

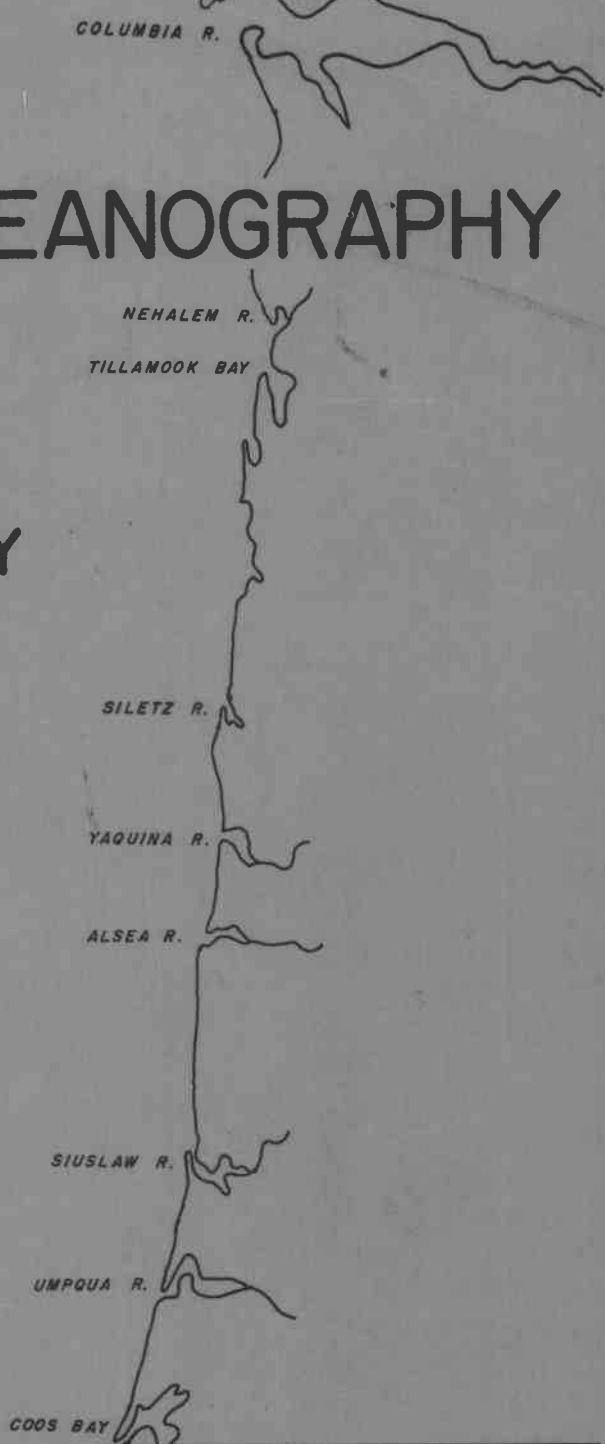
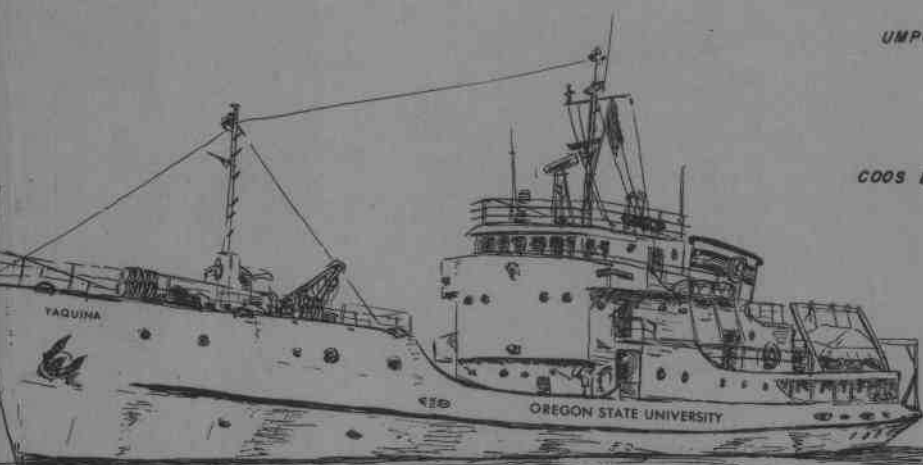
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ASTORIA, OREGON

DEPARTMENT of OCEANOGRAPHY

SCHOOL of SCIENCE

OREGON STATE UNIVERSITY



RESEARCH ACTIVITIES

1 October 1965
through
30 March 1966

Edited by
Susan Borden

Progress Report 17

Reference 66-7

June 1966

Department of Oceanography
School of Science
Oregon State University

Wayne V. Burt
Chairman

Progress Report No. 17

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PHYSICAL OCEANOGRAPHY

Subsurface Currents Off Shore - Stevenson, Pattullo, Wyatt

Data from all cruises to date have been analyzed, and a summary of all subsurface work to date was presented as Dr. Stevenson's dissertation research. A paper summarizing the results has been written and is undergoing review. The abstract from Dr. Stevenson's dissertation follows:

Ninety-nine drogues were set at various times and at selected depths from 0 m to 500 m. Data are examined for mean currents. Time variations in current direction and speed are considered, and vertical shear is examined. Volume transport off the Oregon coast is computed. The feasibility of using subsurface dye patches in the open ocean for an estimate of mean drift and mixing is examined.

The mean longshore current, throughout the water column, is toward the south. A representative speed in the upper 500 m is 5 to 10 cm/sec. Some northward movement of surface water occurs in winter. The mean zonal transport reverses direction in the pycnocline. In the surface layer the transport is toward the east; below the pycnocline the transport is toward the west. Within the pycnocline there is little east-west transport.

By the use of the autocorrelation method of analysis, fluctuations of three dominant periods were detected in the drogue data. A semi-diurnal tidal period was identifiable on two-thirds of the records. On four observations either an inertial oscillation or diurnal tidal period occurred.

Dye dispersal tests showed that the dye concentration at the surface varied as $t^{-2.2}$. This is in good agreement with experiments made by other workers. Data from the subsurface experiments yielded slower dispersal rates. At 50 m depth, the dye concentration was proportional to $t^{-1.1}$; at 100 m, the dye concentration was proportional to $t^{-1.3}$. This change in time dependence occurred within the pycnocline layer. The experiments were compared with two available diffusion models. Okubo's diffusion model appears to describe the surface diffusion; Ichiye's diffusion model describes subsurface conditions.

From these data, the motions appear to be grouped into three distinct domains: the steady state (no change within 25-50 hours), periodic fluctuations of frequency close to that of the semi-diurnal tide, and small random fluctuations.

Variability of Frontal and Tidal Currents on the Continental Shelf -
Collins, Mooers, Pillsbury, Pattullo

The sensor array was successfully moored from 24 January to 19 February at $44^{\circ} 15' \text{N}$, $124^{\circ} 24' \text{W}$. Currents were recorded at 25, 50, and 75 m. Temperature was recorded at 25 and 50 m. An additional thermograph was installed during this period 1000 yards north of the sensor array at a depth of 25 m.

Most of the data from earlier installations are now in digital form, and oceanographic analysis of these records is beginning. A general purpose time series analysis program has been developed; options include correlation and spectral analysis, frequency dependent correlation, and structure function compilation. A program was also developed for the calculation of several statistics related to static and dynamic stability. Also, we have learned how to use canned programs and data processing facilities offered by Western Data Processing Center in Los Angeles.

A portion of the progressive vector diagram for currents at 20 and 60 m is presented in Figure 1. Prior to this period, from 12 July to 18 July, currents had been southward at both 20 and 60 m. However, at 0000 on 19 July, the winds, which had previously blown steadily from the northwest, shifted to the south and remained southerly until 2100 on 21 July. At this time the winds became northwesterly. The response of the ocean to this wind shift is easily observed in Figure 1. The flow at 20 m continued southerly, while at 60 m the flow became onshore and northerly.

The semidiurnal tide is also easily observed in Figure 1.

Figure 2 shows a plot of temperature data recorded at a depth of 17 m in 100 m of water during 24-26 September, 1965, near Stonewall Bank. The two most noteworthy phenomena are the dominant semi-diurnal oscillation with amplitudes of 0.5°C and the general occurrence of shorter period oscillations with periods on the order of 30 minutes and amplitudes of about 0.2°C .

Literature search work has been concentrated on the understanding of the phenomena related to internal tidal waves and the stability of internal waves in general. Work has begun on developing a physical model of the processes inferred from the early data. As a step towards constructing a mathematical model, Fjeldstad's internal wave theory has been

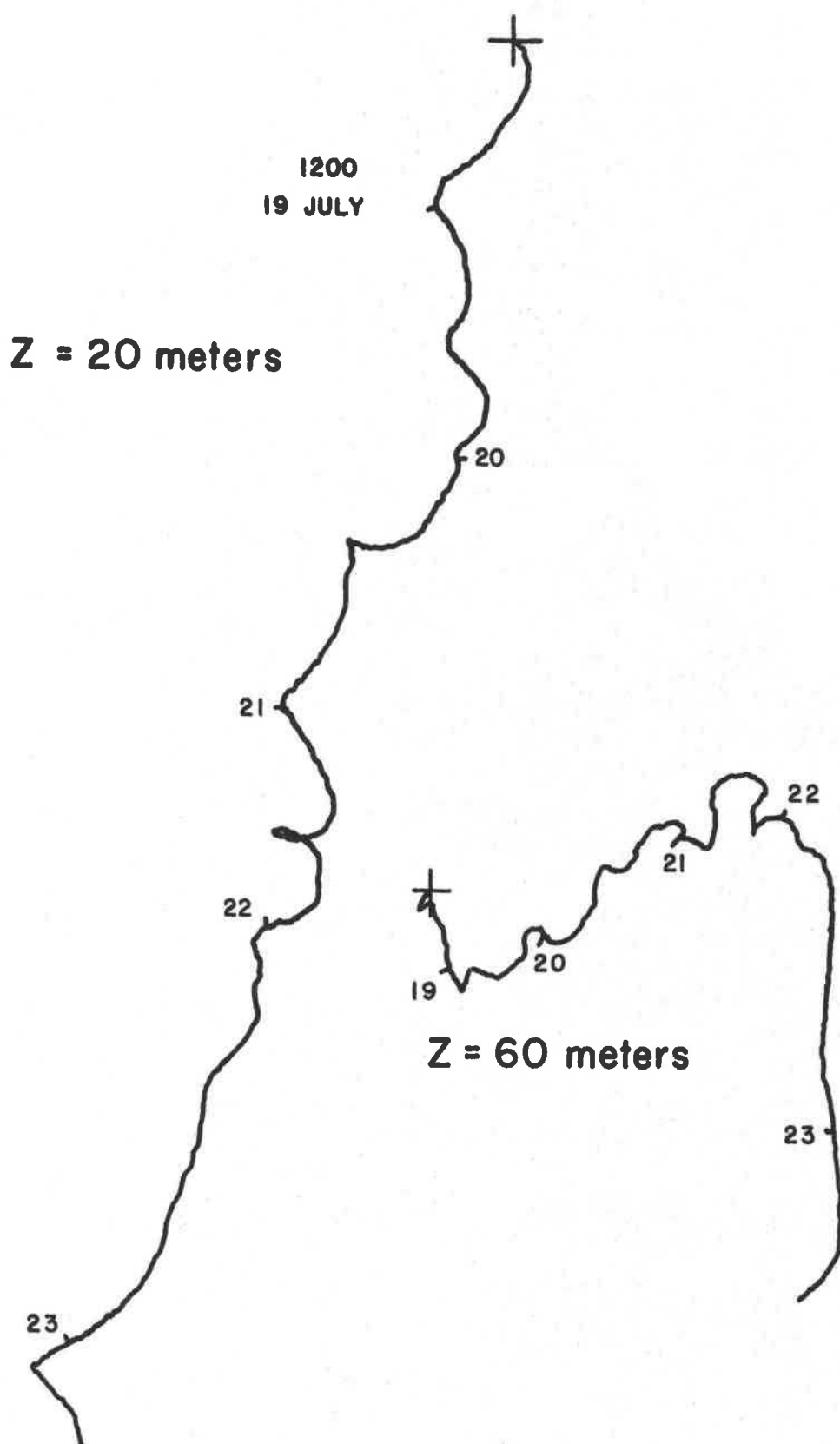


Figure 1. Progressive vector diagram for currents at 20 and 60 meters, from 0000 on 19 July 1965 to 2340 on 23 July 1965.

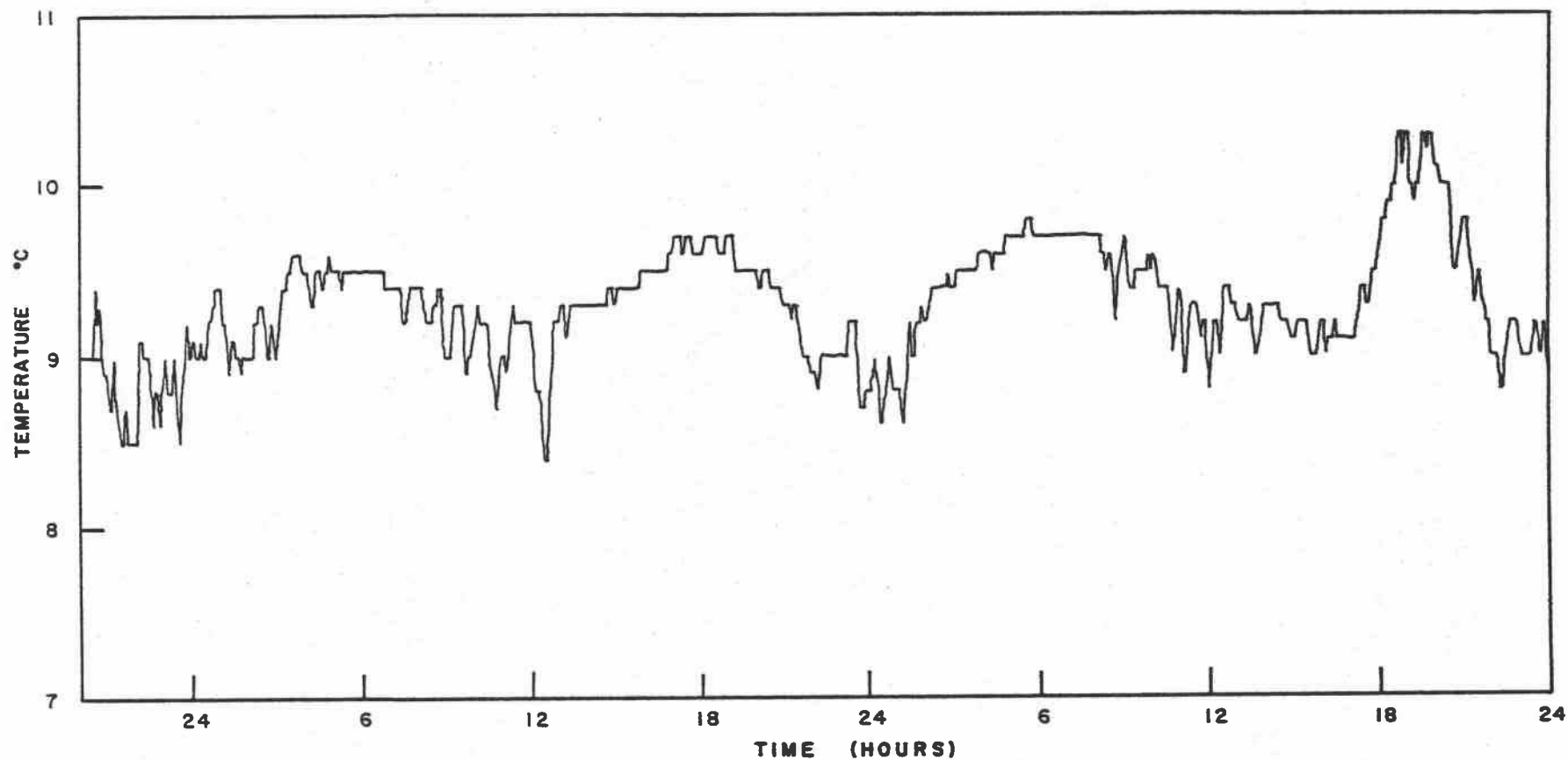


Figure 2. Temperature recorded at 17 m depth in 100 m of water during 24-26 September 1965 near Stonewall Bank.

programmed so that test cases can be run; modification and expansions to this aspect of the effort are anticipated.

