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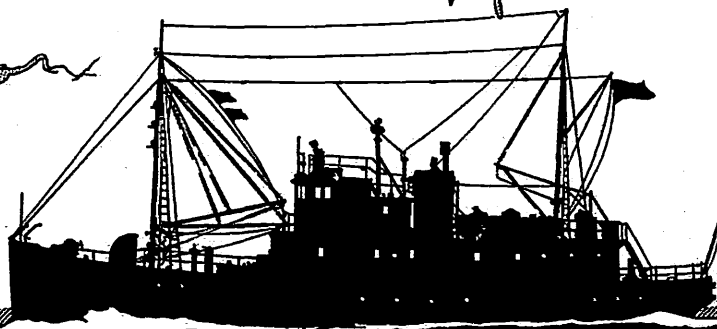
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DEPARTMENT OF OCEANOGRAPHY
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Articles Sponsored by the Office of Naval Research:

Technical Report No. 78

A SIMILARITY SOLUTION FOR CIRCULATION IN AN ESTUARY, by Maurice Rattray, Jr. and Donald V. Hansen. Journal of Marine Research, 20(2):121-133.

Technical Report No. 79

INTERPOLATION ERRORS AND OCEANOGRAPHIC SAMPLING, by Maurice Rattray, Jr. Deep-Sea Research, 9:25-37.

Technical Report No. 80

DISTRIBUTION OF PHYSICAL PROPERTIES BELOW THE LEVEL OF SEASONAL INFLUENCE IN THE EASTERN NORTH PACIFIC OCEAN, by Maurice Rattray, Jr., Cuthbert M. Love, and Diane E. Heggarty. Journal of Geophysical Research, 67(3):1099-1107.

Technical Report No. 81

RESEARCH ACTIVITIES AT THE UNIVERSITY OF WASHINGTON, DEPARTMENT OF OCEANOGRAPHY, by Karl Banse, Joe S. Creager, Richard H. Fleming and Clifford A. Barnes, Maurice Rattray, Jr., Francis A. Richards. The First National Coastal and Shallow Water Research Conference, pp. 724-736.

Technical Report No. 82

NET ZOOPLANKTON AND TOTAL ZOOPLANKTON, by Karl Banse. Rapp. et Proc.-Verb., 153(36):211-215.

Technical Report No. 83

A SIMPLE SEMIAUTOMATIC REAGENT DISPENSER, by Ralph W. Riley and Francis A. Richards.

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RICHARD H. FLEMING
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RESEARCH ACTIVITIES IN BIOLOGICAL OCEANOGRAPHY

By
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Biological research at the Department of Oceanography, University of Washington, is presently concentrated on field studies of plankton. One experimental study deals with grazing rates of zooplankton; there is some taxonomic work on barnacles and benthic polychaetes, but no ecological investigation of the benthos.

Work on phytoplankton productivity and biomass is in progress; at present, little attention is paid to taxonomy as such. In inshore waters the relationship between carbon-14, chlorophyll, and cell counts in vertically mixed water and in a stratified inlet is being studied by frequent sampling with particular reference to the distribution of biomass as calculated from cell counts. The amount of detrital chlorophyll will be estimated by plotting plasma volume and assimilation against chlorophyll. The detrital chlorophyll will be one of the major problems studied in the near future.

In the waters off the coast of Washington the distribution of chlorophyll and assimilation is investigated on bimonthly trips, and is related to nutrients and hydrography. This study will be continued for at least another year. In parts of the material, the distribution of phytoplankton species is studied. It is hoped that nanoplankton sampling will be started soon from three radar picket ship stations at 49° N, 129° W; 45° N, 130° W; and 40° N, 129° W (EPOC Program, Stations 1, 3 and 5). For at least two years, a study of the vertical phytoplankton distribution, by weekly sampling from several depths, is intended to explore the normal annual cycle of phytoplankton in offshore waters. A study of the phytoplankton of the Chukchi Sea is in

progress which will make use of material collected during two summer cruises and samples from icebreaker surveys. Cell counts, chlorophyll and assimilation will be related to season and hydrography. Samples from a two-year investigation of phytoplankton productivity on the shelf off southwest India are being worked up. Phytoplankton samples from two years of observations in the North Polar sea are being counted. The results will be related to environmental factors.

