated by the rapid growth of oceanography, the marine biological environment is now beginning to be understood. Laying the first trans-Atlantic telephone cable in 1956 highlighted the need to develop better ways to prevent undersea damage. Since then, extensive testing of sample materials to be used in underwater marine applications has continued. Results appear in materials now used for recently established submarine listening and tracking stations, and work on long-term protection of marine equipment will continue as more massive underwater equipment is installed.

Early submarine cables were insulated with gutta percha, a natural rubber-like substance, and then covered with hemp, but mollusks and borers were quite successful in destroying them. Mollusks and crustaceans are the most destructive of marine organisms. The 1956 cable has a barrier of copper sheeting wound helically around its internal structure. The latest cables, however, are insulated and covered with polyethylene, which resists most of the marine borers even more effectively, and outer coverings are now black, so as not to attract fish that often bite through light-colored cables.

Fouling is another severe problem. Underwater equipment, particularly that used for communications, must remain reasonably clean in order to operate efficiently, but once a surface is wet, micro-organisms produce a slimy film on it, and very soon afterwards macro-organisms such as barnacles attach themselves to the slime. Protective paints have been developed, and some of them are quite effective in warding off micro-organisms. Effectiveness is related to surface texture, wetting characteristics and stability of the material, relative movement of water around it, and amount of light available; micro-organisms grow faster in warm, lighted water than in cooler deeps.

Compounds of copper, mercury and arsenic that are toxic to fouling organisms have been successfully incorporated in paints for use on hulls. But now that plastics and fibrous glass have become popular in boat hulls, particularly in pleasure craft, there is need for anti-fouling compounds that can be mixed with them to produce a similar effect. Another technique to prevent fouling has been developed recently; it involves pumping a solution of the toxic substance from perforated pipe-lines attached to the underwater area of the ship or structure to be protected. In some cases, this system is used in conjunction with cathodic protection, an electrical anti-fouling procedure which has already proved effective.

Thanks to recent developments, underwater military programs now have a wide range of new and improved materials available. For example, a deep-water basin in the Bahamas, called the Tongue of the Ocean, was chosen as the site for a manned submarine weapons evaluation center; planning for this Atlantic Underwater Tracking and Evaluation Center (AUTEC) would be much easier if we had even better protection against destruction by undersea life. (Abstracted from "Industrial Bulletin," Arthur D. Little, Inc.)