A plan has been developed for an experiment to be conducted late this summer near the end of the so-called upwelling season. We will attempt to define the state of upwelling on Oregon's continental shelf at that time, and improve our definition of the tidal and other internal wave processes, as well. Currents and temperatures will be recorded at several points on the shelf and at selected depths for 10-20 days. During that period we also plan to make several repeated hydrographic stations in the area and to take some vertical profiles of temperature, salinity, and currents from a fixed platform, if the oil drilling rigs return this year.

A study comparing the principal characteristics and statistics of the shelf flow near Stonewall Bank as determined by drogues and current meters at fixed sites is in progress. The study includes a two-day period of concurrent measurements. Density structure and tidal height motions measured at an oil drilling rig are introduced as well. At this point the results are generally consistent with regard to the time and depth dependence inferred.

Tides and Water Levels in Yaquina Bay - Pattullo, Lee, Gilbert

All records collected to date have been read for hourly heights and corrected where necessary for changes in reference level. Simple 24-hour daily sums and means have been computed. Due to changes in facilities at the Marine Laboratory dock, the recorder will be moved. The new location will provide better protection for the equipment and is intended to be its permanent location.

Mr. Gilbert has summarized most of the seiche-like oscillations appearing on the tide records, and has examined several simple models of the bay that would be consistent with the periods observed. He plans to test the models with additional measurements as part of his thesis work for the M.S. degree.

Sea Level and Upwelling - Panshin, Pattullo

Studies of sea level along the Oregon coast and of its relation to upwelling are being continued. Tidal observations, taken by the Coast and Geodetic Survey in 1933-34, have been processed to remove astromic tidal constituents and inverted barometer effect. Multiple

regression analysis is being used to determine the relation of departures of this adjusted sea level from the average level over the period of observation with the north and east components of wind stress. Lowering of sea level is significantly associated with winds from the north and from the east. This finding is consistent with upwelling as it appears to take place off the coast of Oregon. We plan to use the same technique to examine more recent records.

Spectral Analysis of Oregon Sea Level Data - Mooers, Panshin, Smith

The statistical search for the presence of Oregon continental shelf waves with periods greater than one day is continuing. The data being used are tidal records from several coastal locations, one atmospheric pressure record, and geostrophic wind data for a period of eleven months in 1933-34. The principal effort has been devoted to computing and comparing the characteristics of the Doodson and the Cartwright (after D. E. Cartwright) numerical filters for the suppression of tidal energy in the time series. We plan to analyze sea level data processed by each of the filters with correlation and spectral analysis in order to evaluate the significance of using the Cartwright in place of the Doodson filter on actual sea level data.

The results of regression analysis indicate that the relation between wind and sea level is strong enough to require inclusion of the wind data in the shelf wave analysis.

Heat Flow and Abyssal Circulation - Weyl, Olson

We have obtained from the National Oceanographic Data Center copies of data for all oceanographic stations that extend to a depth of 5000 m or more. There are 709 such stations. These are being examined for regions where temperature lapse rates are approximately adiabatic near the bottom. Such regions have been found in some of the deeper basins, as well as in nearly all of the trenches. From analysis of these data we hope to establish and test a model which balances the advective and mixing processes in the abyssal regions against the geothermal flow.

Wave Refraction Study - Griswold, Wyatt, Burt

We are attempting to reactivate the three wave recorders installed in shallow water last fall. All three sensors failed during the winter, and no repairs could be made because of the adverse weather conditions. Three new sensors have been purchased with University funds to make short period observations from a ship.

Hydrographic Survey - Wyatt, Pattullo, Still, Barstow

Renewed efforts are being made to maintain monthly hydrographic stations at 5, 15, 25, 35, 45, 65, 85, 105, 125, 145, and 165 miles west of Newport. Stations were taken each month except October. The 145- and 165-mile stations were not taken during March.

In January and February, a three-week cruise was made in conjunction with Scripps Institution of Oceanography; U. S. Bureau of Commercial Fisheries, Seattle Group; and the Pacific Oceanographic Group. This survey was the first to cover the Eastern Pacific in any detail during the winter months.

On all stations occupied samples were taken for analysis of dissolved oxygen, phosphate, and salinity.

Table I. Summary of Hydrographic Samples

Hydrographic Casts	101
Bathythermograph Casts	205
Drift Bottles Released	214
Surface Temperature and Salinity Observations	96
Midwater Trawl Hauls	26
Vertical Meter Net Hauls	27

Preparation for YALOC-66 Cruise - Neshyba

Activity during much of this period has been directed toward preparation for the Honolulu-Adak leg of the YALOC-66 cruise. Two new techniques will be tested on cruises; both are intended to support the primary hydrographic mission of obtaining total mass transport across the Honolulu-Adak traverse. A second objective is the test and evaluation of the techniques for possible inclusion as a routine part of the standard hydrographic station. The design and development of the apparatus has been almost completed.

A. Hydrography

1. A free-diving bottom current recorder is under construction and should be ready for the cruise. The instrument consists of camera and strobe flash housed in two Corning glass pressure spheres. The assembly is provided with a magnesium release mechanism and is capable of recording bottom currents at 5-minute intervals for 30 minutes before returning to the surface.
2. A rapid-set taut wire buoy has been completed, but not tested. The design is such that the entire buoy set can be completed in 20-30 minutes in 3000 fathoms of water. The buoy is intended to serve as a reference location for drogue and savonius rotor current measurements in the upper 500 meter layer, and for the launch and recovery of the free-diving bottom current recorder.
3. In addition, a computer program for the processing of BT and density data into internal tide amplitudes and phases, using the Fjelstad process, is being tested.
4. Upon completion of the cruise, the hydrographic data will be processed in the following manner:
 - a) A standard isonosteric section will be prepared.
 - b) Extensive BT data will be processed for internal wave information. These will be used to remove internal tide uncertainty from the isonosteres.
 - c) Geostrophic currents are to be computed and where possible, relaxed to fit the direct current measurements by drogue, current meter, or bottom current recorder.

d) Transport will then be extracted from the corrected hydro section. A final evaluation of these techniques and the apparatus, insofar as they might be adopted and included in standard hydrographic casts, will be made.

B. Radiometry. Considerable preparations have been made for the taking of extensive radiation measurements during YALOC-66.

1. A bathyphotometer, formally used for bioluminescence study has been calibrated for absolute light measurements. Illumination will be measured at depths up to 700 meters.

2. Winch arrangements have been made to use an alpha-transmissometer within the upper 500 meters.

3. A combination BT and special purpose winch has been installed from which the long-wave radiometer recently developed at OSU will be employed to obtain back radiation from the sea surface.

4. Pyrheliometer measurements will be available.

C. Biology. The bathyphotometer will be used in conjunction with a colored light stimulus to ascertain whether or not the bioluminescent response of the various deep scattering layers can be measured. This is a continuation of bioluminescent stimulation studies made during the past two years.

Moored Instrument Platform - Wyatt, Burt

A catamaran instrument float was moored from October to February 55 miles west of Newport. The purpose of the mooring was to test the feasibility of maintaining winter hydrographic observations from such a float. A deep fouling experiment was also attached to the bottom of the mooring system to obtain data in activity and occurrence of fouling organisms. Data from this study are being analyzed.

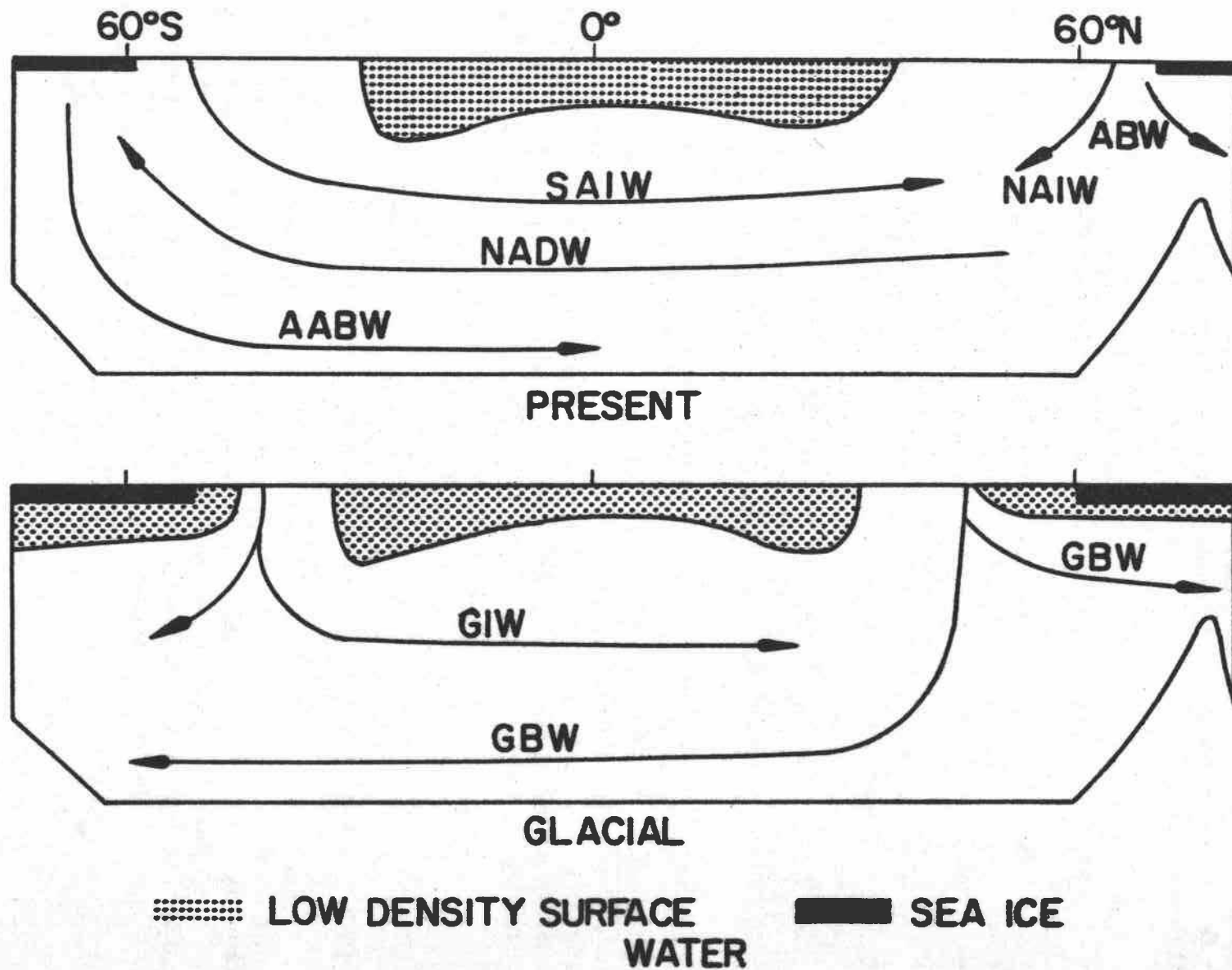


Figure 3. Schematic circulation of the Atlantic Ocean at present and during a glacial period.

Quaternary Oceanography - Weyl

A manuscript on the interaction between the ocean and the atmosphere during the Quaternary period has been prepared for publication in Meteorological Monographs. A reconstruction of the circulation in the Atlantic Ocean during a glacial period and a similar diagram of present circulation are shown in Figure 3. A drastic change in the ice cover and the surface circulation in the North Atlantic is inferred. A reconstruction of the surface circulation of the North Atlantic (Figure 4) is supported by Ericson's data on the coiling direction of Globigerina pachyderma. These data show a southward displacement of the 7° surface isotherm to about 40° N.

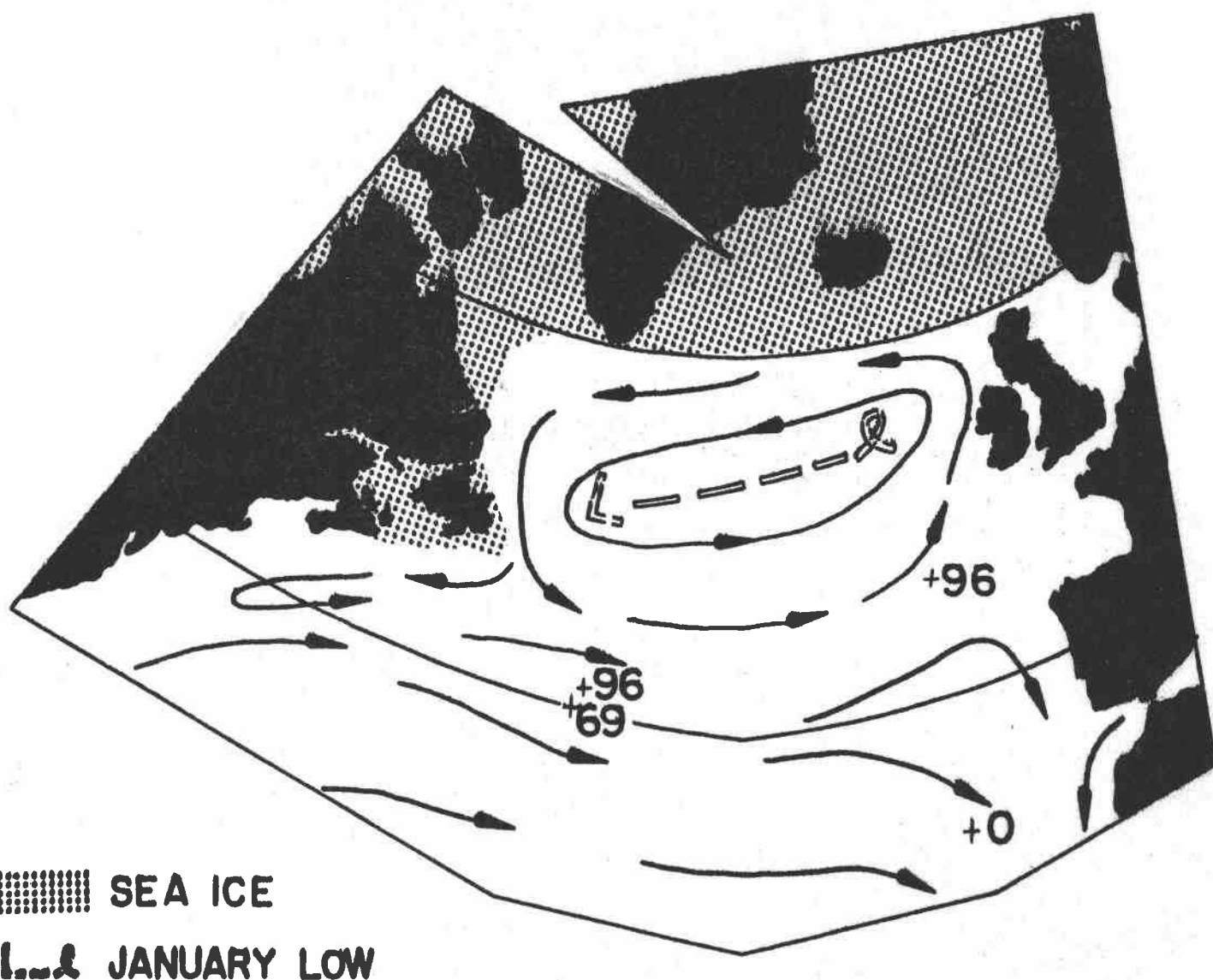


Figure 4. Reconstruction of the surface circulation in the North Atlantic during a glacial period. Numbers refer to percentages of left coiling Globigerina pachyderma during glacial period (D. Ericson, personal communication).