The experimental study of grazing is the connecting link between the phytoplankton and zooplankton investigations. The smaller zooplankton, up to the size of copepods, is collected in the euphotic layer off the coast of Washington along with the productivity studies. Attention is also paid to field studies of the vertical distribution of crustaceans in stratified water. A samplings program of copepods in an inlet during the weak stratification of fall and early winter has been completed. In the unstratified environment of a tropical atoll, the horizontal and vertical distribution of copepods is investigated as well.

Counting of euphausiids and sergestid shrimps from mid-water trawl studies in offshore waters is being continued. The feeding of euphausiids is studied by experiments and by dissection.

Studies on barnacle taxonomy and larval development are being continued. During summer 1961, some smaller polychaetes were sampled from mud and sand bottom in the San Juan Islands. More attention will be paid to the ecology of zoobenthos in the near future when taxonomic experience for the dominant groups is available.

There are no plans for a full-scale departmental participation in the International Indian Ocean Expedition, though participation of individuals is not excluded. The department has offered to help train field workers for the United States Working Groups for Hydrography-Chemistry and Biology. The biologists may be scientists from inland who wish to collect material. The course will be held at Friday Harbor at times other than the summer quarter.

There are two faculty members, three Senior Investigators (plus one vacancy), three Junior Investigators and twelve Graduate Students.

COLLEGE OF FISHERIES
UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON

By
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REVIEW OF RESEARCH

Research in fisheries biology at the University of Washington is done primarily through the Fisheries Research Institute of the College of Fisheries. The teaching and research faculty of the College are both engaged extensively in research, primarily on the ecology and related fisheries problems of the coastal waters of the Northeastern Pacific Ocean and Bering Sea. A recently established faculty of Food Science is administered by the College. They are engaged in research into general problems of food preservation and processing.

The College of Fisheries has eleven members on its teaching faculty seven on research faculty, and 36 on research staff. Dean of the College is Richard Van Cleve, Director of the Fisheries Research Institute is William F. Royce. Publications appear in professional journals, in bulletins and special scientific reports of the Bureau of Commercial Fisheries of the U.S. Fish and Wildlife Service, and in the newly reorganized "Publications in Fisheries" of the University of Washington. The first volume of the new series is scheduled for publication in late 1961. Annual reports summarizing research projects are available.

The college granted eleven BS degrees, four MS, and two PhD degrees in 1960. Fifty-four graduate students were registered during the year.

Campus facilities for research include a specialized fisheries oceanography library, experimental fish and food processing laboratory with walk-in refrigerators, circulating sea water aquaria, flumes with controllable water flow for studying behavior and endurance of fish, hatching and rearing facilities for trout and salmon. There is also a microbiological and a biochemical laboratory, radiological counting equipment, and a collection of over 200,000 specimens of fish from the North Pacific area. A 67 foot vessel equipped for inshore oceanography and trawling for fish, with a berth, is also available. Field facilities include stations equipped with quarters for personnel and basic laboratory equipment at Hollis, Chignik, Iliamna, Aleknagik, and Lake Nerka, all in Alaska. Field equipment in Alaska includes a 30 foot diesel vessel equipped with sonar gear and hydraulic winches for limnology and midwater trawling in lakes, a 30 foot gasoline vessel and numerous outboard powered skiffs up to 24 feet in length.

Grant and contract funds amount to more than \$500,000 annually.

The major areas of research and recent projects of the faculty are as follows:

(1) Ecology of Salmon in Fresh Water. A major part of the research program has included diverse studies of salmon in fresh water, their associated fauna and studies of the waters themselves. Much of this work started in 1946 with the information of the Fisheries Research Institute under the direction of W. F. Thompson. Projects were initiated to study the salmon of Southeastern Alaska, Prince William Sound, Kodiak Island, Bristol Bay, and the Alaskan Peninsula. Work has included development of methods of counting adult salmon and estimating abundance of young salmon, methods of determining age and growth of salmon, studies on spawning behavior of salmon, factors causing mortalities in spawning gravels and in streams and lakes, evaluation of improved spawning channels, measurement of standing crops of phytoplankton and zooplankton in lakes, measurements of photosynthetic rate in lakes using radioactive carbon, bathymetry of lakes, temperature stratification and water chemistry of lakes. Faculty assigned to these projects includes Donald E. Bevan, Robert L. Burgner, Charles O. Jung, Ted S. Y. Koo, Ole A. Mathisen, Gerald Paulik, and William F. Royce.

