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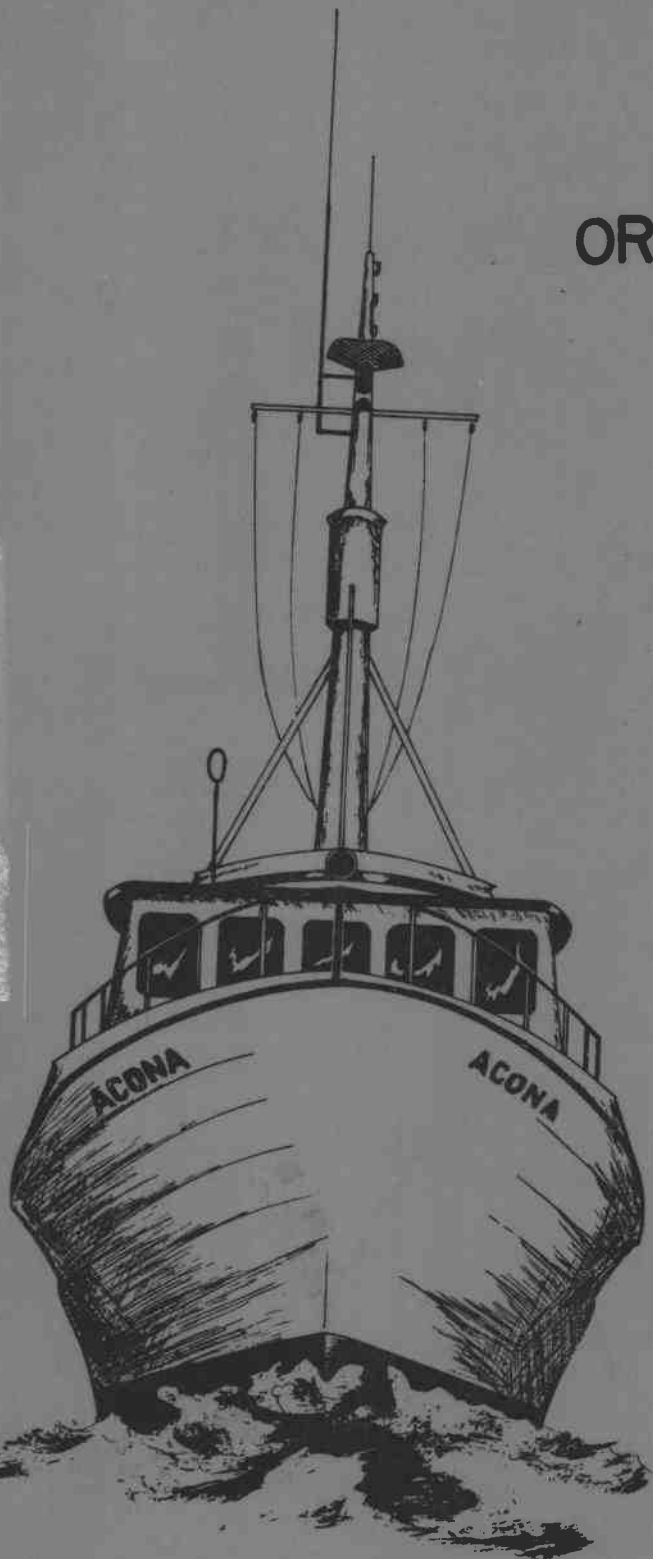
SIUSLAN R.

UMPQUA R.

COOS BAY

COQUILLE R.

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RESEARCH ACTIVITIES

1 October through 31 March
1964

Edited by
Susan Borden

Progress Report No. 13 Reference 64-20
July 1964

Department of Oceanography
School of Science
Oregon State University

Wayne V. Burt
Chairman

Progress Report No. 13

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During the period

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PHYSICAL OCEANOGRAPHY

Hydrography of Oregon Coastal Waters - Wyatt, Kujala, Still

Hydrographic cruises were made during November and February. In November a series of stations was made to 145 miles off both Newport and the mouth of the Siuslaw River (44° N). In February stations were made to 165 miles off both Newport and Coos Bay. A summary of data collected on these cruises is contained in Table I.

TABLE I.

Summary of Data Taken on Hydrographic Cruises

Hydrographic casts - - - - -	41
Bathythermograph casts - - - - -	73
Surface temperature and salinity observations	65
Drift bottle releases - - - - -	528
Midwater trawl tows - - - - -	11
Plankton tows - - - - -	14

Shore Station Observations - Wyatt, Still

The 1963 data for eleven shore stations have been processed for publication. In 1964 five shore stations were discontinued, and emphasis was placed on obtaining daily observations at the remaining six stations located at key positions along the coast.

Effects of Climatological Processes on Coastal Sea Water Characteristics - Pattullo (with Warren Denner, of the University of Alaska)

All coast station data taken during 1961 and 1962 have been analyzed and a paper has been prepared for publication. Mr. Denner presented the results at the Pacific Northwest Oceanographers' Meeting in Seattle on 8 February 1964.

Upwelling - Smith, Moriyasu

The theoretical models developed principally by Yoshida (Yoshida, 1955, and Yoshida and Mao, 1957) have been examined and modified to satisfy oceanic conditions along the Oregon coast. Comparison of the models with observations of temperature and salinity changes and wind patterns appears to yield good results. Mr. Smith is continuing this work as his doctoral dissertation research.

Dr. Moriyasu has modified Yoshida's coastal model (Yoshida, 1955) to include the effects of river outflow. His results indicate that the upwelling common along the southern Oregon coast is largely absent in the northern portion because of masking by the outflow from the Columbia River. He has also pointed out that the value of the horizontal eddy diffusivity is critical in attempting to evaluate the role of horizontal mixing.

Data taken during upwelling in May, 1963, have been intensively studied. The offshore transport of water during three days of upwelling was computed assuming conservation of concentrations. The results are in good agreement with Ekman transports determined from winds measured aboard the R/V ACONA from air pressure gradients. However, there is no indication that the vertical distribution of horizontal velocity was an Ekman spiral. This work was reported at the Pacific Northwest Oceanographers' Meeting in February and will be included in a paper on upwelling along the Oregon coast now in preparation by Smith, Lane and Pattullo.

The Permanent Pycnocline - Collins, Pattullo

Mr. Collins has completed his study on the seasonal changes in structure of the permanent pycnocline off the Oregon coast. His thesis on this subject has been accepted. He is now preparing a paper for publication.

He found that the main pycnocline partakes of the flow pattern in the upper or surface layer, as this upper layer adjusts seasonally under the influence of the winds. In summer both the upper layer and pycnocline are shallow in vertical extent inshore and deeper than average offshore (approximately 100 nautical miles). In winter both layers are deeper than average inshore, but the pycnocline has virtually no change in depth with distance from shore.

The flow rate was computed from the changes in volume of the layers observed on monthly hydrographic cruises. This computation is based on the assumption that the water particles retain their concentrations of heat and salt. That is, there is no change of heat or mass with the environment and no mixing. In the later stages of upwelling (say, late in the season--August and September) this assumption appears to be unrealistic, as would be expected from theory (Yoshida, 1955). Apparently, mixing and formation of pycnocline-type water occur nearshore during later stages of upwelling.

Currents - Stevenson, Pattullo

Bad weather caused cancellation of drogue cruises scheduled for this period.

Mr. Merritt Stevenson has been making a feasibility study on the use of fluorescent dye for the investigation of subsurface currents and eddy diffusivity anticipated in Oregon coastal waters. The use of dye appears feasible, and plans are underway to make tests at sea. Present work includes calibration of the fluorometer for various dyes, test of sea-water background fluorescence, and the development of a computer program for reducing the data. Observations will be in the form of dye concentrations at known time and distance from the release point of a known mass of dye. If observations can be made successfully, the calculations will yield current speed and direction and eddy diffusivity. Estimates of the latter will be particularly interesting in view of the findings of Dr. Moriyasu, mentioned earlier.