Oceanic Heat Storage - S. Kulm, Pattullo

A paper on this study has been written and is being prepared for publication. The abstract follows:

Variations in heat content in the upper 100 meters of the ocean off Oregon during 1962 and 1963 have been examined. Heat content varied with distance offshore during summer but not during winter. Within 65 miles of the coast, heat content was nearly constant throughout the year. Beyond 100 miles from the coast, heat content was approximately 35 ~~kg~~ ^{kg} Cal/cm² higher in summer than in winter. Heat content at southerly stations was significantly higher than at northerly stations during only one of the four months for which a comparison could be made. Values during spring of 1963 were notably higher than during comparable months in 1962. Values from sparse data in 1964 and 1965 were similar to values for 1962.

Rate of storage is compared with local energy budget computations reported in an earlier investigation. Throughout the area, rate of storage and local heat exchange were approximately the same except in summer. Inshore, during summer, storage rate was 240 ly/day lower than expected from heat budget considerations. Offshore, during early summer, the storage rate was 135 ly/day higher than local heating as computed from the energy budget equations. The two large discrepancies are believed to be due to heat transport from the inshore region to the offshore region during summer upwelling.

Atmospheric Effects on Incoming Solar Radiation in a Marine Environment - Quinn, Burt

A large number of articles pertinent to solar radiation and the atmospheric effects on its transmission has been collected for reference purposes. Surface weather observations, atmospheric soundings, and solar radiation data taken simultaneously for one month at Wake Island were obtained from the U. S. Weather Bureau. These data are being studied in detail in order to lay a firm foundation for the more extensive investigation of atmospheric effects on solar radiation. Precipitable water contents have been computed from the atmospheric soundings and

were found to range from 1.8 cm to 3.7 cm for a single winter month. However, computations from additional sounding data indicate that precipitable water contents for the Wake Island area in the summer months will occasionally reach 6 cm or more, so that a sizeable range in moisture content can be studied. Based on the single winter month of data, low clouds were the usual cloud type present. They were generally limited in vertical development by a temperature inversion and its accompanying decrease in humidity which was usually based at altitudes between 4500 and 6500 feet. As a result, most of the periods showing larger depletions in the recorded solar radiation occurred when higher level cloud decks were superimposed. One unusual situation was noted where a cirrostratus overcast caused a solar radiation reduction to about 50% of that normally received with clear sky radiation. Continental studies have usually associated cirrus layers with a reduction factor of about 20%.

Evaporation Over Yaquina Bay - DeRycke, Pattullo

The results of the measurements made last summer are now in hand, and Lt. DeRycke is writing his thesis (for the M. S. degree) on the basis of these results. He has been able to determine the dependence of pan evaporation on wind and vapor pressure, and to estimate the effects of pan wind-shadow and daily heating of water in the pan on the evaporation rates observed. He has also been able to relate pan evaporation to bay evaporation by studying the vertical distribution of evaporation above the bay with evaporating spheres (atmometers). He made one series of measurements at sea on an oil barge (WODECO III) to compare open ocean to bay measurements and to estimate the usefulness of the atmometer array at sea.

GEOLOGICAL OCEANOGRAPHY

Continental Margin Sedimentation - Byrne, Runge

The study of the continental shelf and upper continental slope sediments from the mouth of the Columbia River to Cape Blanco has been completed.

Sediments on the inner portion of the Oregon continental shelf consist of clean, well-sorted, detrital sand. This sand has an average median diameter of 2.53ϕ (.173 mm) and is both positively and negatively skewed. Deposits with median diameters in the coarse sand and gravel classes occur at depths of 20 to 40 fathoms and probably represent ancient beach or fluvial deposits formed during lower stands of sea level.

The outer shelf and upper slope are covered by poorly sorted sediments with median diameters in the fine sand to fine silt classes. Mean diameters of the sediments are almost always smaller than their median diameters, and the sediments are positively skewed.

The heavy mineral assemblages are dominated by the amphibole and pyroxene groups and the opaque-garnet association. Pyroxenes are most abundant in the coarser-grained sediments of the inner shelf and decrease in abundance offshore. Amphiboles are most abundant in the finer-grained sediments of the outer shelf and upper slope. Highest concentrations of the opaque-garnet association also are found in the inshore samples.

Sediments of the continental shelf are derived from two principal sources: rivers, and erosion of coastal terrace deposits. Rivers are probably contributing only fine-grained material to the shelf, as much of the coarser fluvial material is thought to be trapped in the estuaries. The terrace deposits are being actively eroded and are thought to contribute about 21,000,000 cubic feet (.00013 cubic miles) of sediment to the continental shelf annually.

Evidence suggests that much of the inner-shelf sand is probably a relict transgressive sheet sand that was deposited during the last rise in sea level. Most of the deposition of the modern sand on the shelf has been confined to the inner portion of the inner shelf. Finer-grained sediments have been deposited on the outer shelf and upper slope.

A textural model for sediments from river to abyssal plain has been developed for the area of the central coast of Oregon. On the basis of more than 300 samples from Yaquina River, Yaquina Bay, and neighboring

coastal beaches and dunes, and from the continental shelf, slope, and abyssal plain, trends in median diameter, sorting, and skewness were determined. Indices of environmental textural variability were determined from median diameters, sorting, and skewness values. The environments, listed in order of increasing textural variability, are as follows: dune, inner shelf (0-50 fathoms), beach, lower slope (500- 1500 fms), abyssal plain (> 1500 fms), outer shelf (50-100 fms), bay flat, bay channel, upper slope (100-500 fms), and river. The value of such trends and indices of textural variability lies in the recognition of paleoenvironments and in studies of the permeability of subsurface formations and the migration of fluids in these formations.

Astoria Canyon - Byrne, Carlson

Sampling of the Astoria Canyon area has been completed. Eighteen piston cores and 80 gravity cores have been photographed and described. From these cores we have extracted a total of 340 sub-samples for textural and compositional analyses.

Currently, the coarse fraction of each sub-sample is being examined. This information will be used to interpret paleoecological and sedimentological trends in the Astoria Canyon region.

A smooth sheet has been made from the 1500 miles of Precision Depth Recorder tracks through the use of an X-Y plotter routine. Contouring of these bathymetric data will further delineate the canyon and adjacent area. The PDR traces indicate a definite connection between Astoria Canyon and Astoria Channel.

Foraminiferal Ecology - Fowler, Boettcher

Sampling of the Oregon continental shelf and slope for modern foraminifera was continued with a cruise in November. Forty-two stations were occupied, bringing the total to 426. Thirty-four stations are located along a line at the California border extending from 18 m to 3025 m depth. Additional samples were taken off the Umpqua and Rogue Rivers.

The survey of shelf foraminifera in the vicinity of the Umpqua River is more than half completed. All samples have been examined, and their contained foraminifers have been counted. Preliminary plots of data from this study and from a slope profile off the Umpqua River reveal several significant trends. The number of total benthic species per standard sample increases from 10 at 17 m to 50 at 115 m. In deeper water the number fluctuates rather widely; a maximum of 73 was recorded at 1200 meters. The number of live species follows a similar trend but with values an order

of magnitude less. Standing crops on the shelf generally average less than 300 per 10 cm². Exceptionally high numbers of 1660, 960, and 1240 were recorded for samples taken from the central and inner portions of the shelf. The most consistently high values occur on the slope between 656 m and 875 m where three stations average 945 living specimens per cm². From 1200 m to 300 m standing crops average around 150. Hyaline benthic foraminifers dominate the faunas in depths less than 100 m. Agglutinated forms reach maximum values of up to 100% between 100 and 200 m. From 300 m to 1800 m percentages fluctuate between 20 and 40. Seventy-three percent agglutinated foraminifers were recorded at 3000 m. Porcelaneous types account for less than 10% of the fauna in all cases. These are concentrated in zones from 50 m to 100 m and 1500 m to 3000 m. Over the shelf, planktonic foraminifera generally average much less than 5%; on the slope, values range close to 10%. A maximum of 23% was recorded at 3000 m. A second maximum of approximately 10% occurs rather consistently between 50 m and 75 m. Variances as much as 20% occurred in the abundances of a given species found in three discrete samples from a single station.

Deep Sea Sedimentation: Astoria Fan - Byrne, Kulm, Nelson, Russell

The study of sedimentation on Astoria Fan has continued. Forty piston cores and forty Phleger cores have been sectioned, photographed in black and white and color, described in detail, sampled, and analyzed for texture. In addition, composition of the coarse fraction of the sediment has been determined for 370 samples. All Precision Depth Recorder traces have been analyzed, and data from these have been plotted by the X-Y plotter of the IBM 1620 computer.

Generally, the upper meter of sediment in the cores is an olive-gray silty clay, interrupted in its lower portion by one or more ash layers. The remainder of the cores is made up of light olive-gray silty clay interspersed with numerous sand-silt layers. These coarser layers range from silt laminae several millimeters thick to sand, and occasionally, gravel layers more than 40 cm thick. Usually the sand layers are graded in both texture and composition. The upper portions of the sand layers and the thin silt layers often are laminated and cross-bedded. Some of the cores near the slope contain clay with pebbles that appear to be striated and may have been ice rafted.

Sediment stratigraphy correlates with bathymetry and position on the fan. The inner fan has the steepest gradients and the roughest topography. Sediments here have many very thin laminae (1-2 mm) of silt and organic material. Middle fan topography is undulating, grading to a smooth surface on the outer fan. Middle and outer fan sediments include thicker individual

coarse-grained layers. The coarse-grained layers represent a greater percentage of the total sediment in the outer fan than they do in the inner fan. Channels contain the greatest thickness of coarse-grained layers, some of which consist of gravel. Astoria Channel, the largest and most distinct channel on the fan can be traced completely across the fan from the mouth of Astoria Canyon to the abyssal plain. Smaller channels are most common on the inner and middle fan, and where these are most numerous, sand and silt layers are common and tend to be thicker than elsewhere.

Deep Sea Sedimentation: Cascadia Abyssal Plain - Kulm, Fowler, Duncan

Preliminary results from the bathymetric and sampling survey made of Cascadia Abyssal Plain in September 1965 are now in hand. Initial emphasis has been placed on the bathymetry and sediments of Cascadia Channel. The portion of the channel off Oregon has a bottom depth range of 1565 to 1830 fathoms and a slope of about 1:1000. Where the channel runs south at 127° W relief varies from 20 fathoms in the north to 150 fathoms in the south. In the seamount province where the channel enters Cascadia Abyssal Gap, the channel exhibits relief of several hundred fathoms. After emerging from the gap onto Tufts Abyssal Plain the channel widens considerably at the bottom, and relief is reduced to less than 100 fathoms. In the area studied the width of the channel varies from one to five nautical miles at the top and from less than one-fourth to about three miles at the bottom.

Seven piston cores from Cascadia Channel and its immediate vicinity have been studied in some detail. These cores range in length from one to five meters. With one exception, the sediments analysed thus far from the channel consist of several cyclic depositional units. Each unit is made up of a basal very fine sand or coarse silt grading upward into olive brown silt and clay and overlain by gray clay. The sands and silts contain detrital minerals and plant debris derived from continental sources, as well as benthic foraminifers displaced from the continental shelf and slope. Fine-grained clays at the top of each depositional unit are characterized by a high radiolarian content and contain benthic foraminifers indigenous to abyssal depths, suggesting that the clays are pelagic. Reworking by organisms is indicated by the frequent mottling of the pelagic gray clays down into the underlying terrigenous olive brown silts. One core consists predominately of coarse-grained clastics including a 2-meter thick layer grading from gravel at the bottom to fine sand at the top. A faunal analysis of one sample from this core suggests that more than 80% of the benthic foraminifers were displaced from shallower depths. Approximately 25% of the displaced foraminifers came from inner shelf depths of less than 50 m, indicated by the presence of Buccella blancoensis, Cassidulina limbata, Elphidiella hannah,

and Elphidium incertum. The remaining displaced forms represent intermediate depths of shelf and slope.

A marked variation in sediment texture and composition is seen in a profile of three piston cores extending from the western side (abyssal plain) to the eastern side (Astoria Fan) of Cascadia Channel. On the western side of the channel the sediments are composed chiefly of pelagic gray clay interbedded with thin laminations of sandy silt. Sand fractions of the clays in the top 40 cm of the core consist primarily of radiolaria; below this level planktonic foraminifers predominate. The thin laminations of sandy silt consist of varying percentages of planktonic foraminifers and detrital minerals. In contrast, the sediments in the axis of the channel are characterized by terrigenous constituents, although the pelagic clays are similar in composition to the clays found in the top 40 cm of sediment west of the channel. East of the channel the sediments are similar to the terrigenous deposits found elsewhere on Astoria Fan.

Sedimentation on Cascadia Abyssal Plain appears to be controlled, to a large extent, by Cascadia Channel. The channel acts as a sediment trap and as an avenue of dispersal for terrigenous material transported along the sea floor.

The southern border of Cascadia Basin is formed by a ridge which trends northwest from off Cape Blanco to about 130° W. South of the ridge the topography is rough and complex, smoothing out to the southwest in an area just north of the Mendocino Ridge. Through textural, structural, petrographic, X-ray, and microfaunal analyses of sediment samples, the interrelationships of regional structure, volcanism, and topography to Pleistocene and Recent sedimentation patterns and processes along the southern border of Cascadia Basin will be studied. Samples collected in this border zone during the last six months include two piston cores from the abyssal plain off Cape Blanco, one piston core from a small basin south of the northwest-trending ridge, and two pipe dredges in the area of rough topography south of the ridge. A total of 11 samples have been collected from the area to date. An addition of 600 miles of echo sounding lines brings the total number of miles covered by Precision Depth Records to more than 1600. The sounding data are being used to improve bathymetric charts of the area.