(2) Population Dynamics and Problems of Sampling. The local populations of fish in Puget Sound offer excellent opportunity for basic

studies on methods of determining population size and rates of change due to growth and mortality. Studies have been continuing for several years under Allen C. DeLacy and Richard Van Cleve. During the last year, work has been concentrated on developing an instrument to obtain quantities of samples of bottom fish and preliminary tests have indicated the possibility that the device developed may sample invertebrates as well as bottom fish.

(3) Ecology of Invertebrates and Invertebrate Fisheries. Several projects in this field have been started since 1958. These have included growth and mortality of the Japanese oyster in Washington, ecology of paralytic shellfish toxicity in Washington, benthic invertebrates of the Southeastern Chukchi Sea, and studies on Cryptobia salmostica, a blood parasite of coho salmon. Faculty members include Max Katz and Albert K. Sparks.

(4) Fish Behavior. Techniques used by psychologists have been used to study problems of fish guiding, especially the problems of guiding salmon around dams and through reservoirs. Faculty member is Paul Fields.

(5) Use of Fish and Invertebrates for Food. A department of food technology associated with the College of Fisheries carries on studies of fish and shellfish after they have been harvested. Recent projects have included use of dogfish for human food, greater utilization of rockfish, food poisoning problems of frozen seafoods, post-mortem biochemical changes in fish tissue. Faculty members include Alexander Dollar and John Liston.

(6) Marine Bacteria. Special studies of the distribution and taxonomy of marine bacteria have been continued for a number of years under the direction of John Liston.

(7) Brood Stocks of Salmonoid Fishes. A very rapidly growing stock of rainbow trout and a run of chinook salmon which returns annually to the University have been developed in the special hatching and rearing facilities. Faculty member is Lauren R. Donaldson.

(8) Swimming Ability of Fishes. Many people concerned with ships have wondered why fish can swim with so little expenditure of energy. Special facilities at the College have enabled us to visualize the flow of water and the boundary layer conditions about the bodies of fish; other studies have been made on endurance and locomotive performance. Faculty member has been Allan C. DeLacy assisted by Joseph C. Kent of the College of Engineering.

(9) Nutrition and Trout Diseases. In cooperation with the state fish and game agencies of the eleven western states, the College of Fisheries is organizing and coordinating research on the performance of diets and health of fish. These studies are being carried out under A.M. Dollar and Richard Van Cleve.

(10) Review of Soviet Fisheries Literature. Two members of the faculty spent a year in the Soviet Union as a part of the Cultural Exchange program. This exchange, and a collection of a large amount of Soviet literature in our library, will allow us to keep abreast of current Soviet fisheries developments. Faculty members are Donald E. Bevan and Ole A. Mathisen.

(11) High Seas Salmon Tagging. As a part of the broad research program of the International Pacific Fisheries Commission, tagging has been conducted in the North Pacific Ocean, in the Bering Sea, and the Gulf of Alaska. Tagging is aimed specifically at determining the oceanic movement patterns of Pacific salmon with respect to continent of origin. The work is under the supervision of Allen C. Hartt.

RESEARCH ACTIVITIES IN MARINE GEOLOGY AT THE DEPARTMENT
OF OCEANOGRAPHY, UNIVERSITY OF WASHINGTON

By
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For the past two years the major effort has been a study of the marine geology of the southeastern Chukchi Sea. The final report on the areal distribution of sediments and sedimentary environments is now being compiled. This report is based upon the results of two summer field seasons and will include a summary of pertinent data obtained from a bathymetric and current survey and analyses of sediment sizes, foraminiferal content, heavy minerals, and organic carbon and carbonate content. A study of the

variation of sedimentary environments with depth in cores will now be undertaken in an effort to date the last postglacial eustatic shift in sea level in the region. In addition, the sediments and sedimentary environments of the Beaufort and northern Chukchi Seas are being studied.

The distribution and ecology of the planktonic and benthonic Foraminifera of the northeast Pacific Ocean are being investigated. This program includes a study of the Foraminifera of the surface water mass as well as those present in the sediment. The distribution of dead Foraminifera is being determined both areally and with depth in the sediments.

The distribution and genesis of at least three volcanic ash deposits present in cores of the Northeast Pacific is being investigated.

A continuing project is that of compiling a general descriptive summary of the marine geology of the inland waters of the Pacific Northwest. This is being carried out primarily through studies of the sediments and sedimentary environments of deltas and estuaries. At the present time the following areas are under investigation: Nisqually Reach, Bellingham Bay, Dabob Bay, Port Discovery, Port San Juan, Saanich Inlet, and Deep Inlet.