Air-Sea Interchanges - Lane, Minard, Pattullo

Nearly 30,000 marine weather observations from the waters adjacent to Oregon and Washington, covering the period 1952 through 1962, have been used to study air-sea heat exchange processes. Analyses have been made of seasonal and annual variations in evaporation, conduction, and back radiation. Computer programs have been written to compute the heat budget components from monthly averages of the meteorological parameters. A nearshore area in the upwelling region and an offshore area were examined.

The results clearly indicate the effects of upwelling on the heat exchange process. During summer months, the cooling of the surface waters results in less evaporation, conduction of heat to the sea (this is opposite to what occurs offshore), less back radiation, and cooling of the air above the sea.

Analyses of the results are being continued. Annual variations in upwelling as related to variations in the coastal climate will be studied.

Some success has been attained in relating pan evaporation to solar radiation and air temperature. A general equation which proved satisfactory for use in West Coast regions was obtained by the method of least squares. Examinations of data from central and eastern states indicates, however, that the character of the equation varies longitudinally. This is being examined from the standpoint of climatological factors. There is good reason to suspect that such an equation may

have both limnological and marine applications. An observed correlation between heat storage and the difference between "pan" evaporation and lake or ocean evaporation is theoretically feasible. The main difference between the pan and ocean environments is the heat storage capability of the ocean.

Analysis of solar radiation data measured during summer 1963 on the ACONA is now complete, and a paper is in preparation. During this period radiation received on Oregon coastal waters was only 76% of that expected if the skies had been clear. Clear sky radiation was predicted using Kimball's method (Kimball 1928). There was no statistically significant difference between radiation received in Yaquina Bay and offshore to a distance of 165 miles. At the end of the summer the pyrhelimeter became damaged and was returned to the factory for repair. Recording and analysis will be resumed when the R/V YAQUINA is commissioned in the fall of 1964.

Estuarine Studies - Blanton, Frolander, Kulm, Kulm

The studies on tidal flows and mixing in Coos Bay have been described in a Master's thesis written by Mr. Blanton. Dr. Frolander has submitted for publication a paper including analyses of the temperature, salinity and oxygen structure in Yaquina Bay.

La Verne and Sally Kulm have been examining the water budget of the Yaquina Bay watershed and its effect on the salinity structure in Yaquina Bay. During winter, local precipitation is heavy and the bay becomes two-layered. The intensity of the density gradients apparently depends not only on the local rainfall but also on the recent history of the watershed, i. e., the rate of storage of groundwater. Residence time of river water in the bay is also being determined.

GEOLOGICAL OCEANOGRAPHY

Offshore Studies--Geology of the Oregon Continental Terrace - Byrne, Fowler, Maloney, Runge

The preliminary sampling of the continental shelf off the northern Oregon coast has been completed. Grab samples have been collected at 42 locations on a three-mile grid between $46^{\circ}05'N$, and $46^{\circ}20'N$. A pipe dredge was used to collect rock samples from the bank at $45^{\circ}54.7'N$, $124^{\circ}32.3'W$.

Sediment samples were also collected from the southern continental shelf north of Cape Blanco. Between $42^{\circ}56'N$, and $43^{\circ}53'N$, 142 grab samples and two rock dredges were taken.

Textural analyses have been completed for 64 of the nearshore sand samples (greater than 95 percent sand) collected between $45^{\circ}00'N$, and $46^{\circ}02'N$. Median diameters of these samples generally range between 0.135 and 0.246 mm, but in some areas are appreciably larger (0.588 to 0.932 mm). One such area off Cascade Head, previously sampled in July 1961, was resampled in November 1963 at one-mile intervals, but no coarse sand was found. Plans have been made to resample the area during the summer of 1964.

Preliminary studies of the sediments and bedrock geology of the continental slope and shelf off the central coast of Oregon are nearing completion. Size analyses have been completed for all sediment samples. The core samples were analyzed at the top, middle and bottom. In addition, the cores were logged and photographed. The terrigenous, authigenic, and biogenic components of the sand fractions are being counted in an effort to determine the origin of the sediment.

Mechanical analyses were run on 11 rock samples. Ten were found to be clayey silts and one to be a sandy silt. In addition, some 70 thin sections have been cut from the various rock samples. The dominant lithologies are diatomaceous siltstones which are at time cemented with calcite, glauconite sandstones, lithographic limestones, and friable, poorly sorted, volcanic sandstones.

Bench and scarp distribution maps have been compiled for the continental slope area. These maps and the previously constructed bathymetric chart were used for the construction of a physiographic chart. The nature of the bathymetry suggests strongly that the major topographic features of the continental slope were formed by faulting.

Forty of the 138 samples of rock collected from the shelf and slope off the central Oregon coast have been processed for their contained foraminifera. These were selected to give the most representative coverage of the area. Of those not processed 40 are of a lithologic type which cannot be effectively disaggregated. The remainder will be examined in the future.

Only one sample was determined to be older than Pliocene. This contained an excellent assemblage correlative with the Lower Middle Miocene (Relizian Stage) of California. Twenty-two contained faunas exhibiting definite similarities with Lower, Middle and Upper Pliocene faunas of California. More positive correlation must await further analysis. Seventeen yielded non-diagnostic faunas or only contamination by recent forms.

Depths of deposition were determined where possible. These ranged from approximately 100 meters to more than 2,300 meters. Depths indicated by the fossil faunas exceeded water depths at the collecting sites by as much as 1,200 meters.

Coastal Studies - Byrne, Carlson, Kulm, North

Erosion: The investigation of landsliding along the northern Oregon coast has been completed. Landsliding is a significant contributor to continuous erosion of the 150-mile northern Oregon coast. Direct loss of land to the sea by landslides occurs along 47 percent of the coast. The remaining 53 percent has minor shifting of sand along depositional areas such as spits and dunes. These minor movements alter coastal topography but do not erode material directly into the sea.

The type of landsliding is principally controlled by the lithology of the coastline. Landslides are classified on the basis of two features: the lithology of the coastal material in the slide, and the type of movement expressed by the overall shape of the slide. Slump occurs in deeply weathered sedimentary rocks and in marine terrace sands overlying seaward-dipping rocks. Rock and debris fall are mainly confined to headlands. Block glides develop along bedding planes of relatively unweathered sandstone. Debris shift occurs in thick terrace and dune sand deposits in which no slip surface is defined.

Factors contributing to the cause of coastal landslides include high precipitation, easily weathered rock, and high coastal wave energy. Frequency of reported landslides is related to periods of high precipitation and high wave energy. Although rock weathering is continuous throughout the year, the final phase of disruption of slope equilibrium most often occurs during winter storm conditions.

Landslides on headlands and adjacent coastlines disrupt the most extensive land areas. Wave refraction directly influences this relationship by focusing wave energy on promontories and on the coastline within one mile of the headlands. Distribution of coarse and fine beach material is affected by refraction in restricted coves.

Severe coastal erosion has taken place in local areas. The average rates of retreat vary according to the lithology of the coastline, and have been determined as follows: unconsolidated sand and gravel - 23 feet per year; marine terrace sands overlying sandstone and clay - 20 feet per year; marine terrace sands overlying mudstone and sandy shales - 6.5 feet per year.

Deposition: The study of nearshore carbonate sediments of the Island of Bermuda is being continued. A total of 121 recent carbonate sand samples have been analyzed for sediment texture. These sands were collected in the beach, dune and nearshore environments around the Island of Bermuda during August 1963. Several beach profiles from 11 of the most prominent beaches were sampled and measured to determine beach texture and morphology for summer oceanographic conditions. In order to evaluate seasonal effects of hydrography of the Bermuda beaches, the same beach profiles were again sampled and measured during March 1964. The March data and samples were collected by Dr. Fred T. MacKenzie, Bermuda Biological Station, St. George's, Bermuda. A total of 82 carbonate sand samples were collected at this time from the various beaches.

Faunal Studies - Fowler

A laboratory of Modern Foraminifera is being organized within the Geological Oceanography group. It is anticipated that all phases of research on recent foraminifera will eventually be conducted. Speciation of foraminifera is underway on material in departmental collections obtained from Yaquina Estuary to the base of the slope off Newport. Permanent reference slides are being set up from this material. Plans are being formulated for a systematic study of benthic foraminifera along six profiles from shore to a depth of more than 3,000 meters. Profiles are to be evenly spaced along the entire Oregon coast. Initial collections will be made in May. Seasonal collections will begin in Yaquina Bay during June.