Coastal Sediments - Kulm, Byrne

Petrographic analyses of heavy minerals from 26 coastal rivers of Oregon and northern California have been completed. On the basis of the heavy minerals, three, or possibly four, petrologic provinces can be defined for the drainage basins of these rivers. These data are in final stages of reduction. They should be useful in determining the sources of sands on

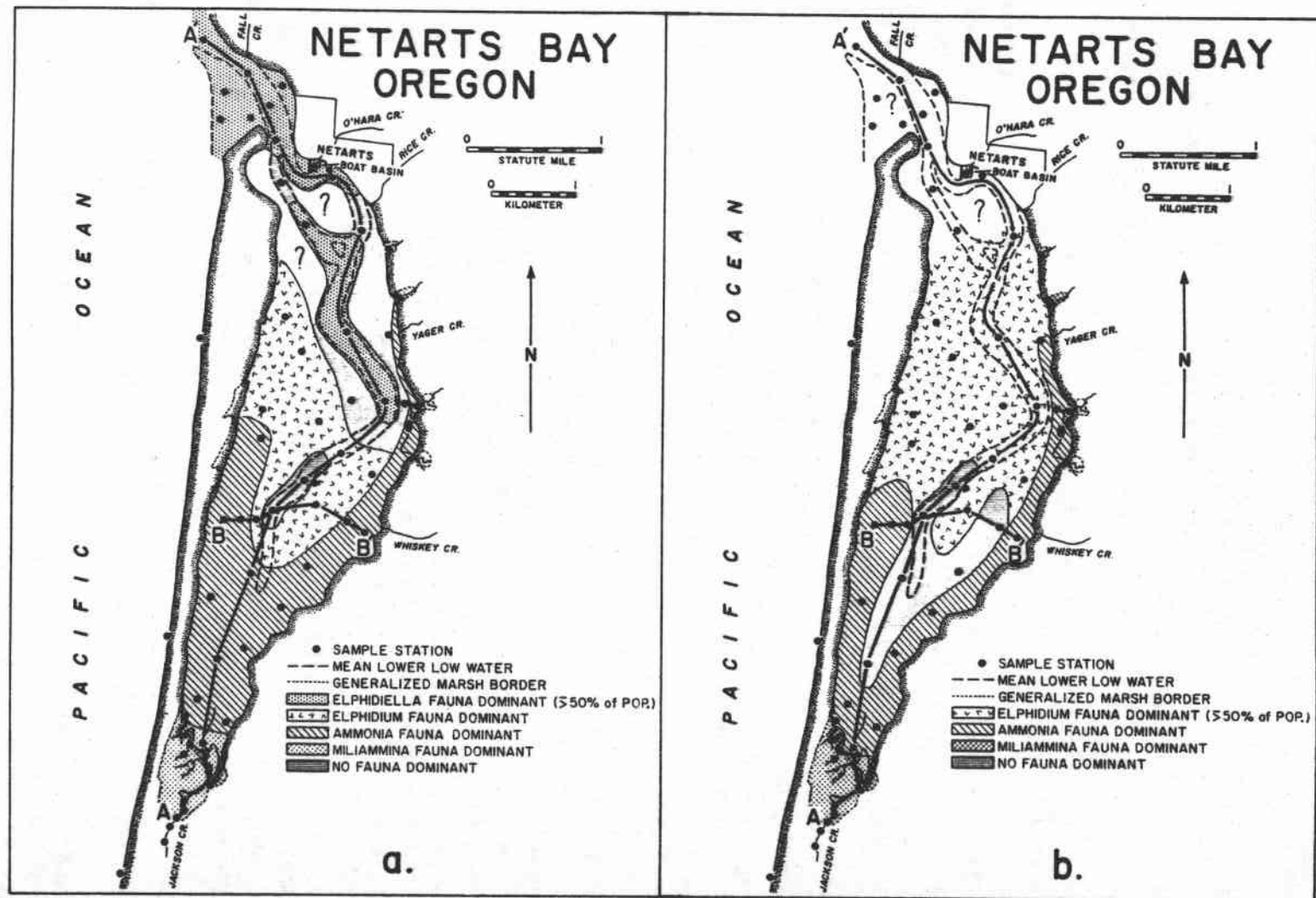


Figure 1. Distribution of foraminiferal biofacies in Netarts Bay:
a) Dead faunas; b) Live faunas.

the continental shelf and in helping to delineate the pattern of sediment transport on the shelf.

Nearshore Carbonate Sands of Bermuda - Kulm

A manuscript concerning the textural aspects of beach and nearshore carbonate sediments of Bermuda is in the final stages of preparation for publication.

Estuarine Foraminiferal Ecology - Fowler, Hunger, Manske

Netarts Bay. An analysis of the foraminiferal biofacies of Netarts Bay has been completed (Fig. 1). Results of the investigation are presented in a Master's thesis by Arthur A. Hunger. The thesis is in its final stages of completion. A manuscript is being prepared for publication.

Yaquina Bay. Fifty-three additional samples were collected during the period covered by this report. Weekly collections at main channel stations accounted for nineteen of the samples, completing that phase of the project. The remaining samples were taken from seasonal stations on the tidal flats, in marshes, and in tributary channels. To date, 362 samples have been taken; all have been washed and stained in preliminary processing. Of the total, 246 have been concentrated by flotation and are ready for microscopical examination.

Gorda Ridge - Deffeyes

A cruise of the R/V YAQUINA in January explored the axial valley of the Gorda Ridge. The Gorda Ridge is presumed to be a portion of the worldwide mid-ocean rise system on the basis of its earthquake activity, abnormally high heat flow, low seismic velocities in the upper mantle, and magnetic anomaly pattern. The purpose of the cruise was to test whether the sea-floor-spreading hypothesis of Hess applies to the Gorda Ridge. Eight PDR profiles across the axial valley showed that the valley floor is irregular and that sediment has not accumulated there. Two successful dredge hauls along the bottom of the valley produced fresh pillow basalt, without visible manganese coating. Both the lack of sediment and the lack of manganese suggest ages less than 100,000 years. Radiometric age determinations on the basalt are being made by Professor Garniss Curtis at Berkeley.

A dredge haul on a seamount near the rim of the axial valley produced a suite of 1- to 5-mm gabbros, some of which are heavily altered to chlorite. These fragments resemble the rocks from the Mid-Atlantic Ridge described by Shand.

GEOPHYSICAL OCEANOGRAPHY

Seismic Work at Sea - Berg, Dehlinger, French, King

The seismic reflection profiler has been overhauled after the sea tests made during the summer of 1965. This instrument is now operational, and studies will be conducted over the edge of the continental shelf and in deep ocean starting in June 1966.

A report entitled "Seismic Reflection Studies of Buried Channels off the Columbia River" is being finalized for publication.

Selected seismograms from the 11 regranction lines shot jointly between Oregon State University and Scripps Institution of Oceanography off the coast of Oregon and northern California were analyzed. Crustal layering and upper mantle velocities were determined from these data. Results of this study are being prepared for publication.

Seismic Wave Studies - Berg, Trembly, Long, Souders, Sarmah

Records from nuclear explosions are being used to investigate the continuity of amplitudes and energy at all distances from the source. Emergence angles, wave type, propagation path, and amplitudes are being investigated.

Analysis has been completed and a report written on studies from a quarry blast (110,000 lbs. explosive) near Newport, Oregon. Results indicate an apparent crustal thickness of about 16 km and an apparent sub-crustal (mantle) velocity of 8 km/sec for northwestern Oregon.

Earthquake Seismology - Dehlinger, French, Gallagher

The World-Wide Seismic Station at Corvallis and satellite station at Klamath Falls, Oregon, have been operated continuously during this report period. Seismological Bulletins No. 5 and No. 6 have been completed and No. 7 and No. 8 are being prepared.

The investigations of earthquake focal depths has been continued, with emphasis on the possibility of using waves arriving just after P_n , as a measure of focal depth.

Marine Gravity - Dehlinger, Couch, Gemperle

Corrections for non-linear responses of LaCoste and Romberg gravity meter S-9 were made for most measurements obtained in the Pacific Ocean between 1963 and 1965. Free-air anomalies corrected for vertical accelerations were determined for all measurements made off Oregon, northern California, and the Inside Passage of British Columbia and Alaska, and free-air maps constructed. Free-air anomalies were also corrected for vertical accelerations for measurements obtained off Hawaii. Crustal and subcrustal cross-sections have been constructed across the Mendocino escarpment and the Hawaiian archipelago from these free-anomaly values. Results from these studies are being prepared for publication.

Land Gravity - Berg, Thiruvathukal

Free air and Bouguer anomaly maps of Oregon have been constructed. The data are being analyzed. A preliminary report has been written.

The gravity anomaly maps will be constructed so that the gravity map for the state of Oregon will be continuous with a gravity map for off-shore Oregon.

Magnetics - Berg, McKnight, Emilia, Bales

Reduction of data for magnetic measurements made off the coast of the Pacific Northwest has been completed. The reduced data have been put on maps, contoured, and a preliminary report written. A final analysis of the data is in progress.

Paleomagnetic studies have been made of a sequence of recent volcanics in the high Cascades. An investigation of the homogeneity of the paleomagnetic field of a widespread formation will be conducted as soon as weather permits.

Thermal Studies - Berg, Bodvarsson, Hutt, Vossler

A new thermal probe for measuring long time variations in temperature at the sea-bottom interface of the ocean floor is being constructed. Thermal measurements will be made to a depth of several meters in the bottom and to a height of 1 or 2 meters above the floor of the ocean. The initial design of this instrument is nearly complete. Recovery techniques are now being investigated.

Initial studies about the relationship between thermal conductivity and electrical conductivity of sea sediments has been completed. A report is being written concerning this topic.

Experiments are being conducted in connection with the possibility of obtaining data on the terrestrial heat flow through the ocean bottom on the basis of temperature gradients measured in sediment cores that have been recovered from the ocean floor.

Theoretical Studies - Bodvarsson, Maloof, Berg, Papageorge

The work on direct interpretation methods in applied geophysics and on the two-phase flow problems in geothermal areas has been continued.

In connection with the thermal studies a number of eddy diffusion models for the transport of heat in the bottom layers of the oceans are being studied. A particular emphasis is placed on the problem of temperature fluctuations at the bottom due to the upward transport of terrestrial heat by forced and free convection.

Work is being conducted on analytical continuation of potential fields and the filtering of potential field data.

Studies have been made using filter theory for predicting the output wave forms for seismic sources. A report has been written, and work is continuing on this topic.

CHEMICAL OCEANOGRAPHY

Physical Chemistry of Sea Water - Weyl, Connors, Duedall

A thesis on the measurements of the partial equivalent volumes of the major salts in sea water is in preparation. The measurements of the partial equivalent conductance of the major salts in sea water has been completed.

The data are now being analyzed, and a thesis is being prepared.

Chemical Reactions in Sea Water - Pytkowicz, Kester, Culberson

The apparent dissociation constants of phosphoric acid were measured in sea water between 5 and 25° C at 30, 33, and 36‰ salinity. The results show that estimates by earlier workers, based on extrapolations from data in single salt solutions, were in error because they did not take into consideration complex formation between phosphate and metal ions. A paper on this topic is being prepared.

Electrodes for the redetermination of the apparent dissociation constants of carbonic acid at high pressures are being calibrated.

Oxygen and Phosphate in the Oceans - Pytkowicz, Kester

Apparent oxygen utilizations and preformed phosphates were used to characterize the waters present in the 1000-2000 m depth range in the Northeast Pacific. Three water masses were found, and a paper on the results will appear shortly in Deep-Sea Research. This work is being extended to the Northwest Pacific.

Chemical data obtained in the Southern Ocean by the Lamont Geological Observatory during cruise 14 of the USNS ELTANIN, in which R. M. Pytkowicz participated, is being interpreted.

Improvement of Shipboard Techniques - Park, Latimer

1. Conductometric alkalinity determination. Concurrent determinations of salinity and alkalinity from a single sample are now possible. We hope to test the new system at sea shortly.

2. Gas chromatographic determination of dissolved gases. A technique has been developed for the routine gas chromatographic determination of oxygen, nitrogen and total carbon dioxide from a single 2-ml water sample. The technique will be used routinely aboard the R/V YAQUINA beginning 20 April 1966.

3. Equipment for infra-red CO₂ analysis and automatic nutrient analysis are being assembled at present.

Estuarine Chemistry - Park, Kujala, Catalfomo, Webster*

A study of the nutrient and alkalinity budgets of the Columbia River continues. Monthly water samples are taken at Astoria and upstream stations. The Pacific Northwest Water Laboratory is cooperating on the gathering of samples in the upstream waters.

Offshore Chemistry - Park, Erdmann, Catalfomo, Wyatt, Still

Deep-sea chemical conditions off Oregon were investigated during the January 1966 cruise of the R/V YAQUINA. Seven deep casts were taken. Oxygen, pH, alkalinity, total carbon dioxide, phosphate, nitrate and silicate were measured. The data analyses are underway.

Seasonal and spatial distribution of oxygen and phosphate for 1965 is being examined. A report on the results is in preparation.

Examination of seasonal and spatial distribution of pH and alkalinity in 1963 and 1964 is completed. Figure 1 shows a simplified vertical distribution of alkalinity, pH, and specific alkalinity off Newport, Oregon. Figure 2 shows the alkalinity-salinity relationship, while Figure 3 shows the similarity between the pH-salinity and oxygen-salinity relationships off Oregon.

* Pacific Northwest Water Laboratory

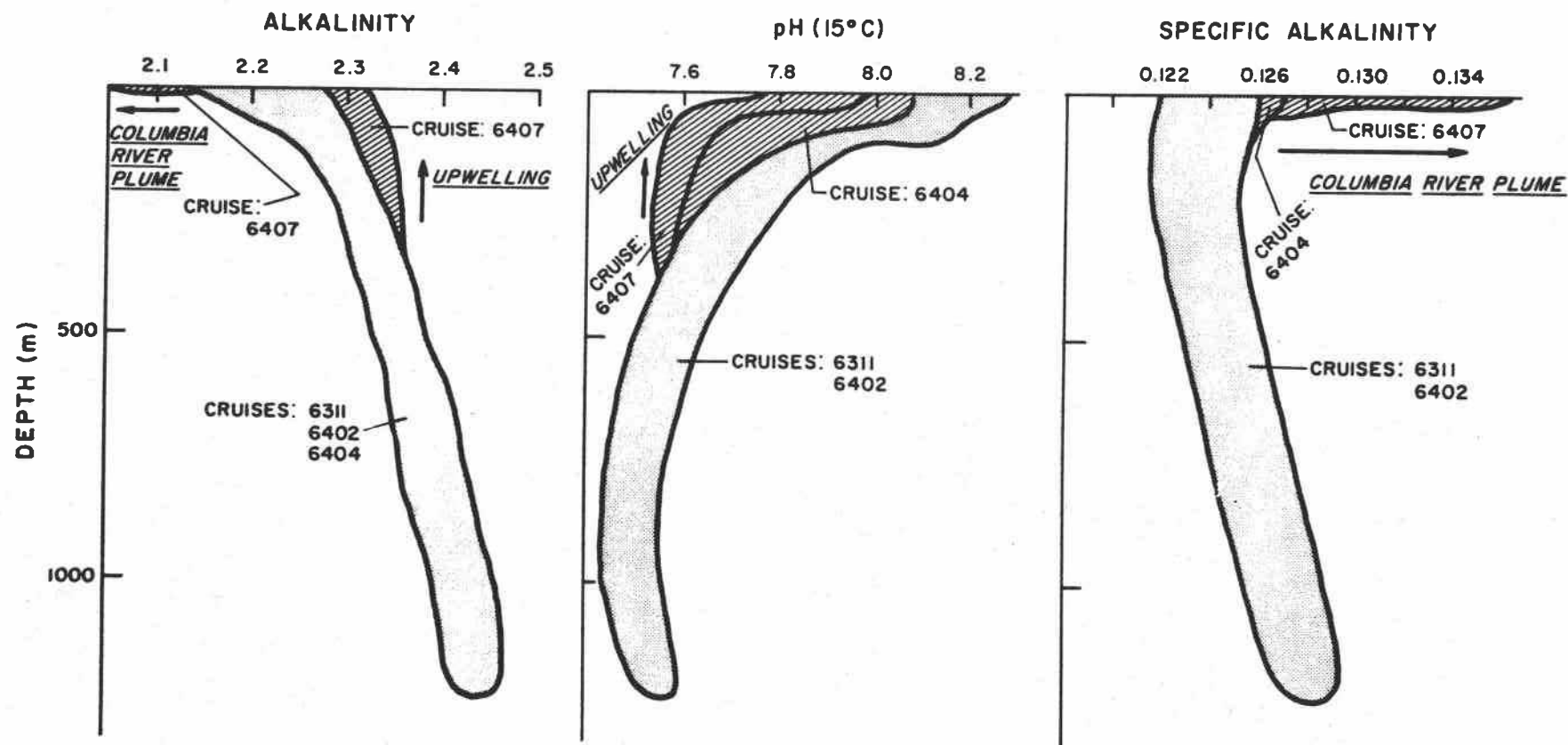


Figure 1. Simplified vertical distribution of alkalinity, pH, and specific alkalinity off Newport, Oregon, 1963-1964. Alkalinity is in meq/liter.