A program to determine the area and rate of deposition of the sediments supplied to the Pacific Ocean by the Columbia River has just been started. This program will involve an intensive study of the sedimentary environments present along the continental terrace, Astoria Trough, the beaches and estuaries of the Washington and Oregon coasts. Associated with this will be an investigation of the properties of sediment particles which may serve as tracers in the identification of Columbia River sediments.

Support programs in instrumentation and analytical procedures are also being pursued. These fall primarily into the areas of IBM identification, computation, sorting and correlation of data, and detailed testing of some of the accepted sediment size analysis techniques.

The research staff in marine geology consists of two faculty members, three senior and two junior research associates. At the present time there are five doctoral candidates, six master's candidates, and four unclassified graduate students studying in marine geology.

RESEARCH ACTIVITIES IN WATER PROPERTIES AND CIRCULATION
AT THE DEPARTMENT OF OCEANOGRAPHY
UNIVERSITY OF WASHINGTON

By

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Research on water properties and circulation is being conducted at various locations in the embayed and coastal waters of the Northeast Pacific from Oregon north through the Bering Sea, the Chukchi Sea and into the Arctic Ocean. These studies are descriptive in part, but stress is given to a better defining of the processes involved. There is an overlap of certain of these primarily physical field studies with those in the biological, chemical, and geological subfields and with the more theoretical studies in marine hydrodynamics.

The emphasis of studies in the Puget Sound area during the past two years has shifted from wide surveys to more detailed studies in specific sub-areas. Some measurements are being continued at selected locations to provide a basis for year-to-year comparisons and to key local conditions to those prevailing in the over-all system. Sub-areas studied include the head of Southern Puget Sound, and Elliott, Bellingham, and Dabob Bays.

Southern Puget Sound is fed by several rather shallow inlets in distinctive features. Here the flushing of the individual inlets and a variable cross-feed of water from one inlet to another depends upon the conditions of wind, tide and river flow as well as the properties of the water in seaward approaches. A tidal model of this section of Puget Sound has been constructed and will be used to supplement further field studies of circulation. A monitoring device for sampling at hourly intervals, constructed and installed in the entrance to one of the inlets, has provided information pertinent to the salt budgets and flushing rate.

The fresh water and salt budgets and circulation are being studied throughout a yearly cycle in Bellingham Bay which lies north of Puget Sound proper. This work is being supported in part by commercial interests.

Initial investigations have been made of the formation, persistence and dissipation of thermal microstructure in Dabob Bay, a fiord-like water body of 180 meters depth contributing indirectly to Puget Sound. Associated microstructure has been found in salinity and in the concentrations of dissolved oxygen and soluble phosphate. Tidal action and the flushing process contributes to the formation of the microstructure, and wind and tide to the diffusion which leads to the decay of the microstructure. The rate of utilization of dissolved oxygen in the bottom waters of Dabob Bay and other arms has been determined for "non-circulating" periods of several months duration. Diffusion and advection has been studied in Lake Union, a partly controlled estuary, and in the relatively open Bellingham Bay using fluorometric techniques and Rhodamine-B, a fluorescent dye. These studies will be extended to other locations in Puget Sound and coastal waters. In local areas such as Elliott Bay the circulation and diffusion is important in considering the marine disposal of domestic and industrial wastes.

The movement and dispersal in the open sea of fresh water from the Columbia River, is being investigated in continuing all-season study under varying conditions of wind, oceanic circulation and river discharge. The movement of the effluent varies from a northward trend in winter to southwesterly trend in summer. Associated studies of the biology, chemistry and sediments are being made. Cooperation is being effected with other interested agencies working in the local area.

In the seas bordering Alaska studies have been made of the currents, water properties and water structure from the northern Bering Sea through Bering Strait and the eastern Chukchi Sea into the Arctic basin. In the Bering-Chukchi area conventional oceanographic measurements have been supplemented by currents measurements made at anchor and observations of drifting buoys and bottles. The contribution of Bering Sea water to the Arctic Ocean has been described. A long existing lack of knowledge of conditions in autumn was partly filled in 1960 by observations from ice breakers. A series of measurements were made over a period of several months from the drifting ice floe station ARLIS I, and some were also made from the Arctic Research Laboratory at Point Barrow. A review has been

made of the literature of the Arctic regions, a number of Russian articles translated, and an analysis is being made of the water in the Arctic Basin which is under more or less direct influence from the water in the Atlantic Ocean.