A device has been constructed to simultaneously obtain five normal Phleger Core samples within an eleven-inch circle. This will allow greater statistical control for quantitative study of foraminifera distribution. In addition, individual samples from a small collecting area will enable various analyses to be made independently.

GEOPHYSICAL OCEANOGRAPHY

Seismic Work at Sea - Berg, Whitcomb

Seismic reflection studies have been made of the shallow geologic structure in the area immediately off the coast of Newport, Rhode Island. This work is being reported in a thesis by Mr. Whitcomb.

Land Gravity Studies - Berg, Dehlinger, W. Rinehart, Thiruvathukal

Gravity data for the State of Oregon are being compiled. Two hundred twenty-five gravity measurements have been made at key locations to establish six gravity lines extending eastward from the Oregon coast to beyond the Cascade Mountains. An additional 1,785 measurements have been obtained from Dr. George P. Woollard and 2,800 measurements from Standard Oil Company of California. These measurements are being combined with measurements taken at sea to extend the six lines mentioned above more than 100 miles at sea. The data are currently being analyzed in terms of earth structure with emphasis on the transition between deep ocean and continent.

A system of gravity base stations has been established in Oregon using a light airplane. A report has been published on this work.

Theoretical Studies - Berg, Maloof, Stone, Stone, Odegard, Papageorge

A method has been developed to analyze potential field data in the frequency domain. The method is being finalized and will be submitted for publication shortly.

Studies are in progress on wave generation and transmission in solid media to follow the continuity of energy from a point explosive source to several thousand kilometers.

Thermal Studies - Berg, Hutt

The thermal probe equipment has been received and tested at sea. The system is currently being redesigned as a result of the sea tests.

Parts for a bridge to determine heat conductivity of a core have been ordered and received. The bridge is currently being assembled.

Magnetic Studies - Berg, W. Rinehart, Ropes

A map of total magnetic field intensity measurements for offshore Oregon is being completed. Analyses of the measurements are in progress.

Instrumentation for the study of paleomagnetism is currently being constructed. Initial measurements will be made during summer 1964.

Instrumentation - Bales

A nuclear precession magnetometer has been constructed and is now operating.

Precision radar ranging equipment is being installed aboard the YAQUINA, and will be tested during fall 1964.

Seismic equipment obtained through surplus has been renovated.

Seismicity and Crustal Structures of Oregon - Dehlinger, Chiburis, V. Rinehart, Collver

Construction of traveltime curves for Oregon and adjacent regions have been completed. These were based on five earthquakes in western Washington, Oregon, and northern California, eight in Idaho, western Montana, and western Wyoming, and 12 off the coasts of Oregon and northern California as recorded at some 40 seismic stations in the Pacific Northwest. Because of the locations of the seismic stations and epicenters, it was found that the data from the land-based epicenters could be best analyzed in terms of waves traveling northerly and southerly west of the Cascade Mountains and easterly and westerly east of the Cascades. Data from the ocean-based epicenters were analyzed from all waves recorded at the land stations.

Velocities of propagation in a north-south direction west of the Cascades were found to be

$$P_n = 7.70 \text{ km/sec}; P^* = 6.54; \bar{P} = 5.50; S_n = 4.32$$

and in an east-west direction east of the Cascades they are

$$P_n = 7.94 \text{ km/sec}; P^* = 6.53; \bar{P} = 5.65; S_n = 4.58$$

Poisson's ratios of the materials beneath the Mohorovicic discontinuity were found to be 0.27 ± 0.01 west of the Cascades and 0.25 ± 0.01 east of the Cascades. The nature of the differences in rocks in eastern and western Oregon causing the velocity and Poisson's ratio contrasts has been investigated and will be studied further.

Velocities of propagation based on the offshore epicenters were determined with less accuracy. They are $P_n = 8.0$ and $S_n = 4.5$ km/sec.

Surface-wave dispersion curve analyses to determine the nature of crustal and subcrustal materials and configurations in the Pacific Northwest were initiated. This work will comprise most of the dissertation material for E. F. Chiburis.

The Standard Seismic Station at Corvallis and the Seismic Station at Klamath Falls were operated full time during this report period.

Sea Gravity Investigations - Dehlinger, W. A. Rinehart, Couch, Berg

Sea gravity measurements were made aboard the USCGS ship SURVEYOR between Seattle, San Francisco, Honolulu, and Kodiak Island, with a detailed survey made north of the Hawaiian Islands.

Sea gravity data analyzed during this report period include measurements made off the Oregon coast, particularly those over the seaward extension of the San Andreas fault zone, and those made previously between Seattle and Alaska (on a U. S. Fisheries ship BERTHA ANN). Crustal analyses were made over the San Andreas fault zone in an effort to locate this zone at sea. A negative gravity anomaly was observed along the zone when the effects of subterranean topographic features were removed.

Analyses have also been made to further evaluate the reliability of the LaCoste meter by checking measurements over a known gravity range, against nearby sea pendulum gravity measurements, and from intersections of numerous gravity profiles. Factors causing errors in measurement were analyzed further and have been defined in greater detail than previously.

CHEMICAL OCEANOGRAPHY

Offshore Chemistry - Park, Dobson, Matson

Studies on the effects of upwelling and Columbia River runoff on the chemical conditions in the sea off the Oregon coast are continuing. Seasonal variation of the salt budget is being analyzed. Alkalinity and pH determinations are still continuing for all hydrographic samples.

Changes in the distribution of inorganic reactive silicate due to upwelling, river runoff, and biological utilization are being summarized by Mr. Matson for his M. S. Thesis.

Estuarine Chemistry - Park, Frolander, Wyatt, Dobson

Analysis of data collected during 1961-1963 has shown that the chemical composition of Yaquina Bay, Oregon, is greatly influenced by the open sea. The estuarine chemistry is also affected by meteorological conditions and local river runoff. All three of these effects are reflected in the distribution of biomass found in the bay.

A manuscript comparing estuarine and offshore chemical conditions is in preparation.

Gas Chromatographic Determination of Dissolved Gases in Sea Water - Park, Dobson

We have recently combined the gas chromatographic methods for the determination of dissolved oxygen and nitrogen (Swinnerton and Sullivan) and total carbon dioxide (Park et al). Results with this combined method are reproducible within approximately one percent for each of these three gases contained in surface sea water. A typical chromatogram of the dissolved gases from a 4 ml sea water sample is shown in Figure 1. Gas content as a function of salinity is shown in Figure 2.

Physical Chemistry of Sea Water - Weyl, Connors, Duedall

A project to measure the partial molar volumes and partial equivalent conductances of salts in sea water was initiated in September. To date, the equipment required has been procured, and the instrumental techniques are being worked out. Actual measurements will begin this summer.