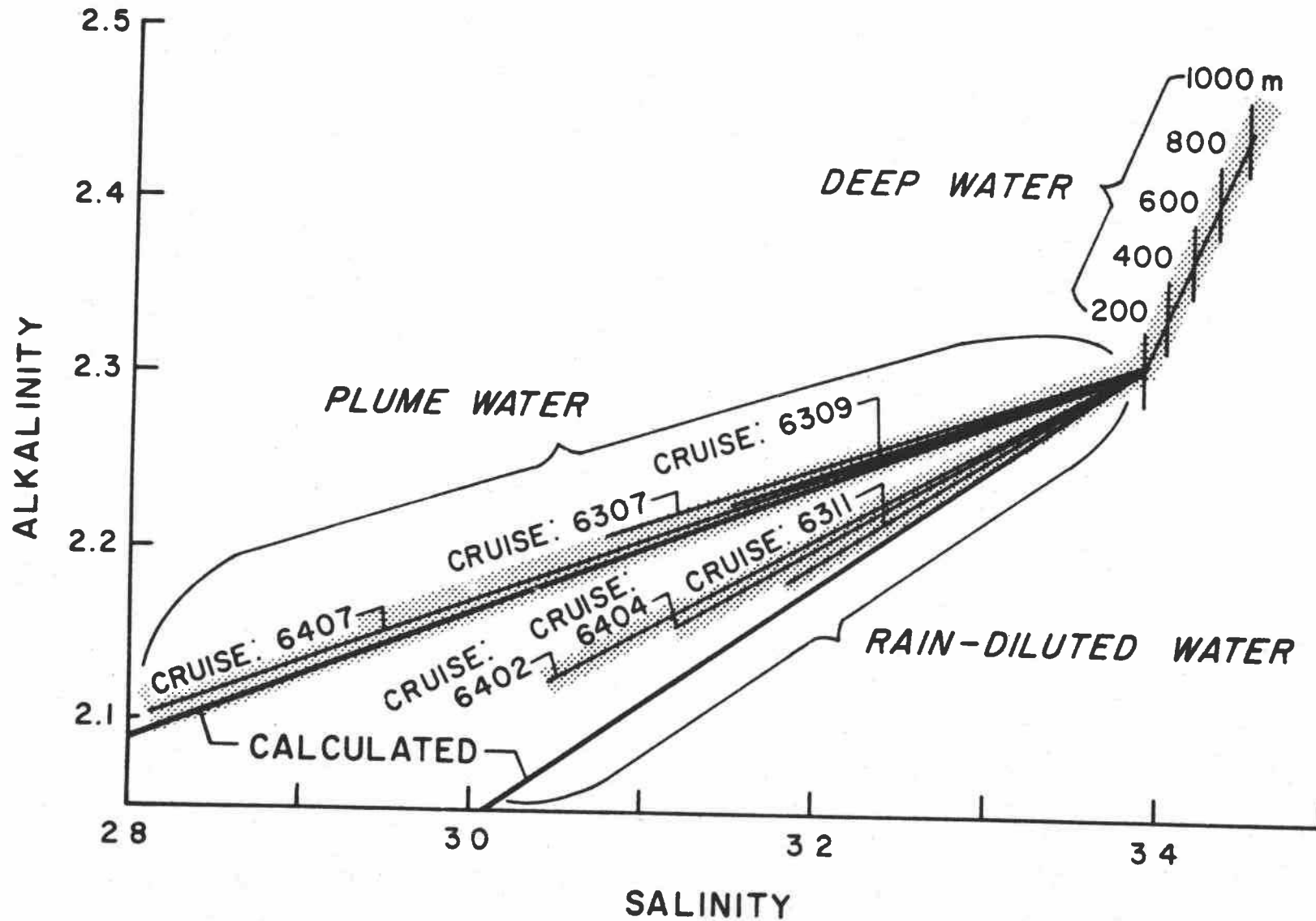


Figure 2. Simplified alkalinity-salinity relationship of six cruises of the R/V ACONA, off Newport, Oregon, 1963-1964.

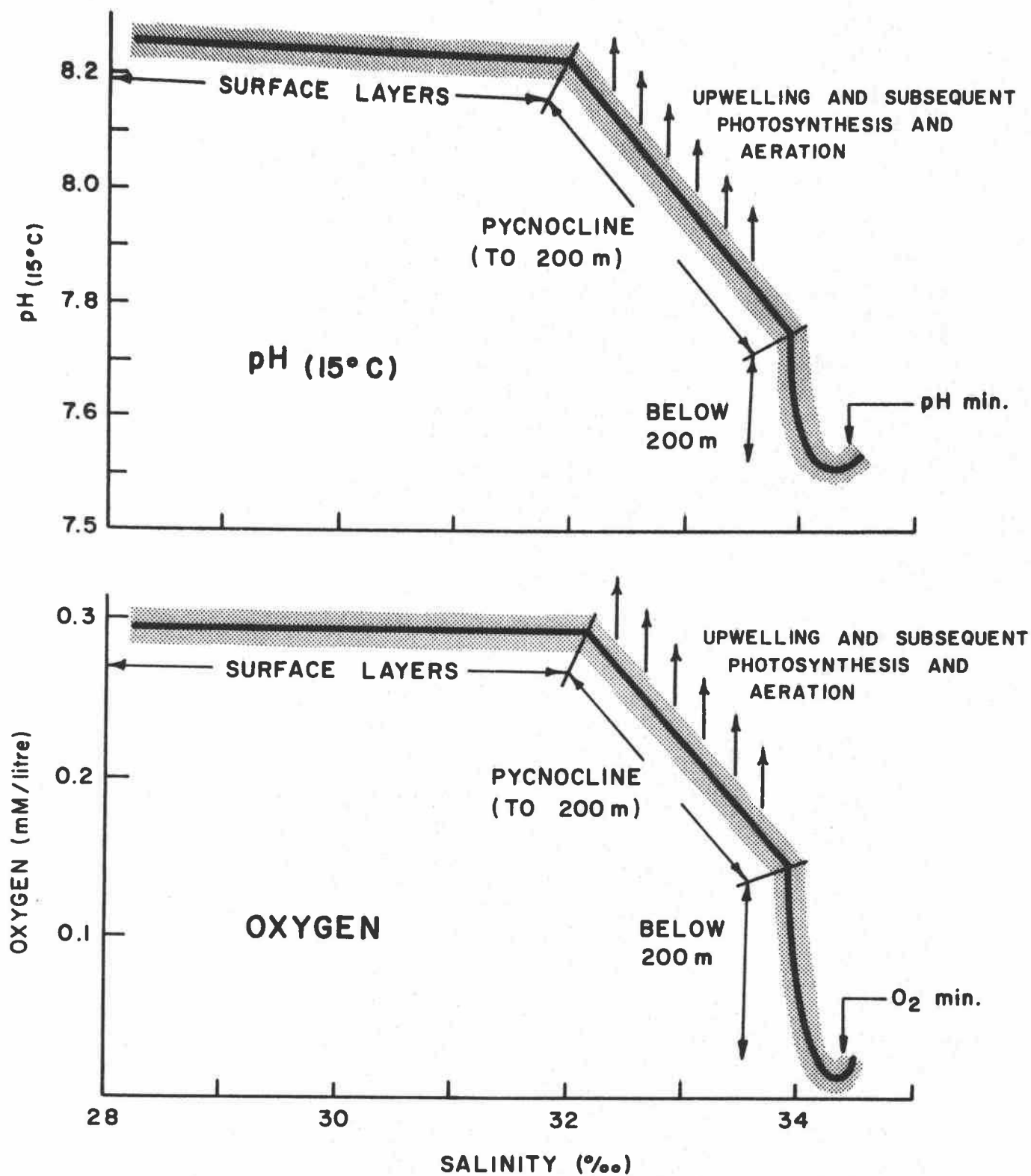


Figure 3. Simplified pH-salinity and oxygen-salinity relationships off Oregon.

Dolomite from Astoria Canyon - Deffeyes, Russell

We have discovered a partially consolidated layer of micron-sized dolomite, magnesian calcite, feldspar, and quartz in a core taken near the head of Astoria Canyon. The core was taken 30 miles off the Oregon coast in 358 meters of water. The consolidated layer occurred 1.6 m down in the core below soft gray mud and turbidity current deposits. Dr. Fowler made a preliminary examination of the foraminifera from above and below the layer. They were typical faunas found today at the same temperature and water depth. The O^{16}/O^{18} and C^{12}/C^{13} ratios were measured to test for an evaporite origin of the dolomite. The results, δO^{18} of +5.8‰ and δC^{13} of -35.2‰ are different from any previously reported dolomite. The carbon is lighter than any known natural carbon except for the lightest petroleum fractions.

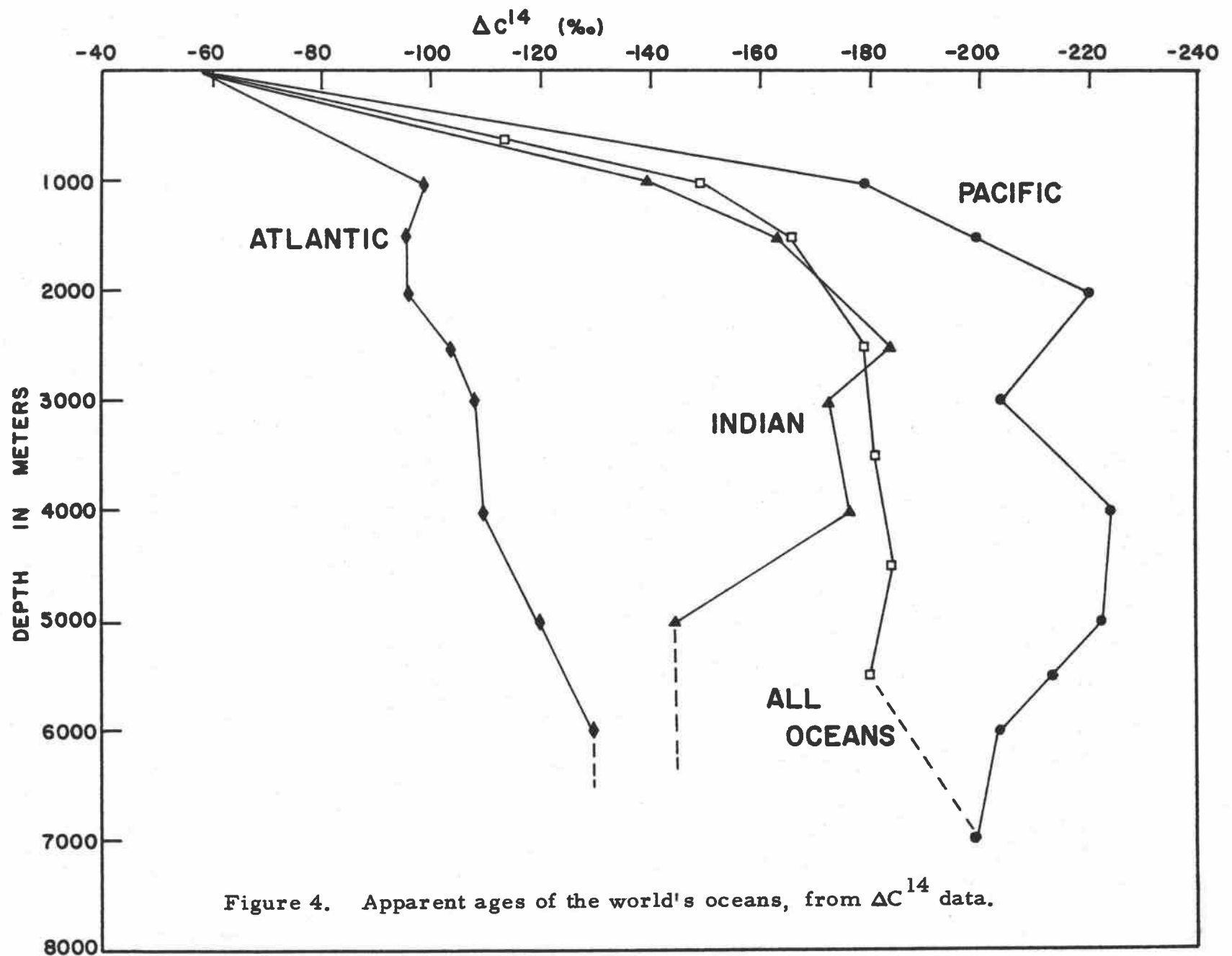
Because this sample was so unusual we are making a collection of deep marine dolomites for comparison and further study.

Carbon-14 Data for the World Ocean - Weyl, Olson

Mean Δ Carbon-14 values for the Atlantic, Indian, and Pacific Oceans, and for all oceans combined, have been computed from published data. The term ΔC^{14} represents the percentage change in activity using Nineteenth Century wood as a standard.

Profiles showing the computed means of ΔC^{14} at 500 m depth increments are shown in Figure 4. The overall averages for each ocean and for all oceans combined are as follows:

	Mean ΔC^{14} (‰)	Apparent Age (years)
All surface waters	-58	574
Atlantic Ocean	-98	825
Indian Ocean	-155	1350
Pacific Ocean	-192	1700
All Oceans (all depths)	-162	1400



RADIOCHEMISTRY AND RADIOECOLOGY

Radioecology of the Benthos - Carey, Osterberg, McCauley, Hancock, Alspach, Larsen

During this period, 235 samples, representing 42 animal species and 14 sediment types, have been radioanalyzed for gamma-emitting radionuclides. A station line off Tillamook Head was sampled several times, once in conjunction with the in situ gamma-ray probe. The proximity of the Columbia River and the consequent higher radionuclide levels allow us to better study the relationships between the benthic organisms and their sedimentary environment. Seasonal data will continue to be obtained from standard trawling stations on the Newport line. The data on variations of zinc-65 levels in the benthic invertebrates are being prepared for publication.