A supporting program of instrumentation carried along with the field program has provided current meters, salinity bridges, and various types of sampling devices for water, biota and sediments.

The research staff in physical and general oceanography currently consists of two faculty members, three full-time senior researchers, a number of research assistants, routine supporting personnel and fifteen graduate students.

RESEARCH ACTIVITIES IN HYDRODYNAMICS AT THE DEPARTMENT
OF OCEANOGRAPHY, UNIVERSITY OF WASHINGTON

By
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Theoretical studies on estuarine circulation are in progress. The equations which describe the dynamics and the salt balance are known for a large variety of estuarine types, and the investigation in progress is on obtaining solutions to these known equations. Success has been achieved for certain simple circulation systems. Extension of the mathematical techniques to more complicated systems is envisioned.

Model studies of estuarine circulations are in progress on the Puget Sound model. The present investigation aims at determining the equilibrium salinity distribution over a wide range in the values of river inflow and tidal range. Preliminary studies have been made on the mechanics of the circulation and mixing within the model.

Internal waves are being investigated both theoretically and with models. The mechanism of generation of internal waves is under continuing study with the earlier results on the effects of bottom irregularities being extended and other possibilities explored.

New programs on the behavior of ocean currents have been initiated. At present a mathematical model for the current through Bering Strait is being formulated.

The research staff in marine hydrodynamics consists of one faculty member and two senior research associates. There are at present five graduate students carrying on research in these fields.

RESEARCH ACTIVITIES IN CHEMICAL OCEANOGRAPHY

By

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There are presently six graduate students in chemical oceanography at the University of Washington, Department of Oceanography. Two of these have their M.S. degrees, the others are working toward that degree. In addition, the staff includes a number of full-time employees involved in research and routine activities in chemical oceanography.

The research projects in chemical oceanography are under the auspices of the University, the National Science Foundation, the Office of Naval Research and the Atomic Energy Commission.

Investigations of oxygen-deficient marine environments include exploration for such environments in the coastal waters of Washington, British Columbia and Alaska. Initial reconnaissance of five inlets in southeast Alaska was made during the summer of 1960. This included the occupation of hydrographic stations in Deep Inlet, Snipe Bay, Big Branch Bay, McKenzie Inlet and Walker Cove. None of these inlets was found to be oxygen free; Deep Inlet thus appears to be a promising site for future investigations.

An additional site of interest in the southeast Alaska region is Lake Redoubt on Baranoff Island, whose topography suggests that it may contain

relict sea water, such as has been reported to be present in two Norwegian lakes by Strøm (1957, 1961) and more recently has been found in Powell Lake, British Columbia (Williams, Mathews and Pickard. Nature, 1961, in press).

Of particular interest in the study of oxygen-deficient environments are the relationships between the regeneration of nutrient elements and the consumption of oxygen from dissolved oxygen, from the nitrate ion and from sulfates. Oxygen-deficient environments generally are sites where abnormally large quantities of organic matter accumulate and decompose, and thus offer regions where exceptional accumulations of the products of organic decomposition can be found. Studies of the relationships between the consumption of oxygen and the accumulation of the products of organic decomposition are now under way in both natural and laboratory environments. Preliminary results indicate that there are certain marked regularities in these relationships, which form the basis for a stoichiometric model of these processes which is now under study. One of the most interesting of these results indicates that during nitrate reduction (following the disappearance of dissolved oxygen), free nitrogen is released to the water. These relationships are now being investigated in Saanich Inlet, British Columbia.

Studies of the primary precipitation of metallic sulfides in sulfide-bearing waters have been initiated.

The development and refinement of analytical methods used in chemical oceanography are part of the department's program. A modification of Saruhashi's (1953) diffusion method for the determination of total carbon dioxide in sea water, which promises to give good results quickly and easily, has been made.

The group is now embarking on a program for the study of the dissolved gases in sea water. It is our plan to use refinements of standard chemical methods, micro-gasometric methods, gas chromatography and mass spectrometry to make possible the semi-routine observation of both molecular and isotopic species of gaseous components of sea water. These observations will be used in studies of inter-phase and in situ gas exchanges, with the objective of describing both physical and biological processes which are important in bringing about the observed distributions of sea water gases. The department now has in operation a Consolidated-Near

COASTAL AND SHALLOW WATER RESEARCH CONFERENCE

Isotope Ratio mass spectrometer, a gas extraction and measuring train, micro-gasometric equipment and conventional chemical procedures which will be applied to these problems.

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