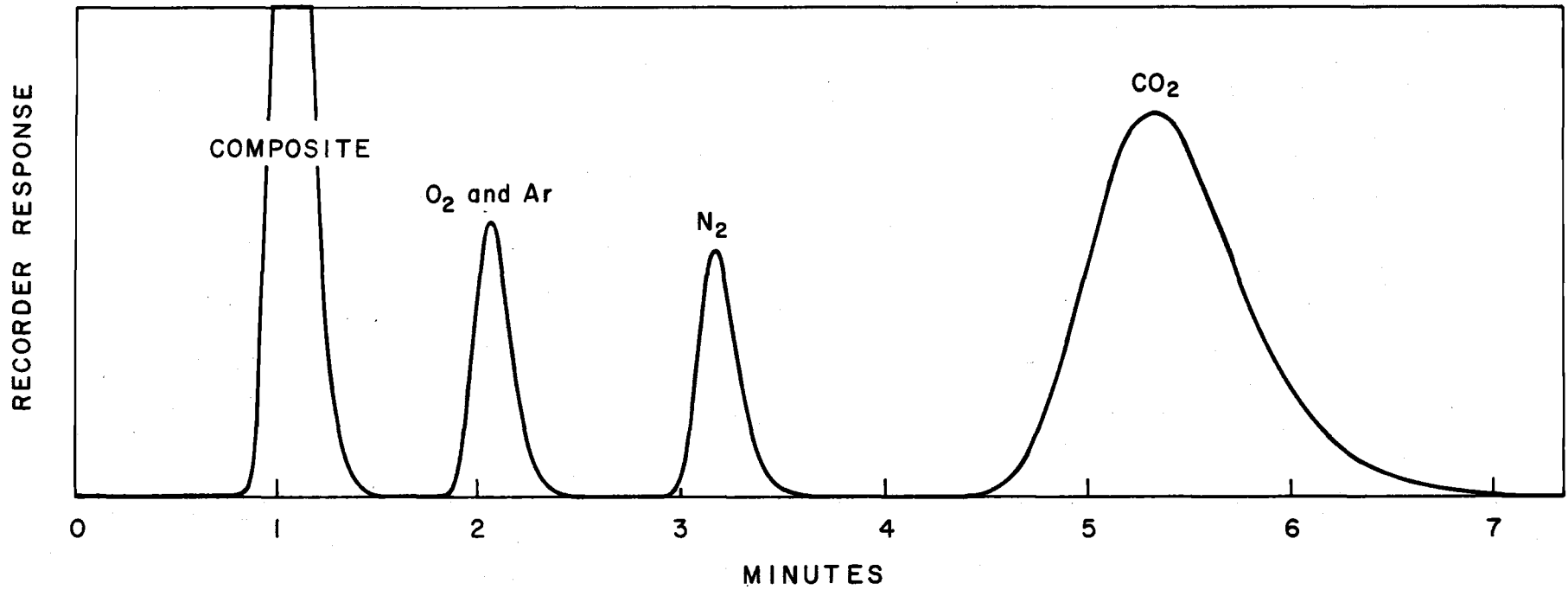


Figure 1. Gas chromatogram of oxygen (plus argon), nitrogen, and total carbon dioxide.

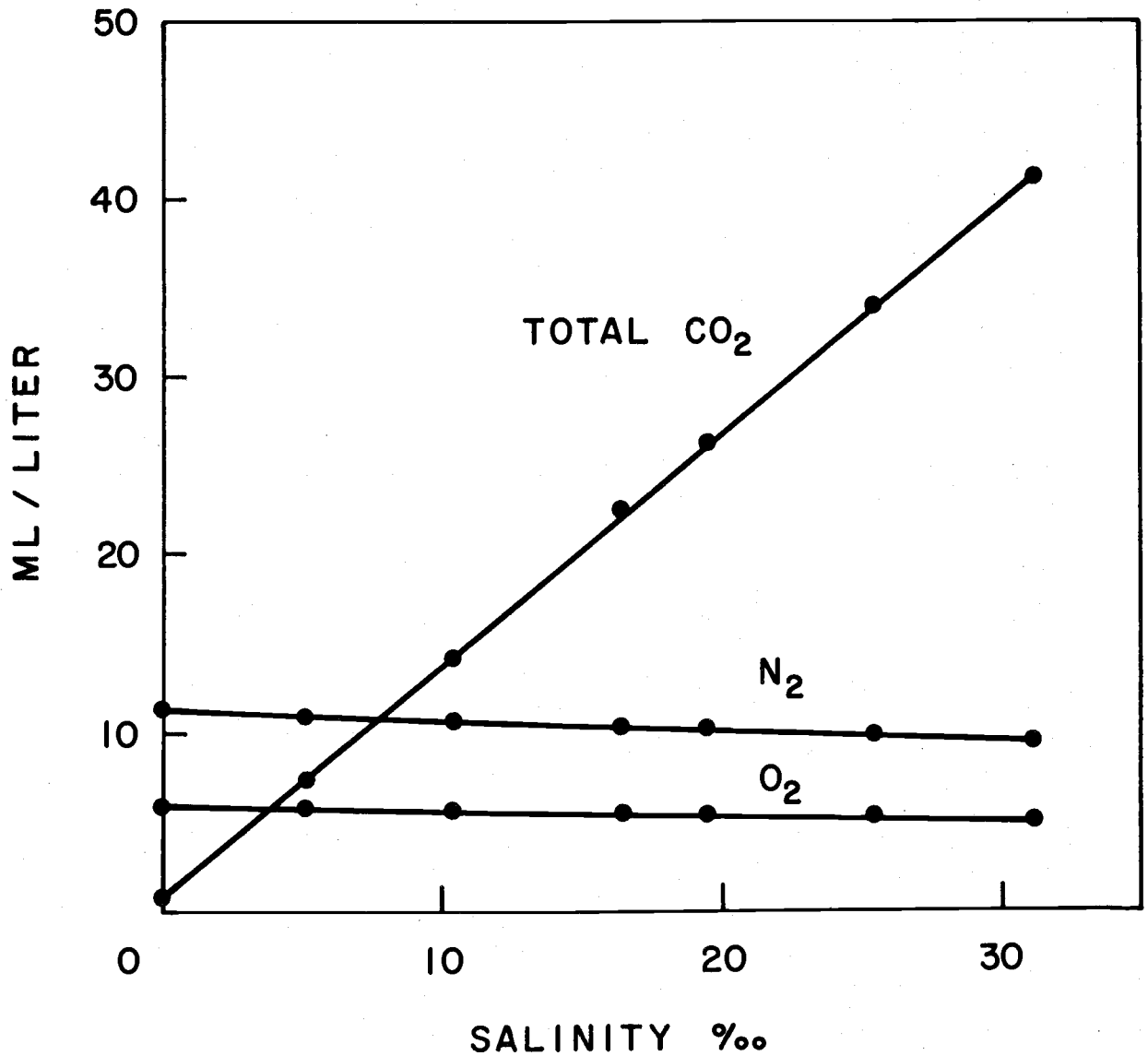


Figure 2. Oxygen, nitrogen and total carbon dioxide in sea water as a function of salinity.

The method originally proposed for determining partial molar volumes by changes in density has been improved. A special dilatometer (Figure 3) was developed for the direct determination of the volume change due to salt addition. A constant temperature bath for the system has been constructed, and initial tests of the equipment have been satisfactory.

The partial equivalent conductances of salts in sea water will be determined with a transformer ratio bridge. One sample of sea water will be compared with another to which a small amount of salt has been added. The constant temperature bath for this system consists of an oil bath contained in a commercial water bath. The outer bath has refrigeration accurate to 0.01° C. The inner bath is contained in an aluminum pot and is maintained about $1/2$ degree warmer than the outer bath. The temperature of the inner bath is controlled by a thermistor temperature regulator. (Initially this bath was heated by a copper clad immersion heater. Temperature fluctuations of 0.02° C were encountered, however, due to the thermal lag of this heater. By replacing the heater with a heating lamp, these fluctuations were reduced to 0.002° C.) The oil bath holds three Jones type conductance cells. Initial tests show that the system performs satisfactorily and that resistance ratios can be determined to one part in 10^5 .

The Paleochemistry of the Oceans - Weyl

The chemical evolution of the oceans has two aspects; the evolution of sea water over the last few billion years, and the relative chemical stability, particularly of the pH of sea water, during the last half billion years. We have become interested in the latter problem. The oceanic residence times of bicarbonate and calcium, the pH controlling species, are of the order of 10^5 and 10^6 years, while the paleontological evidence indicates relative stability of pH over at least 5×10^8 years. This indicates that the pH stability of the oceans is not the result of chance but rather due to an elaborate feedback mechanism.

To get a better feeling for the problem and to break it down into more limited areas of investigation, we have studied a simple two layer model of the oceans. This study has led us to the investigation of four areas.

1. The rate of exchange between the surface waters and the deep waters and how this rate of exchange is altered by changes in climate and sea level. We have looked at the oxygen minimum surface in the Pacific to obtain data on the deep circulation of that ocean. To better understand the mechanics of the deep thermo-haline circulation, we are studying vertical thermo-haline eddy diffusion.