Radioecology of Pelagic Animals - Percy, Eagle, Larsen, Tennant

Studies of the seasonal, depth, and diel variation of whole samples of mixed species composition have been completed. We are currently determining the radioactive and stable zinc from ashed samples of individual species of oceanic animals in order to estimate specific activities.

Gamma-ray spectrometry has been performed on 249 samples and atomic absorption spectrometry on 175 samples during the past quarter.

Radiochemistry - Osterberg, Cutshall, Cronin, Frederick

The large volume (160 gallon) tanks for removing trace radionuclides from seawater by coprecipitation have proved useful for following chromium-51 introduced by Hanford reactors into the Columbia River. Information gained with this apparatus verifies that most of the Cr^{51} in the ocean off Oregon is in hexavalent form. In order to achieve maximum recovery by coprecipitation, the Cr^{51} must first be reduced to trivalent chromium. These conclusions appear in a recent article in Science by Cutshall et al.

Shipboard Counting of Coprecipitates - Frederick, Cutshall, Osterberg

To avoid the need for bringing coprecipitate samples to the laboratory for analysis, a 4-ton lead-shielded counting chamber has been fabricated on the R/V YAQUINA. Certain trace radionuclides from 160 gallons

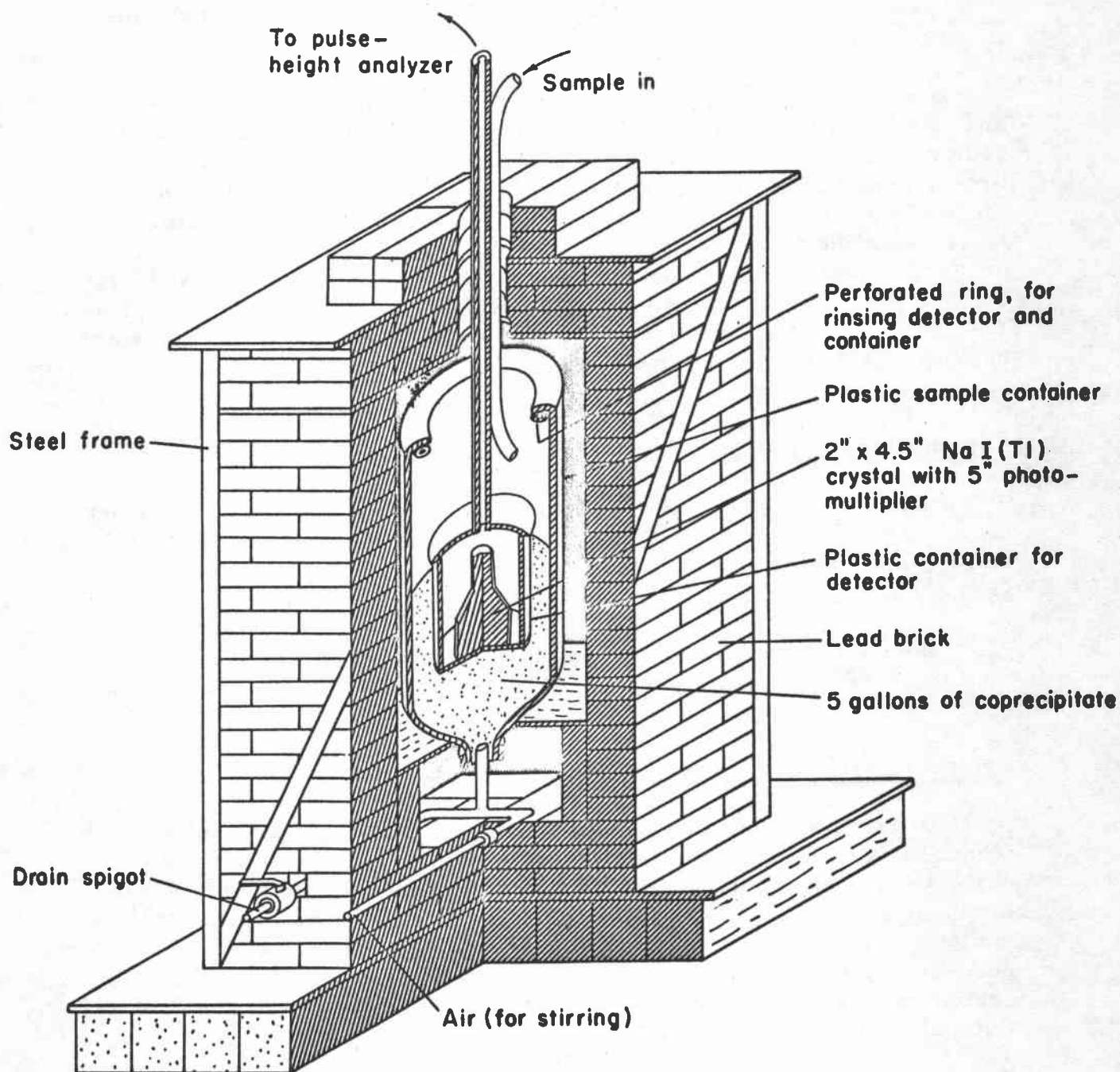


Figure 1. Gamma-ray counting chamber.

of sea water are concentrated to about four gallons through the use of FeCl_3 and NH_4OH (pH 9.5). After the precipitate is concentrated in the conical bottom of the large volume tank, excess water is siphoned off. The 12 gallons of concentrate flows into secondary plastic tanks. Here it is heated to room temperature and further concentrated (by settling) to 4 gallons, and residual water removed. The final concentrate flows into the lead-shielded counting chamber, where it surrounds a 4.5 x 2-inch NaI (Tl) detector, coupled to a 512-channel gamma-ray spectrometer (Figure 1).

Because the sample is heated to room temperature before it enters the counting chamber, minimum thermal protection is needed to avoid damage to the crystal. Temperature-induced drift in the photomultiplier is also reduced.

Certain radionuclides (such as Cr^{51} , and probably Sb^{124} and Zn^{65}) are concentrated forty times by these chemical procedures, and are readily detected in the precipitate. Data are available on punch tape about four hours from the time water is collected, and the cruise plan can be altered to follow interesting features. The winter plume of the Columbia River was followed northward as far as Cape Flattery, Washington, in February 1966, using the shipboard counting chamber.

Even greater sensitivity is achieved by returning the precipitate to the laboratory (after counting at sea), where the sample is dried, compressed, and counted in the well of a 5x5-inch crystal. Frederick *et al.* hope to use the ratio of Cr^{51} and to Sb^{124} as an absolute timing device to give rates of horizontal and vertical water transport.

Dissolved Organics in Sea Water - Cronin, Berger*, Martin*, Aungst*, Swift*, Osterberg

A reverse flow pulse jet column extractor was used on a recent cruise of the R/V YAQUINA to remove dissolved organics from surface sea water. This device was built at Battelle-Northwest, and promises to further our knowledge of non-filterable ($< 0.45\mu$) organics in the ocean.

In recent tests, approximately 3000 gallons of sea water were extracted using hexane as the solvent. The solvent is currently being distilled, and the organics remaining will be analyzed by chromatography, mass spectrometry, and NMR at Battelle-Northwest. The data will be a part of Cronin's Ph. D. dissertation which is supported by the AEC and carried out jointly with Battelle-Northwest and Oregon State University.

* Battelle-Northwest Laboratories, Richland, Washington.

Relation of Radioactivity to Turbidity - Hanson, Osterberg

A device to measure changes in salinity, temperature, turbidity, and radioactivity over short distances in the water column has been built. It is hoped that a relationship between the suspended sediment load (turbidity) and the salt wedge in the Columbia River estuary can be established, and the role of the particulates in transporting Hanford-induced radionuclides examined.

The detector slides up and down a taut cable which is anchored to the bottom with 160 pounds of lead. This arrangement permits us to measure changes in depth accurately throughout the water column. Temperature and salinity are measured with an Industrial Instruments CTI and turbidity with a Hydro Products transmissometer. A plastic footvalve and rubber hose inlet are also included in the detector.

In operation, salinity, temperature, and transmissivity are read out on meters on the boat. Water is pumped through 5-inch membrane filters (0.65 μ) into 5-gallon plastic precipitating tanks. Radionuclides are removed from the filtered water by coprecipitation techniques, reduced in volume, and analyzed in the laboratory by gamma-ray spectrometry. The filters are packed into plastic counting tubes and can be analyzed with no further treatment.

A 32-foot boat, obtained as surplus from the Corps of Engineers, has been equipped to handle the operations required for this project.

Stable Zinc in Sea Water - Buffo, Cronin, Cutshall

Considerable effort is being devoted to working out optimum techniques for the analysis of stable zinc in sea water. These experiments are not complete, but the results of our latest tests are encouraging.

The technique is as follows: 750 ml of sea water, collected with an all-plastic system, are filtered through a 50-mm membrane filter (0.65 μ), placed into a 1000-ml separatory funnel and buffered to a pH of 7.3 (with citrate). A chelator (sodium diethyl dithiocarbamate) is added. After 35 minutes of agitation, 75 ml of solvent (methylisobutylketone) are added and shaken for 30 minutes. After separation occurs, the 75 ml of solvent are recovered. The next step is to "back extract" the MIBK with 20 ml of 0.36N HCl. After 20 minutes of shaking the acidified water is separated and sufficient 0.36 N HCl added to bring to 25 ml. The sample is now ready for analysis by atomic absorption extraction.

Advantages of this two-step extraction process are as follows:

1. Instead of the ten-fold concentration, back extraction gives a thirty-fold concentration.
2. Any zinc which may have adsorbed to the separatory funnel is removed by the acid.
3. Any worries about the stability of the zinc complex are eliminated.

To make our results as reproducible as possible, samples receive carefully-timed, uniform mixing. A laboratory shaker (Burrell Corp.) has been modified to handle eight 1000 ml separatory funnels simultaneously. The above methods were recently tested at sea.

BIOLOGICAL OCEANOGRAPHY

Benthic Ecology and Systematics - Carey, McCauley, Alspach, Hancock

Five joint cruises during this period yielded 22 Shipek Grab, 15 Smith-McIntyre Grab, 10 Phleger Core, 16 Anchor-Box Dredge, and 17 Otter Trawl samples. The majority of the samples was collected on the continental shelf, continental slope, and Cascadia Abyssal Plain on the Newport station line or the Tillamook Head line. However, our deepest trawl to date (4300 m) came from south of the Mendocino Escarpment off Northern California.

Laboratory analyses of the samples continue. The polychaete collections identified to date have been counted and the abundance per unit area calculated. Asteroid feeding studies continue; stomach analyses of all starfish collected during this period have been examined. Data on the ecology of the benthic invertebrates are being prepared for publication.

Reproduction of Benthic Invertebrates - Hufford, Carey

The gonadal index (volume of the gonad/wet weight) of the sea urchin Allocentrotus fragilis has been measured to determine its reproductive cycle. Preliminary results indicate that sea urchins reproduce one a year around the month of April. This was determined by the fact that the gonads in the animals observed in May were spent, as compared to the full gonads found in March and early April. There is some evidence to suggest that the reproductive cycle may be correlated to the period of upwelling.

Deep-Sea Fouling Studies - Tipper, McCauley

Several racks for holding sample panels to be subjected to biological deterioration on the ocean floor have been designed and constructed. Test panels and racks were placed on the ocean bottom in conjunction with departmental studies on a deep-water taut-line mooring system which employs a catamaran buoy. Structural failures in the mooring system have prevented recovery of four sample racks placed previously. Three additional racks, now under construction, will be placed on the ocean floor in 2800 m of water early in April 1966. Each rack contains 16 matched pairs of panels: nine woods (Douglas fir, Incense cedar, redwood, oak, pine, maple, ash, mahogany, and untempered hardwood), five plastics

(acrylic, polypropylene, polyvinylchloride, polyethylene, and teflon), and two metals (stainless steel and aluminum). All are attached to an epoxy-coated steel frame in such a manner as to eliminate electrolysis. Sample lengths of hemp, nylon, polypropylene, and cotton line are attached. A timed series recovery of these three racks has been planned, and a machine data processing program has been generated to aid in ecological analysis of the resultant data with respect to time and location of exposure.

Distribution and Ecology of Oregon Echinoids - McCauley, Carey

Sea urchins from more than 350 samples have been studied and identified. The ten species represented fall into three definite bathymetric groups. Strongylocentrotus purpuratus (Stimpson) 1857, S. franciscanus (A. Agassiz) 1863, and Dendraster excentricus (Eschscholtz) 1831, occur in shallow waters down to 64 m. All three are known from intertidal waters. Strongylocentrotus echinoides Agassiz and Clark, 1907; Brisaster sp.; and Allocentrotus fragilis (Jackson) 1912 occur on the continental shelf and upper continental slope in depths from 80 to 800 m. Aeropsis fulva (A. Agassiz) 1898; Urechinus loveni (A. Agassiz) 1898; Sperosoma giganteum Agassiz and Clark, 1907; and Ceratophysa rosea (A. Agassiz) 1879 occur in deep waters (2000-3000 m).

Strongylocentrotus purpuratus and S. franciscanus are well-known intertidal species from Oregon shores but have not been reported previously from subtidal waters off Oregon. Dendraster excentricus is also well-known intertidally, but the only published records have been made by geologists.

Only one specimen of Strongylocentrotus echinoides has been found off Oregon previously, and to this we add 10 specimens. Allocentrotus fragilis is extremely common on the continental shelf and upper slope; we have collected 4868 specimens. About 300 specimens belonging to the genus Brisaster are currently being studied. Both B. townsendi and B. latifrons have been reported from the west coast of North America. These two species are closely related and may be variants of a single species. Our collections may eliminate some of this taxonomic confusion.

Sperosoma giganteum is a large echinothurid urchin previously known from a single specimen collected off Japan. Our 23 specimens extend the range to the northeastern Pacific.

Urechinus loveni has been collected from widely separated areas; from the Pacific Ocean off Mexico, from the Bering Sea, and from the

Sea of Okhotsk. Our collections confirm its occurrence in the Northeastern Pacific.

Aeropsis fulva has previously been reported from the Pacific Ocean off the west coast of South America and from the Bering Sea. We collected eight specimens off Oregon.

Fragments of a specimen believed to be Ceratophysa rosea were collected in 2600 m off Oregon. This species is known only from fragments collected once before from the central Pacific Ocean. Our fragments have been deposited in the United States National Museum.

No new species have been found. All the species from shallow (0-64 m) and intermediate (80-800 m) depths have been reported previously from the Northeast Pacific, but the deep sea species are new distributional records for the Northeast Pacific.

Table 1 shows the bathymetric distribution of these sea urchins.

Table 1. Bathymetric Distribution of Sea Urchins Collected Off Oregon.

<u>Species</u>	<u>Depth (m)</u>
<u>Dendraster excentricus</u>	0 - 52
<u>Strongylocentrotus purpuratus</u>	0 - 64
<u>Strongylocentrotus franciscanus</u>	0 - 64
<u>Strongylocentrotus echinoides</u>	80 - 110
<u>Allocentrotus fragilis</u>	80 - 800
<u>Brisaster</u> sp.	100 - 800
<u>Aeropsis fulva</u>	2600 - 2870
<u>Urechinus loveni</u>	2600 - 2830
<u>Sperosoma giganteum</u>	2090 - 3000
<u>Ceratophysa rosea</u>	2600

Systematics of Deep-Sea Fishes - Coleman, Eagle, Percy

The mesopelagic and bathypelagic fishes collected in midwater trawls and the abyssobenthic fishes collected in otter trawls are being identified.