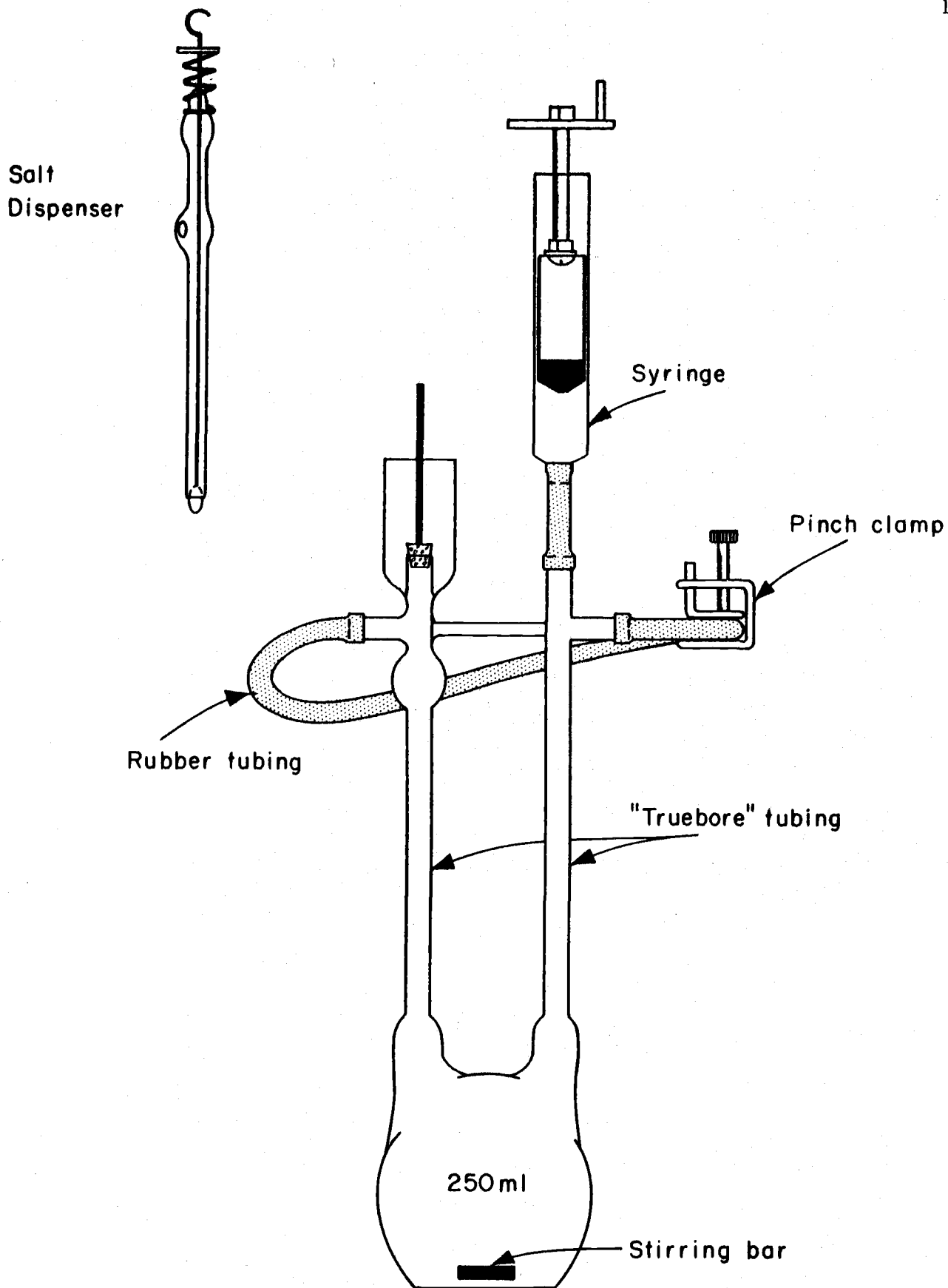


Figure 3. Dilatometer.

2. The effect of the CO_2 pressure in the atmosphere on the rate of continental weathering. This is important because, as the surface water of the ocean becomes more acidic, the partial pressure of CO_2 in the atmosphere will increase. This should result in a faster rate of weathering and, hence, in more rapid addition of alkalinity to the oceans by runoff. The net effect is to stabilize pH.

3. The interaction between the sea water chemistry and dolomitization. Since the rivers add more bicarbonate to the ocean than calcium and since marine organisms precipitate calcium carbonate almost exclusively, the calcium content of the sea should decrease with a consequent rise in pH. Only dolomitization can compensate for this loss of calcium. While dolomitization has taken place in the past, it is difficult to understand how direct feedback can alter the rate of dolomitization to keep the calcium concentration relatively constant. In this connection, the cyclic occurrence of dolomites in ancient rocks is intriguing.

4. The alkalinity consumption by deep-sea diagenesis. The pH of the deep water is altered by the diagenesis of deep-sea sediments. This includes solution of calcium carbonate, formation of new minerals from volcanic glass, etc. If the pH gets extremely high (between 9 and 10) magnesium hydroxide would precipitate.

We do not expect to solve the problem of the chemical stability of sea water in the near future. Rather, we hope that by focusing on a broad problem, we will be better able to integrate the more limited studies and see their results in better perspective.

Chemical Reactions in Sea Water - Pytkowicz, Connors

The high pressure solubility of calcium carbonate in sea water was measured in the laboratory. Results suggest that deep oceanic waters are undersaturated. This implies that, calcareous matter dissolves as it sinks. Consequently, the specific alkalinity of the sea water should increase in the direction of the motion of the waters.

The laboratory results were used to analyze the raw data obtained by Hood et al, during the USNS ELTANIN Cruise 3 off the west coast of South America. The deep waters in that area were found to be undersaturated. An increase in specific alkalinity was found, indicating a northward drift of those waters.

The stability of supersaturated calcium carbonate in surface waters was examined. The laboratory experiments showed that magnesium, present as an impurity on the surface of calcium carbonate nuclei, inhibits precipitation, thus causing the calcium carbonate stability.

Oxygen-Phosphate Relationships in the Ocean - Pytkowicz

A sub-surface oxygen maximum is found in the North Pacific Ocean in summer. The formation of this maximum off the Oregon coast was studied by means of oxygen-phosphate relationships. The maximum was shown to result from oxygen loss above the layer in which the maximum occurs, when the temperature of the surface waters rises. Eddy diffusion coefficients were calculated from the rate of oxygen exchange. The exchange coefficient was estimated and agrees well with the result of Redfield for the Gulf of Maine.

The preformed phosphate is being determined in the North Pacific and is being used in studying water masses off the west coast of North America.

MARINE RADIOECOLOGY

Nekton - Osterberg, Pearcy, Larsen, Dickson

Radioactivity of animals from several depths in the water column down to 1000 meters is being measured. A paper (Pearcy and Osterberg) discussing results of this study is in preparation.

Benthos - Osterberg, Carey, McCauley, Larsen, Dickson

Both fission products and neutron-induced radionuclides from Hanford are being found in benthic animals. A recently published paper (Osterberg, Carey and Curl) concludes that fall-out radionuclides are being swept from surface water by herbivorous plankton, passed through digestive tracts and released as fecal pellets. Settling rates of fecal pellets was shown to be much greater than for small, unincorporated fall-out particles. Thus, in some cases at least, the role of organisms in the transport of radionuclides seems to be more important than purely physical processes.

River Sediments - Cutshall, Johnson, Osterberg

Samples collected from five stations on the Columbia River between the Hanford reactors and the estuary were analyzed after drying and sorting. In general, the activity from most Hanford-induced radionuclides was greater in the river sediments, but fission products were more variable. In the course of this study, an unusually radioactive particle was found and described (Cutshall and Osterberg).

Geochemistry - Johnson, Cutshall, Osterberg

The exchange properties of graded Columbia River sediments are being studied. Levels of radioactivity (mostly chromium-51, zinc-65, scandium-46, and cobalt-60) in these sediments are sufficiently high to permit quick gamma scans before and after elution with such agents as sea water, dilute acetic acid, EDTA, and ammonium acetate. Techniques are being developed to carry out these studies in the field using wet sediments, to avoid changes due to drying and bacterial action while in storage. These studies will form the basis of Mr. Johnson's thesis.

In-Situ probe studies - Osterberg, Jennings

A gamma-ray probe using a 3 x 3-inch NaI(Tl) crystal as a detector has been used in the lower 130 miles of the Columbia River. Data from the probe, which "sees" radioactivity both in the solute and on suspended

particles are compared with results from laboratory radioanalysis of membrane filters. The filters, through which surface waters have been passed, trap radionuclides that are associated with particles. These studies shown that Zn^{65} and Cr^{51} increase their association with particles with distance downstream. The estuary is a region of fluctuation, partly due to increased turbidity and the presence of salt water. The latter has been shown to displace some Zn^{65} from particles.

The probe is being modified to use for in situ measurement of the radioactivity of sediments. The probe can be used at depths to 150 feet, and will, therefore, reach the deepest parts of the estuary. Mr. Jennings will use the sediment probe in his thesis research.

Estuarine Collections - Haertel, Wiese, Osterberg

Monthly collections have been made at three stations in the Columbia River estuary, using a 22-foot otter trawl. Animals from all three stations have roughly comparable quantities of Zn^{65} , but levels of Cr^{51} vary inversely with salinity. Plankton samples are taken, and physical parameters (such as salinity, temperature, and turbidity) are measured at each station.

Stable Element Analysis - Cronin, Osterberg

The recently developed atomic absorption spectrometer (Perking Elmer Model 303) has been obtained, and initial tests have been carried out. This equipment will be used to measure transition elements in sea water. Solvent extraction techniques will be used for removal and concentration of these elements.

Analysis of 48 samples of irradiated plankton, fish and other animals reveal the presence of several elements. The most noticeable peaks in spectra of samples (after a 3 to 6 month's decay period) are due to zinc-65, scandium-46, cobalt-60 and selenium-75.

A comparison of these two techniques is planned.

BIOLOGICAL OCEANOGRAPHY

Marine Microbiology - Morita

Growth and cell yield studies on an obligate psychrophilic marine bacterium (Vibrio marinus MP-1) have shown that low temperature is certainly not inimical to the growth of this organism. At 15° C a yield of 10¹¹ cells per ml can be obtained in 24 hours while at 3° C a cell yield of 10⁹ cells per ml in 24 hours can be obtained. The organism has the ability to grow under various hydrostatic pressures from 1 to 400 atm at either 15° C or 3° C.

Thermal studies on washed cells of Vibrio marinus MP-1 have shown that exposure of the cells to moderate temperatures (20 to 30° C) increases their ability to take up oxygen endogenously or in the presence of glucose. This definitely indicates that the enzymes involved are sensitive to moderate temperature.

When cells of Vibrio marinus are exposed to temperature above the organism's maximum growth temperature (20° C), 260-280 mu absorbing material leaks out of the cell. Some of this material has been identified as DNA and RNA. This study definitely indicates that permeability of the cell is lost at moderate temperature.

Studies are now underway to isolate the various isozymes of malic dehydrogenase in Vibrio marinus MP-1 as well as to elucidate the various thermal sensitive enzymes.

Funds have just been received from the National Institute of Health for the construction of a pressure-temperature controlled polarimeter. This will enable us to carry out work dealing with optical rotation of enzymes and proteins as affected by pressure and temperature.

Studies on Beggiatoa have indicated that catalase in the medium is important in the growth of the organism in pure culture. Further studies have been made to trace the biochemical utilization of acetate in this organism.

Seasonal and Geographical Distribution of Pelagic Copepods - Cross, Small

Mr. Cross has concluded his work on seasonal and geographical distribution of pelagic copepods off the Oregon coast. His M. S. thesis is in the OSU library.

Energy and Element Transfer in the Lower Marine Food Web - Small, Curl

Work continues on the assimilation rates of Calanus finmarchicus IV using Zn^{65} labelled Skeletonema costatus as the food source. Effects of different concentrations of algal food are being assessed initially in flask experiments. A flowing water system is being developed for comparison with flask experiments. Temperature, light, and grazer concentration effects will be investigated.

Phytoplankton Ecology - Curl, Small, Hardy

In situ productivity experiments have continued at NH-25. Pigment-light data have been collected on all cruise lines for estimates of gross primary productivity off the Oregon coast. Special emphasis was placed on areas of upwelling. Species identification work continues, and standing crop estimates are being made.

A 24-hour primary productivity study was performed in Yaquina Bay.

Respiratory Metabolism of Nekton - Karinen, Curl, Percy

Data from seven cruises have been evaluated and a positive correlation has been found between "potential respiration", measured enzymatically, and the extent to which certain bathypelagic fish undertake vertical migrations. Experiments are underway to perfect the method of standardization and to determine the relationship between gaseous respiration and "potential respiration".

Enzymatic Measurement of Primary Production - Davey, Curl

Enzyme activity by TPN-dependent glyceraldehyde-3-phosphate dehydrogenase (GAPD) in Skeletonema costatum was determined. The quantitative measurement of TPN-dependent GAPD was low compared to the theoretical yield calculated from oxygen data. DPH-dependent GAPD appears to play a major role in the pentose phosphate pathway of this organism. These experiments are continuing as part of a general research program in phytoplankton physiology and biochemistry.

Oceanic Trematode Studies - McCauley, Eagle

During the six month period from September 1963 through March 1964, 162 fishes were examined and 129 were found to harbor one or more parasites. More than 1700 parasites were recovered. Trematodes have been stained and mounted, and identifications are in progress. Lepidapedon luteum var. abyssensis has been described from a deep sea macourid fish Coryphaenoides sp. from a depth of 2800 meters.

This was the first published record of a trematode parasite from more than 2000 meters. Subsequent collections have produced at least two other species of Lepidopedon and several other trematodes (including one monogenetic from Coryphaenoides sp. from 2800 meters or deeper. These may show some interesting patterns of host specificity, but identifications of the fish hosts are delayed because an ichthyologist who will tackle this difficult group has not been found.

Trematodes have been collected from several pelagic fishes and fishes from shallower water as well. One of the more interesting is a species of Lecithophyllum from the alepocephalid fish Alepocephalus convexifrons.

Acanthocephalan Parasite of Saury - Laurs, McCauley

A new species of Acanthocephala, Rhadinorhynchus cololabis, from the intestine of the epipelagic fish Cololabis saira has been described. The fish was taken from the Brookings area.

Hydroid Ecology - McCormick, McCauley

Hydroids from offshore Oregon are being studied to determine species distribution, bathymetric relationships, and interspecific relationships. Twenty-seven species of non-epizoic hydroids have been found; all have been identified to genus and eighteen to species. A number of hydroid species epizoic on snails have been submitted to specialists for identification.

Plankton Inventories at Yaquina Bay - Frolander

During the period of this report, four stations in Yaquina Bay were sampled weekly. Both biological and physical data were collected. Quantitative and qualitative net tows were made with both # 6 and # 12 mesh nets. Surface and bottom water samples were taken at each station, and measurements of temperature, salinity, and dissolved oxygen were made.

On February 21 and 22 a special survey was taken to study the winter conditions of Yaquina Bay. The study consisted of two parts. The first was a spatial survey to determine biological and physical-chemical variability. Six stations were spaced over a distance of nine nautical miles from the bridge at Newport, Oregon, to buoy 45. A time survey of 24 hours immediately followed the spatial survey. As in previous surveys, buoy 21 was manned. The second station was changed from buoy 15 to buoy 12 to minimize the effect of land drainage. During both surveys, 55 quantitative #6 mesh CB samples, 6 quantitative # 12 mesh samples, 3 qualitative half-meter samples, and 116 water samples were taken.

Quantitative samples of zooplankton collected from 21 October 1963 through 11 January 1964 were analyzed by the vacuum displacement method. All zooplankton samples for the period 1 October 1963 through 31 March 1964 have been accessioned into ledgers, cataloged in card files, and deposited in chronological accessioning cases. Oxygen saturation values for the ranges of salinity and temperature encountered in Yaquina Bay have been calculated for both surface and bottom levels for all observations made during the period covered by this report.