Distribution of Euphausiids and Copepods in Relation to Oceanographic Conditions - Hebard, Percy

A total of 104 species of copepods and 21 species of euphausiids were identified from the meter net collections off Oregon. Of these only eight copepods and twelve euphausiids are numerically important.

Several species showed seasonal or geographic trends in occurrence that are related to changes in oceanographic conditions. For example, inshore extensions in distribution were noted during the winter when there was little difference between inshore and offshore conditions.

Two methods were used to determine species associations of copepods and euphausiids. Although recurring species groups were found, neither method separated the species or samples into discrete, well-structured associations. This suggests that in a localized area which is a transition or a gradient between water mass types, discrete communities of zooplankton may be difficult to define.

The Distribution of Pelagic Amphipods - Van Arsdale, Percy

The hyperiid amphipods collected off Newport, Oregon, from June 1963 through June 1965 have been identified to species. These identifications have been verified by Dr. Thomas E. Bowman, Associate Curator at the Smithsonian Institute.

Numerically dominant species in the meter-net collections are Parathemisto pacifica Stebbing, Paraphronima gracilis Claus, Streetsia challengerii Stebbing, Hyperia hystrix Bovallius, Tryphana malmi Boeck, and Primno abyssalis Bowman. The vertical distribution, estimated from opening and closing multiple meter net during day and night periods, and the seasonal distribution of these species have been examined. The abundances of the dominant species are being compared with the amount of heat present in the upper portion of the water column.

Ecological Study in an Area of Upwelling - Laurs, Pearcy

Preliminary results from an ecological study in an area of seasonal upwelling off Southern Oregon show that mesopelagic fishes are least abundant during early upwelling and most abundant in late or post-upwelling periods. Intermediate numbers occur in the pre-upwelling period.

A great difference in the heat content between the nearshore and off-shore waters during early, late, and post upwelling periods correlates with numbers of mesopelagic fishes; greatest numbers of fishes are found on the cold side of the gradient. Before upwelling the regions exhibit little difference in the heat content or numbers of mesopelagic fishes.

Ecology of Oceanic Shrimps - Pearcy, Forss

Analyses of the vertical distribution of oceanic shrimps collected in opening-closing meter nets and midwater trawls have been completed. Most of the species are mesopelagic in distribution. Only one species, Sergestes similis, clearly demonstrated diel vertical migrations.

The seasonal variation in number and sizes of S. similis are being examined to provide data on migrations and growth.

Distribution and Occurrence of Salpidae off Oregon - Hubbard, Pearcy

Six species of salps representing six genera were collected off Oregon from 1961-1964. Salpa fusiformis and Sasis zonaria were the most abundant species. Since salps are generally epipelagic and warm water species, their occurrence off Oregon is being correlated with wind stress and advection of surface waters.

Chaetognath Populations off the Oregon Coast - Renshaw, Pearcy

The chaetognaths from 106 samples collected by opening-closing multiple meter nets have been analyzed. Twelve species of chaetognaths are represented in the waters off the Oregon coast. The four numerically dominant species, Sagitta bierii, S. decipiens, S. scrippsae, and Euhrohnia hamata, show trends in seasonal abundance and vertical distribution. Evidence for vertical migrations was lacking. Breeding periods were established for most of the species.

Deep Scattering Layers Off Oregon - Donaldson, Percy

Since 1962 recordings of deep scattering layers have been made off the Oregon coast. Echograms from the Newport stations were analyzed for seasonal and daily variations in the number and depth distribution of the layers. Changes in the layers from inshore to offshore waters are also under investigation.

Plankton Inventories at Yaquina Bay - Frolander

We continued to collect samples weekly from four locations in Yaquina Bay. In addition to Clarke-Bumpus tows, we also collected surface and bottom water samples for determining temperature, salinity, and dissolved oxygen. A summary of the data collected during this period appears in Table II. All samples have been accessioned into ledgers, catalogued in card files, and deposited in chronological accessioning cases.

Ten samples collected between 25 February 1965 and 3 March 1965 have been analyzed by the vacuum displacement method.

Table II. Summary of Data Collected at Yaquina Bay.

Sampling Days	13
Clarke-Bumpus Tow - #6 mesh	46
Clarke-Bumpus Tow - #12 mesh	46
Water samples (for measurement of temperature, salinity, and dissolved oxygen)	97

Phytoplankton Pigments - Curl, Iverson

As part of a program involving the characterization of pigment system of various marine algae, coupled with the determination of photosynthetic action spectra of the algal pigment system, thin layer chromatography was used to separate pigment components of the marine phytoplankton algae Skeletonema costatum, Nitzschia closterium, and Rhizosolenia spp.

After elution from silica gel G. adsorbant, absorption spectra of the different pigment components were determined with a Beckman DB spectrophotometer. Absorption maxima for the different pigment

components were determined with a Beckman DU spectrophotometer.

A technique for the determination of photosynthetic action spectra involving manometric measurement of oxygen evolved under stimulus of monochromatic light is in development.

Phytoplankton Ecology - Curl, Small, Davey, Glooschenko, Iverson, Marmelstein, Bruce

On four cruises between July 1965 and February 1966, chlorophyll samples were taken every two hours at depths of 1, 10, 15, 25, and 50 m. In July and September, the chlorophyll values at 1 and 10 m showed diel variation, the highest values occurring in the middle of the night, the lowest in the late afternoon. No variations were seen in November or February. We are now investigating the relationships between light intensity and duration and this periodicity, as it appears light is the controlling factor. Concurrently, C^{14} productivity studies were made in order to determine assimilation ratios. Also, nutrient enrichment experiments were performed in situ. These experiments showed that iron, and possibly nitrate, may be limiting for primary production off the Oregon coast. More work is being done here in order to determine seasonal effects. Phosphate did not seem to be a limiting factor.

Phytoplankton Physiology - Curl, Davey

We are attempting to determine the photosynthetic and respiratory quotients of marine phytoplankton species grown under various light, temperature, and nutrient conditions. We also hope to determine the changes in amount of inorganic carbon, particulate carbon, and dissolved organic carbon with time as the cultures mature.

Work to date has been in 1) development of suitable gas chromatographic columns for the analysis of carbon dioxide, oxygen, argon, and nitrogen in artificial sea water. A $1/4'' \times 1'$ silica gel column treated with 10% diglycerol is on trial for CO_2 analysis and a $1/4'' \times 14'$ molecular sieve column activated with argon at $450^\circ C$ for the detection of Ar, N, and O. An F & M 720 or 700 gas chromatograph is used for these analyses. 2) Development of a closed system for the growth of marine phytoplankton without gaseous exchange with the atmosphere. The best containers found for this purpose are 50 ml glass syringes stoppered with serum caps. 3) Development of suitable method for the collection of phytoplankton for determination of their total C, H, and N content. Glass fiber filters cut to fit into Swinney adaptors have been devised for

this purpose. The total CHN analysis is carried out on a F & M 185 analyzer.

Present and future work also includes: 1) development of a method for the determination of dissolved organic carbon, 2) construction of an apparatus for the growth of marine phytoplankton under simulated environmental conditions, 3) development of a gas chromatographic method for analysis of available nitrogen, and 4) development of a gas chromatographic system with sufficient sensitivity to measure changes in nutrients and permanent gases by natural phytoplankton populations at sea.

Annual Phytoplankton Cycle in Auke Bay, Southeast Alaska - Bruce

A summary report on the phytoplankton in Auke Bay, Alaska, covering the period from 1 June 1965 to 1 March 1966 has been written. No attempt was made to give a detailed account of all species identified. The summary sketches the annual cycle and describes the bloom-producing species and other species which at one time or another represent 5% or more of the total cells present. No attempt was made to identify the small pennate diatoms which are present from time to time but are never numerically abundant. During the course of this study approximately 45 species of diatoms have been identified.

In addition to the two original stations, Auke Bay Monitor and Spuhn Island, one additional station off Portland Island was established in September. This station is in Stephens Passage and should be somewhat representative of major straits and passages in the northern area of the inside waters. Hence, it was felt that this station would give comparative data to support that taken within Auke Bay.

Energy and Element Transfer in the Lower Marine Food Web - Small, Hebard, Bergeron, Fowler

Respiration studies on euphausiids have been extended to include summer data as well as that from winter (see Progress Report 16). Rates of respiration during the two seasons were statistically similar, and analysis of combined data is in progress. We have also performed experiments on respiration of temperature-acclimated animals, as opposed to respiration under conditions of no acclimation. We hope to gain insight into the ranges of euphausiid respiration in the natural environment, for use with growth estimates, to predict assimilation, or energy transfer.

Mr. Fowler is completing his M. S. thesis on uptake and retention of "pollution concentrations" of zinc-65 from sea water by Euphausia pacifica. Mr. Bergeron will soon complete his work on uptake of Zn^{65} through a simple food chain.

Physiological Ecology of Cryophilic Algae - Curl, Hardy

Extraterrestrial organisms, if indeed they exist, probably include simple autotrophic plants. Our present state of knowledge indicates that the ranges of the important environmental parameters on Mars do not exclude the growth of many terrestrial organisms. For instance, cryophilic or extremely eurythermal terrestrial autotrophs, capable of withstanding considerable dessication, might survive and grow in the Martian environment. Such organisms exist in extremely harsh environments on the earth. In particular, many species of snow algae grow abundantly in the high mountain and polar regions of the world. Algae in these regions are subject to daily freezing, thawing, and dessication. Nevertheless, these cryophilic algae often grow in abundance. In the spring and summer, they frequently form visible algal blooms which cover the surface of the snow. Areas of frozen water vapor on Mars, perhaps around the rims of craters, might provide a habitat for cryophilic autotrophs similar to terrestrial snow algae.

Our research is directed toward the physiological ecology of snow algae and studies on their tolerances to extreme environments. Two phases of the study have been more or less completed. Following is an abstract of a paper, soon to be submitted for publication, on our findings:

"Snow samples from several alpine areas in Oregon, Washington, and Montana have been examined and found to contain cryophilic algae, often in such abundance as to color the snow green, orange, or red.

"Twenty-three genera of algae are described, including three new species (Chroococcopsis nivalis n. sp., Ourococcus cascadenis n. sp. and Scotiella gigantea n. sp.). The following species have been isolated from snow and grown in unialgal cultures at 5° C: Chlamydomonas yellowstonensis Kol, C. nivalis (Bauer) Wille, Coccomyxa dispar Schmidle, Chromulina chionophila Stein, Ulothrix sp., Rhabdoderma lineare Schmidle, and Stichococcus bacillaris Nageli."

"The presence on the snow of species of Cyanophyta that have previously been reported to occur in hot springs is discussed. And, it is suggested that many species of snow algae are not "cryophilic"; but, instead, may simply be extremely eurythermal."

"The presence of red pigment in many snow algae is probably a response to high light intensity."

Much work remains to be done on the taxonomy, life histories, and geographic distribution of snow algae. However, more important to the question of possible Martian life forms is the effect of environmental parameters on growth and photosynthesis of snow algae. Therefore, taxonomic study of snow algae will not constitute an important part of future investigations.

Marine Microbiology - Morita

Research is still being continued on the basic reasons for the low temperature for growth of obligate psychrophilic bacteria and why they will not grow at moderate temperatures of 20° to 30° C. Several approaches have been taken at the molecular as well as the cellular level concerning this problem. One approach currently under investigation is the study of the metabolic pathways (glycolytic pathway and TCA cycle) to determine if the enzymes in the pathways are abnormally thermolabile or whether it is one or a few key enzymes. Other enzymes (glucose-6-phosphate dehydrogenase and gelatinase) isolated from obligate psychrophiles are also being characterized as to their thermolability as well as the kinetics of their reaction under various conditions. The effect of temperature on cellular permeability is also undergoing investigation. Initial studies are being conducted to determine the effect of hydrostatic pressure and temperature on protein synthesis and DNA synthesis, as well as on RNA synthesis.

Systematics and Evolution of Opisthobranch Gastropods - Gonor

During this period detailed work proceeded on the collections from Costa Rica and the tropical Pacific, prepared for study during the previous report period. Good material was secured in Fiji of Volvatella sp., a rare and little known genus of Sacoglossa important in attempts to understand phyletic relations in this group. Observations on the living animals were supplemented by anatomical work on the nine well preserved specimens secured. Some of the information so obtained was sent to another worker, K. Baba of Japan, enabling him to complete a similar study, done on only two preserved specimens and without recourse to living material. The collections under study have allowed, for the first time, careful anatomical comparisons of Caribbean and Indo-Pacific specimens of similar but nominally different species of the genus Elysia. It was found that these were all of a single cosmopolitan species, Elysia ornata,

which shows variations in superficial characteristics depending upon age and locality. This finding allowed many Elysia specific names to be synonymized, clarifying long standing taxonomic and zoogeographic confusion in this group.

Structure and Function in the Digestive System of Marine Mollusca - Gonor

In the fall and winter I began training in the use of the electron microscope and techniques for the study of animal tissues with this instrument in order to prepare to use these methods in an expansion of my previous studies on structure and function of the molluscan digestive gland done within the limitations of the methods of light microscopy. In March, work began on a study of gastropod digestive glands with the electron microscope. It is often difficult to adequately fix marine invertebrates for electron microscope study, and to date this work has been limited to a search, still underway, for favorable experimental species and fixation techniques suitable for them. Certain of the species used were found to be adaptable to these techniques, and some interesting results have been obtained on the structure of the digestive cells in the gland of Littorina and Thais. These preliminary results indicate that the fixation problem will not present a serious barrier and that it will soon be possible to commence the major part of the study.

DEGREES GRANTED

Three students completed the requirements for the Ph. D. in Oceanography. Three more completed work on an M. S. in Oceanography. These students, the titles of their theses, and the major professors who guided their work are listed below.

MAUGHAN, Paul M. Ph. D. , Physical Oceanography

Thesis Title: Measurement of Radiant Energy Over a Mixed Water Body

Major Professor: Wayne V. Burt

RUNGE, Erwin J. Ph. D. , Geological Oceanography

Thesis Title: Continental Shelf Sediments, Columbia River to Cape Blanco

Major Professor: John V. Byrne

STEVENSON, Merritt R. Ph. D. , Physical Oceanography

Thesis Title: Subsurface Currents off the Oregon Coast

Major Professor: June G. Pattullo

JENNINGS, Charles D. M. S. , Oceanography (Radioecology)

Thesis Title: Radioactivity of Sediments in the Columbia River Estuary

Major Professor: Charles L. Osterberg

JOHNSON, Vernon. M. S. , Oceanography (Radioecology)

Thesis Title: Retention of Zinc-65 by Columbia River Sediments

Major Professor: Charles L. Osterberg

MORRISON, George E. M. S. , Biological Oceanography

Thesis Title: An Investigation of the Distribution of Nephtys caecoides in Yaquina Bay

Major Professor: Andrew G. Carey, Jr.