Herring Feeding Habits - Frolander, Russell

A study of the feeding habits of herring in Yaquina Bay is complete. Results show that Yaquina Bay is a feeding ground for the Pacific herring (Clupea pallasii). Acartia clausii and Pseudocalanus minutus, common copepods endemic to the bay, furnish a major portion of the herring food supply, but the data suggest that the herring will select larger sized organisms when they are available. Herring were highly selective for Ostracods when the "normal food supply" was lacking. Quantities of debris, wood particles, and mica were present in a fish stomach containing the Ostracods. The data are suggestive of opportunistic feeding habits.

Distribution of Oceanic Animals - Percy, Hebard, Hubbard, Forss

Studies of the seasonal distribution of intermediate oceanic consumers in relation to their environment are being continued. A total of 29 midwater trawl samples and 32 one-meter plankton net samples were collected during the period along the latitudinal lines of hydrographic stations off Oregon. These samples have been subsampled and are being analyzed taxonomically in the laboratory so that species variations can be correlated with hydrographic and biological conditions.

Species identification of euphausiids, shrimps, fishes, cephalopods, and salps from previous samples have been completed and spatial and temporal variations in distribution are being investigated.

Effects of Upwelling on the Biomass of Trophic Levels - Laurs, Percy

In April 1964, a cruise was made off Brookings, Oregon, an area of intense upwelling during the summer. This cruise was part of a program to study possible relationships between physical-chemical properties and biomass of various trophic levels. In addition to regular hydrographic observations, tows were made with a six-foot Isaacs-Kidd midwater trawl of uniform mesh-size and a one-meter plankton net with "O" mesh. Millipore filtrations for standing crops of phytoplankton were also made. Many pyrosomes and salps, possibly indicating occurrence of warm water, were collected. Of special interest was the capture of a melanostomiid fish Opostomias sp.

Examination of hydrographic data and biological samples from this area is in progress.

Vertical Distribution and Migration Studies - Pearcy, Renshaw

Monthly cruises were scheduled for collections of oceanic animals at various depth strata at a station over the outer edge of the continental slope. Tows with a Multiple Plankton Sampler as an opening and closing cod-end unit yielded 27 samples each from depths of 0-150, 150-500 and 500-1000 meters.

Multiple opening-closing one-meter plankton nets were also used in conjunction with the midwater trawl to sample the macroplankton. In the last six months 37 samples have been collected from 0-150, 150-450, 450-600, 600-1000, and 1000-1500 meters. During most cruises two day tows and two night tows were made over each 24-hour period using each sampling method. Hydrographic casts to 1000 meters and bathythermographs were completed in conjunction with these studies.

Radioecology of Pelagic Animals - Pearcy, Osterberg, Larsen, Wyandt

Gamma-ray spectrometry of whole midwater trawl samples is in progress to estimate daily variations in the radioactivity of certain radioisotopes associated with animals collected at various depths. Fifty-three samples are being radioanalyzed.

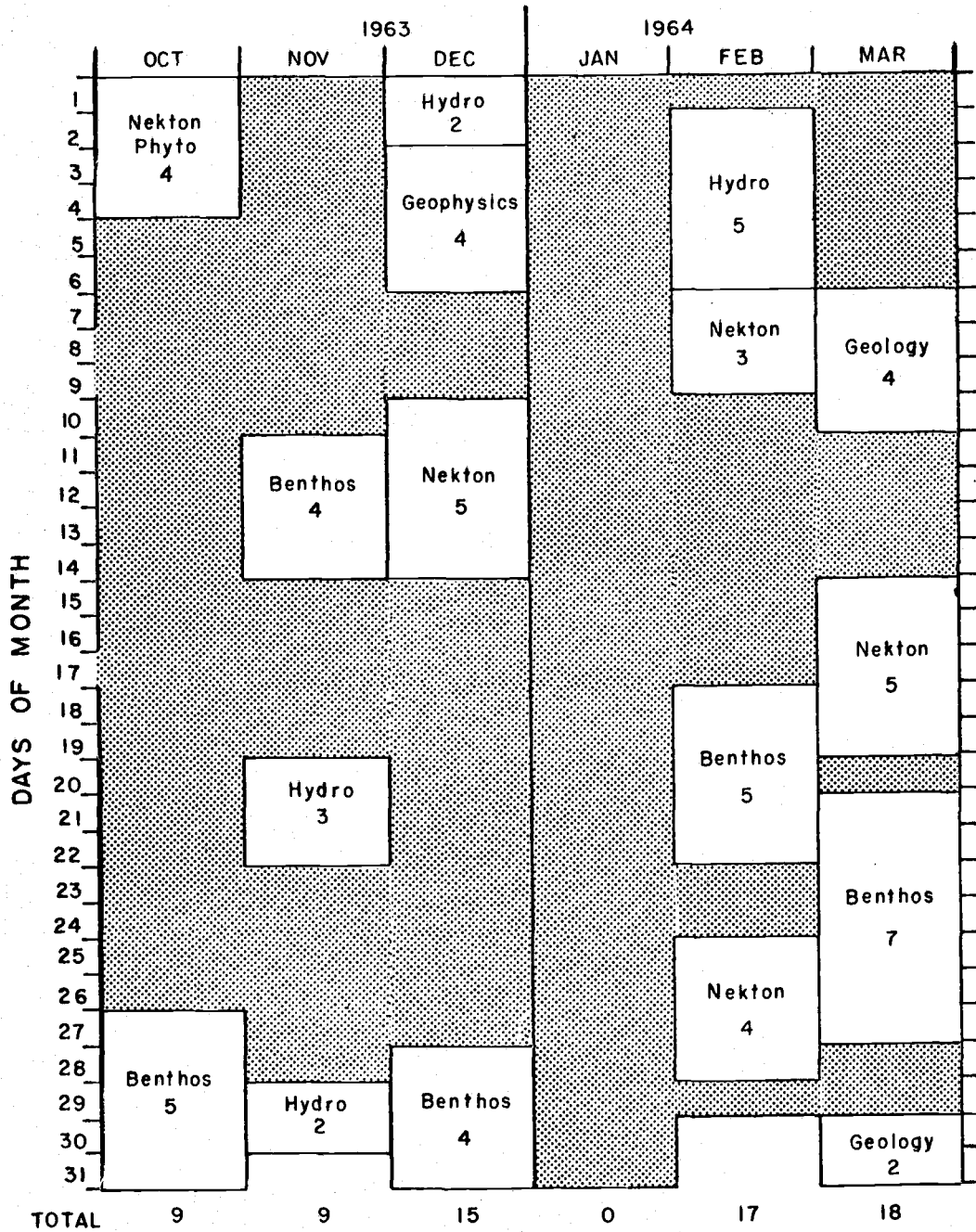
In addition, 23 individual species of oceanic animals have been radioanalyzed for gamma emitters. These include fishes, cephalopods, shrimps, euphausiids, mysids, copepods, chaetognaths, medusae, pteropods, ctenophores, and salps.

Benthic Studies - Carey, McCauley, Alapach, Hancock

Benthic studies off the Oregon coast were continued with the aid of 26 anchor dredge and 12 otter trawl samples collected during this period. Analyses of the collections is progressing.

A newly developed towing frame for the anchor dredge has enabled us to improve the quality and quantity of our samples.

TIME AT SEA



FACILITIES

Research Vessel ACONA

The ACONA spent 68 days at sea during this period. Bad weather forced cancellation of all cruises scheduled for January. Three hydrographic studies, one geophysics cruise, two geology cruises and several biological studies of benthos, nekton, and phytoplankton were successfully completed.

Research Vessel YAQUINA

Conversion of the YAQUINA for use as a research vessel is underway at the shipyards in Portland. The vessel is 180 feet long and will displace approximately 800 tons. She will berth up to 20 crew members and 20 scientists. The YAQUINA is scheduled for sea duty in early September.

Oceanography Building

Construction on the new Oceanography Building has been completed, and nearly all of the staff have moved into their new quarters. Final touches and landscaping are scheduled for completion by mid-summer.

Coastal Marine Science Laboratory

Docking facilities have been completed, and the construction of the main laboratory building is underway. The facility is expected to be ready for occupancy by the end of 1964. Dr. Wayne V. Burt has been named Director of the laboratory by the Oregon Board of Higher Education.

NEW STAFF MEMBERS

Dr. Ricardo M. Pytkowicz has joined the staff as Assistant Professor of Chemical Oceanography. Dr. Pytkowicz was formerly with the University of Washington where he held the position of Research Assistant Professor. He attended the Faculd. de Filosofia in Sao Paulo, Brazil, and later Louisiana State University where he received the Bachelor of Science degree. He then attended the University of California at Berkeley from which he received the Ph. D. degree in physical chemistry. He was granted a post-doctoral fellowship from Massachusetts Institute of Technology where he studied polyelectrolyte solutions. He also worked in industrial operations research with Arthur D. Little, Inc. Dr. Pytkowicz is a member of several professional societies.

He is currently engaged in research in the physical chemistry of sea water at atmospheric and high pressures and on the distribution of non-conservative properties in the oceans as related to the water masses.

Dr. Shigeo Moriyasu joined our staff in October as visiting professor in Physical Oceanography. Dr. Moriyasu is on leave from the Kobe Marine Observatory in Kobe, Japan, where he has been engaged in oceanographic and meteorological research since 1949. He has published many articles in physical oceanography, particularly in the field of currents and water mass characteristics and their relationships to meteorological conditions. He holds a Doctor of Science from the University of Tokyo where he presented a dissertation entitled "On the Fluctuation of the Kuroshio South of Japan." Dr. Moriyasu is engaged in research on currents and water masses off the Oregon coast. He is also investigating the relationships between meteorological and oceanographic conditions off our coast.

Mr. Gerald A. Fowler is now with our staff as Assistant Professor of Geological Oceanography. He is engaged in research relating to the use of the Foraminifera as marine environmental indicators. His studies will be a significant contribution to determining the geologic history of the sea floor. Mr. Fowler comes to us from the Geology Department of the University of Southern California. His Ph. D. dissertation is entitled "Stratigraphy and Paleontology of the Pliocene Montesano Formation of Western Washington."

Dr. William M. Stone, Professor of Mathematics at Oregon State is now working with the Geophysics Research Group on a part-time basis. Dr. Stone is investigating the application of information theory to signal-to-noise optimization.

Mr. Roderick S. Mesecar has joined our staff as Assistant Professor of Physical Oceanography. He is in charge of the design of a shipboard computer system for use aboard the R/V YAQUINA. Mr. Mesecar has been with OSU as project engineer with the Galaxy Computer project for the departments of Mathematics and Electrical Engineering. He holds B. S., M. S., and Electrical Engineer degrees from Oregon State University and has worked as a design engineer in development programs for Doppler navigation systems, sonar tracking systems, and infrared fire control systems.

Mr. Victor T. Neal has been appointed as Instructor in Oceanography and is currently acting as administrative assistant in charge of arrangements for the move to the new Oceanography Building. He will also be instructing the course in "Estuarine and Shoreline Processes." Mr. Neal has been associated with the department as a Ph. D. candidate and graduate assistant in physical oceanography. He holds a B. S. from the University of Notre Dame and an M. Ed. from the University of North Dakota. He has extensive teaching experience in both high school and college.

VISITING LECTURERS

- September 14, 1963 Dr. Y. Miyake, Meteorological Institute, Tokyo, Japan. "Radionuclides in the Ocean."
- November 14, 1963 Dr. Howard L. Sanders, Woods Hole Oceanographic Institute, "Deep Ocean Benthic Studies."
- January 8, 1964 Dr. Timothy Joyner, Bureau of Commercial Fisheries, Seattle, Washington. "Trace Elements in the Marine Environment."
- January 17, 1964 Dr. Gordon Groves, Institute of Geophysics, University of California, San Diego, "Spectrum Analysis of Sea Level Changes."
- February 5, 1964 Dr. Keeva Vozoff, Department of Physics, University of Alberta. "Electrical Conductivity of the Earth at Depth."
- February 12, 1964 Mr. J. R. Cheney, Division Chief Geophysicist, Shell Oil Company. "Geophysics in the Pacific Northwest."
- February 12, 1964 Dr. R. J. Bean, Staff Geophysicist, Shell Oil Company, "Interpretation of Magnetic Data."
- February 13, 1964 Dr. Richard C. Dugdale, Institute of Marine Science, Fairbanks, Alaska, "Nitrogen Fixation in the Ocean."
- March 4, 1964 Dr. L. F. Giovando, Pacific Oceanographic Group, Nanaimo, British Columbia. "Seasonal Temperature Structure in the Eastern Subarctic Pacific Ocean."
- March 20, 1964 Dr. Armand Eardley, College of Mineral Industries, University of Utah, "Tectonics of the Pacific Northwest."

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Biological Laboratory
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U. S. Fish & Wildlife Service
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- 1 Director, Biological Laboratory
Bureau of Commercial Fisheries
Navy Yard Annex
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Washington 25, D. C.
- 1 Dr. Orlo E. Childs
U. S. Geological Survey
345 Middlefield Road
Menlo Park, California
- 1 Dr. John S. Schlee
U. S. Geological Survey
c/o Woods Hole Oceanographic
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Rutgers University
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Johns Hopkins University
121 Maryland Hall
Baltimore 18, Maryland
- 1 Mail No. J-3009
The Martin Company
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Estuaries Section
Waterways Experiment Station
Corps of Engineers
Vicksburg, Mississippi
- 1 Director, Marine Laboratory
University of Miami
#1 Rickenbacker Causeway
Virginia Key
Miami 49, Florida
- 1 Nestor C. L. Granelli
Department of Geology
Columbia University
Palisades, New York
- 2 Head, Department of Oceanography
and Meteorology
Texas A & M College
College Station, Texas
- 1 Director
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La Jolla, California
- 1 Allan Hancock Foundation
University Park
Los Angeles 7, California
- 1 Department of Engineering
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Berkeley, California

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- 1 ONR Special Representative
c/o Hudson Laboratories
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Monterey, California

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Scott Air Force Base, Illinois
- 1 ARCRL (CRZF)
L. G. Hanscom Field
Bedford, Massachusetts

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- 1 Director
Arctic Research Laboratory
Barrow, Alaska
- 1 Dr. C. I. Beard
Boeing Scientific Research
Laboratories
P. O. Box 3981
Seattle 24, Washington
- 1 Head, Department of Oceanography
University of Washington
Seattle 5, Washington
- 1 Geophysical Institute of the
University of Alaska
College, Alaska
- 1 Technical Information Center,
CU-201
Lockheed Missile and Space Division
3251 Hanover Street
Palo Alto, California
- 1 University of Pittsburgh
Environmental Sanitation
Department of Public Health
Practice
Graduate School of Public Health
Pittsburgh 13, Pennsylvania
- 1 Director
Hawaiian Marine Laboratory
University of Hawaii
Honolulu, Hawaii
- 1 Dr. F. B. Berger
General Precision Laboratory
Pleasantville, New York
- 1 Mr. J. A. Gast
Wildlife Building
Humboldt State College
Arcata, California
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Cambridge University
Cambridge, England
- 1 Applied Physics Laboratory
University of Washington
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Lockheed-California Company
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Honolulu 14, Hawaii
- 1 Advanced Research Projects Agency
Attn: Nuclear Test Detection Office
The Pentagon
Washington 25, D. C.
- 1 New Zealand Oceanographic Institute
Department of Scientific and
Industrial Research
P. O. Box 8009
Wellington, New Zealand
Attn: Librarian
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Osservatorio Geofisico Sperimentale
Trieste
- 1 Head, Department of Oceanography
Oregon State University
Corvallis, Oregon
- 1 Director
Bermuda Biological Station for
Research
St. Georges, Bermuda
- 1 Chemistry Department
College of Engineering
University of Wisconsin
Madison 6, Wisconsin
- 1 American Biophysical Research Laboratory
P. O. Box 552
Lansdale, Pennsylvania
- 1 Department of Geology & Geophysics
Massachusetts Institute of Technology
Cambridge 39, Massachusetts
- 1 Dr. Wilbur Marks
Oceanics, Inc.
114 East 40th Street
New York 16, New York
- 1 Mr. Neil L. Brown
Bissett-Berman Corporation
"G" Street Pier
San Diego, California