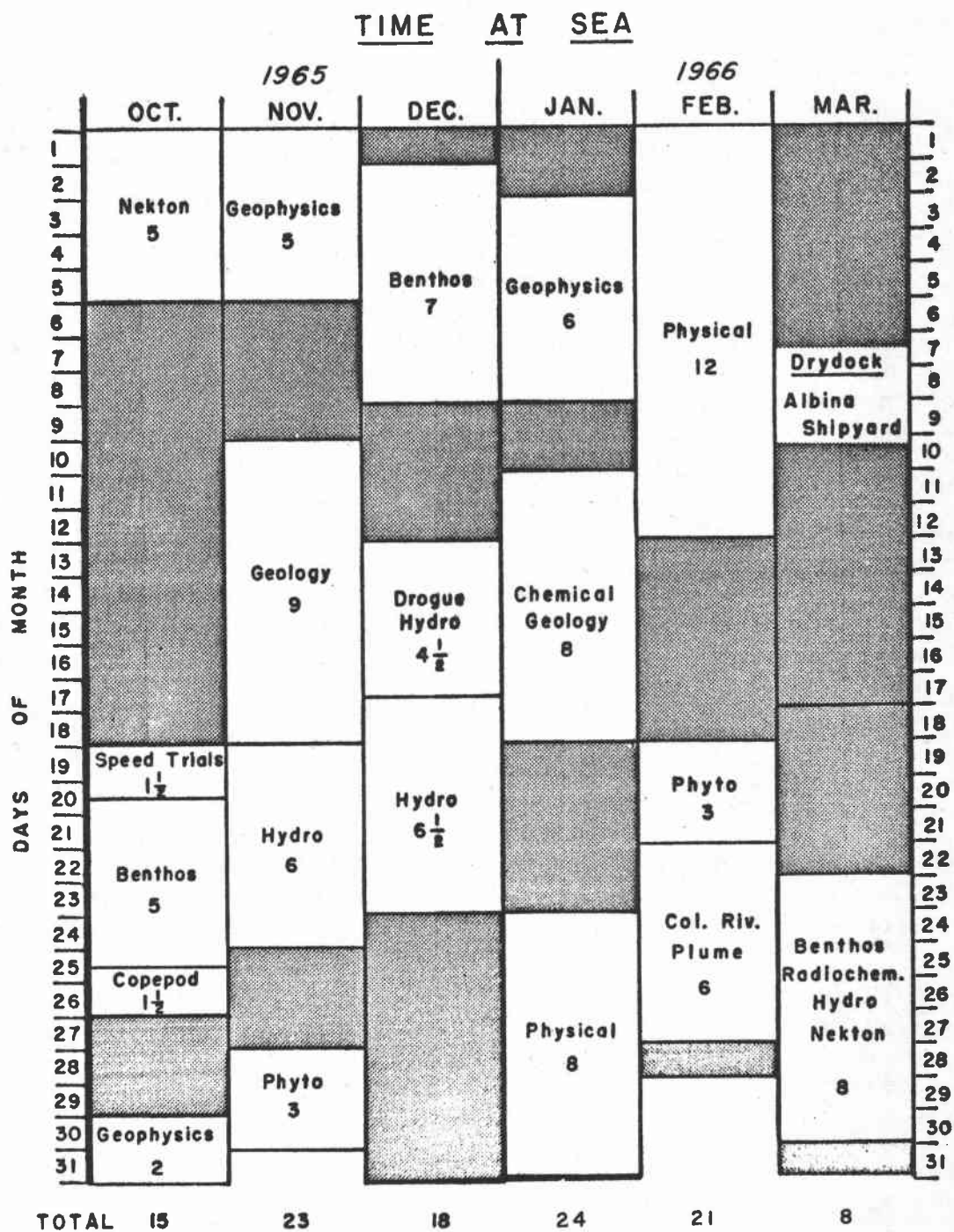


Figure 1. Time at sea, October 1965 - March 1966.

FACILITIES

Research Vessel YAQUINA

The YAQUINA has continued to operate at sea for an average of more than 20 days per month. She is being used for all types of marine research. Every effort is made to plan multiple-purpose cruises in order to make the maximum possible use of the vessel.

All ship scheduling is done by a committee consisting of a physical oceanographer, a biological oceanographer, and two operational personnel. Quarterly questionnaires are submitted to all staff members requesting a resumé of their anticipated ship needs. All active research programs are given consideration in drawing up the ship schedule.

In April 1966 the YAQUINA will embark on a 100-day cruise dubbed YALOC-66. The cruise will take her from Newport to Honolulu, Hawaii, where nearly two weeks will be spent in surveys connected with Project Mohole. She will then travel northward to Adak, Alaska, and return to Newport from there.

Figure 1 shows the time spent at sea during the report period.

Marine Science Center - Aquarium and Museum

Since the Marine Science Center was opened to the public on June 19, 1965, more than 33,000 visitors have been recorded through March 31, 1966. About a third of these visitors have signed the guest book, and addresses from 49 states and 20 foreign countries have been recorded. There have been many visits by school groups, some of them at hours when the tally was not kept. While most school groups have made advance arrangement for their visit, others have arrived without notice. Most of the school groups come from towns along the coast within 50 miles of Newport, but there have been groups from North Bend, Corvallis, and other inland towns. Grades from Kindergarten through high school have been represented. For the older groups, especially high school level, a motion picture on oceanography is shown. There have also been visits by Boy Scout groups and the Job Corps.

The meeting room has been frequently used by professional groups as well as various state boards and committees.

The visitor tally, by months from October 1 through March 31, is as follows:

October	1,482
November	1,284
December	603
January	1,599
February	1,763
March	3,152

During March, extensive renovations were started in the Center Aquarium. Mr. David Young successfully designed and built a set of temporary test filters for the Aquarium sea water lines, solving the problem of turbidity in the tanks, and maintaining the necessary non-toxic and low temperature conditions. Clear water made feasible for the first time the use of small aquaria to effectively display small fishes and invertebrates. Mr. Young has also constructed supports and filtered sea water supply lines for a new wall of small aquaria. These have been very popular with the visiting public.

Renovations of the displays in the large aquarium tanks were also completed during March, as new lines for filtered sea water were added. A new system of illuminated labels for the tanks was built. The stock of animals on display, depleted during the winter, has been greatly increased recently. This work continues in preparation for heavy summer visitor attendance.

During the spring Mr. Young will complete the final filter design and supervise the construction and installation of the new permanent filters along with sea water and air distribution lines. New walls of small aquaria are being planned, and Mr. Young will design and supervise the construction of these, also.

NEW STAFF

The following persons have accepted appointments with the Department of Oceanography for the fiscal year 1966-67:

Victor T. Neal, Assistant Professor of Physical Oceanography

George F. Beardsley, Jr., Assistant Professor of Physical Oceanography

Donald F. Heinrichs, Assistant Professor of Geophysical Oceanography

William O. Forster, Assistant Professor of Oceanography (Radioecology)

VISITING SCIENTISTS

- October
- Dr. Earl Doe, Bedford Institute of Oceanography, Canada
"The Oceanography Program at Bedford Institute of Oceanography, Dartmouth, Nova Scotia"
 - Dr. Claude E. ZoBell, Scripps Institution of Oceanography
"Some Microbial Aspects of the Marine Pollution Problem"
 - Dr. Carl W. Correns, Sedimentpetrographisches Institute, University of Gottingen, Germany
"Geochemistry of Sediments - Transportation of the Major Elements"
 - Dr. Earl Bronson, Marine Physical Laboratory, Scripps Institution of Oceanography
 - Dr. H. W. Menard, Scripps Institution of Oceanography
 - Dr. Mayumi Yamada, Zoological Institute, Hokkaido University, Sapporo, Japan
 - Dr. William Graf, Department of Biology, San Jose State College
- November
- Dr. Allegra A. Genest, Cordia Corporation, Miami, Florida
"Vitamin A and Vision"
 - Dr. George Humphrey, Division of Fisheries and Oceanography, C. S. I. R. O., Cronulla, New South Wales, Australia
"Oceanographic Programs in Australia"
 - Mr. D. E. Cartwright, National Institute of Oceanography, England
"Linear and Non-Linear Analysis of Tides and Surges"
 - Dr. Robert R. Rofen, Aquatic Research Institute, Stockton, California
 - Dr. Francis G. Gilchrist, Lewis and Clark College, Portland, Oregon
- December
- Dr. Tai Soo Park, Friday Harbor Laboratory, University of Washington
- January
- National Science Foundation Advisory Panel for Oceanographic Facilities
 - Dr. Joe S. Creager, NSF Program Director for Oceanography
 - Miss Mary Johrde, Assistant Director for Facilities and Special Programs
 - Dr. Eugenie Clark, Director of Cape Haze Marine Laboratory, Placida, Florida
 - Mr. Russell Thornberg, Vice-President in charge of engineering and construction, Global Marine, Inc.
 - Dr. John Lyman, Coordinator for the Bureau of Commercial Fisheries of the Fish and Wildlife Service
 - Mr. Donald F. Heinrichs, Stanford University
"Paleomagnetism"
 - Dr. J. A. Jacobs, University of British Columbia
"The Thermal History of the Earth"
 - Dr. John W. Winchester, Massachusetts Institute of Technology
"Halogens in the Marine Atmosphere"

Dr. Eduard Berg, Geophysical Institute, University of Alaska
 "Triggering by Low Ocean Tide Load of the Alaska Earth-
 quake of March 28, 1964, and Major Aftershocks"

Dr. R. E. MacDougall, Chief of Exploration Services, Kennicott
 Copper Corporation
 "The Changing Scope of Mining Geophysics"

Dr. Richard L. Miller, Biology Division, Cal-Tech, Pasadena

Dr. Ralph G. Johnson, University of Chicago

Dr. William R. Holland, Scripps Institution of Oceanography

Mr. G. Clifford Carl, Provincial Museum, Victoria, B. C.

Mr. J. F. L. Hart, Victoria, B. C.

March

Dr. Lars G. Sillen, Department of Inorganic Chemistry, Royal
Institute of Technology, Stockholm, Sweden
"An Inorganic Chemist Looks at the Ocean and its History"
Dr. Daniel Mazia, University of California, Berkeley
Dr. R. L. Fernald, University of Washington
Mr. Peter W. Frank, Eugene, Oregon

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- Pearcy, W. G. and C. A. Forss. Depth distribution of oceanic shrimps off Oregon. J. Fish. Res. Bd. Canada (in press).
- Pytkowicz, R. M. and D. R. Kester. Oxygen and phosphate as indicators for the deep-intermediate waters in the Northeast Pacific Ocean. Deep Sea Res. (in press).
- Pytkowicz, R. M., I. W. Duedall, and D. N. Connors. Magnesium ion activity in sea water. Science (in press).

- Pytkowicz, R. M., D. R. Kester, and B. C. Burgener. Reproducibility of pH measurements in sea water. *Limnol. and Oceanog.* (in press).
- Robison, S. M. and R. Y. Morita. The effect of moderate temperature on the respiration and viability of Vibrio marinus. *Z. Allge. Microbiology.*
- Small, L. F. Photosynthesis. *Encyclopedia of Earth Sciences* (in press).
- Thiruvathukal, J. V. and J. W. Berg, Jr. Gravity measurements and their meaning. *The Ore Bin* (in press).
- Trembly, L. D. and J. W. Berg, Jr. Amplitudes and energies of primary seismic waves near the Hardhat, Haymaker, and Shoal nuclear explosions. *Bull. Seismol. Soc. Amer.* (in press).
- Weyl, P. K. Environmental stability of the earth's surface. *Geochimica et Cosmochimica Acta.*
- Weyl, P. K. The role of the oceans in climatic change: a theory of the Ice Age. *Meteorological Monographs.*

Papers Presented at Scientific Meetings

- Berg, J. W., Jr. Exploring the earth with seismic waves (invitational).
Pacific Northwest Region, American Geophysical Union, Portland,
Oregon, October 1965.
- Berg, J. W., Jr. and L. T. Long. Character of refracted arrivals.
Pacific Northwest Region, American Geophysical Union, Portland,
Oregon, October 1965.
- Berg, Joseph W. AGU Visiting Scientist Lecture Tour, North Carolina,
Florida, New Jersey, New York, New Hampshire, Delaware.
December 1965.
- Byrne, J. V. and N. J. Maloney. Textural Trends of Continental
Margin Sediments Off the Central Coast of Oregon. Ann. Mtg.
Geol. Soc. Amer., Kansas City, November 1965.
- Byrne, J. V., L. D. Kulm, and N. J. Maloney. Textural Trends of
Recent Sediments from River to Abyssal Plain off Oregon. Soc.
Econ. Paleon. and Min., Pacific Section, Long Beach, California,
March, 1966.
- Dehlinger, P. Oregon State University gravity measurements in the
Pacific Ocean. Soc. of Exploration Geophys., Dallas, Texas,
November 1965.
- Dehlinger, P. Marine geophysics at OSU. Pacific Northwest Oceanog-
raphers Meeting, Vancouver, B. C., February 1966.
- Fowler, Gerald A. Stratigraphy of the Montesano Formation, Wash-
ington. Presented at Pacific Section Meeting American Assoc.
of Petrol. Geol. - Soc. Econ. Paleon. and Mineral., March 1966,
Long Beach, California.
- Hedgpeth, Joel W. NSF Panel Systematic Biology, Washington, D. C.,
November 4-6.
- December 27 - Organized and presided over symposium on Pacific
Coast Estuary and bay problems at AAAS Meeting
in Berkeley, California.
- December 28 - Presented paper on problems of systematic biology
to Symposium arranged by Society Systematic
Zoology, AAAS meetings, Berkeley.
- January 21 - NSF meeting in Washington, D. C. for Directors
of RPTT program.
- February 5 - Addressed Oregon Marine Biological Society at
Corvallis on RPTT program.

- February 9 - Gave seminar to Fisheries Department on bottom communities.
- February 11 - Gave seminar at Department of Zoology, University of Washington, Seattle, on history of marine biology.
- February 14 - Same seminar, Department of Zoology, Corvallis.
- February 22-23 - ONR Advisory Panel on Marine Biology, Washington, D. C.
- February 24-25 - NSF Advisory Panel on Systematic Biology, Washington, D. C.
- March 26 - Addressed Oregon Biology Teacher's meeting at Milwaukie on RPTT.
- Kulm, L. D. The influence of Cascadia Channel on Abyssal Sedimentation. Soc. Econ. Paleon. and Mineral., Pacific Section, Long Beach, California, March 1966.
- Morita, R. Y. Discussion Leader and participant in the 4th meetings on marine biology entitled "Unresolved problems in marine bacteriology". January 9 to 12, 1966. Princeton, N. J. (see Science 152: 108- (1966).)
- Morita, R. Y. Participant, Environmental Extremes Conference, 10-11 February, 1966. San Diego, California.
- Park, Kilho. "On the alkalinity of Columbia River and Columbia River Plume", Department of Oceanography, University of Washington, Seattle, Washington, November 1965.
- Park, Kilho. "Effects of Biogeochemical Processes on the Electrolytic Conductance of Sea Water", Institute of Marine Science, University of Alaska, College, Alaska, November 1965.
- Pearcy, William G. "Biological Oceanography at Oregon State University", Pacific Northwest Oceanographers Meeting, Vancouver, B. C., February 1966.
- Thiruvathukal, J. V. and J. W. Berg, Jr. Gravity measurements in Oregon, Pacific Northwest Region, American Geophysical Union, Portland, Oregon, October 1965.

Trembly, L. D. and J. W. Berg, Jr. Amplitudes and energies of primary seismic waves near Hardhat, Shoal, and Haymaker nuclear explosions, Pacific Northwest Region, American Geophysical Union, Portland, Oregon, October 1965.

Weyl, Peter K. "Physical Chemistry of Sea Water," Hanford, Washington, January 1966.

Weyl, Peter K. "The Oceans and Climatic Change," Lamont Geological Observatory, March 1966.