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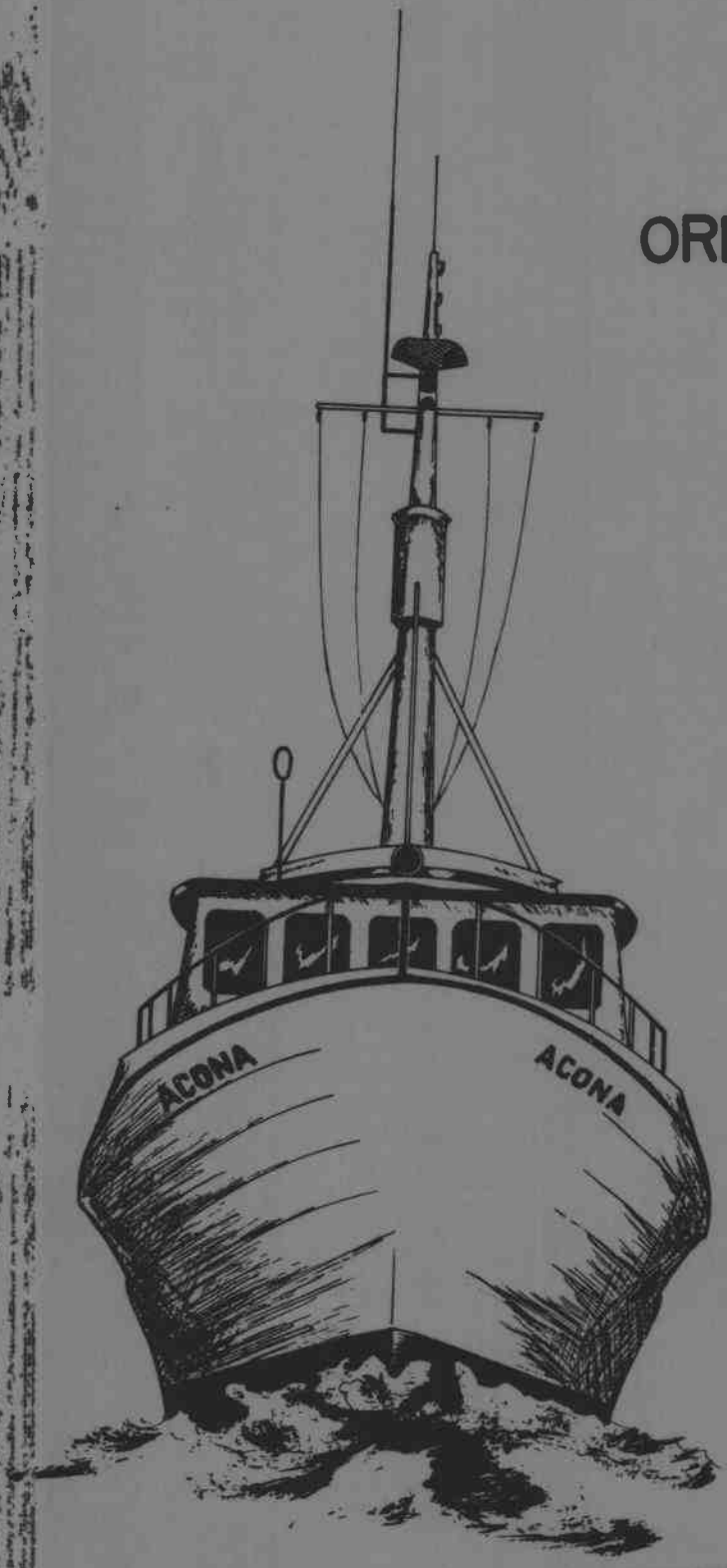

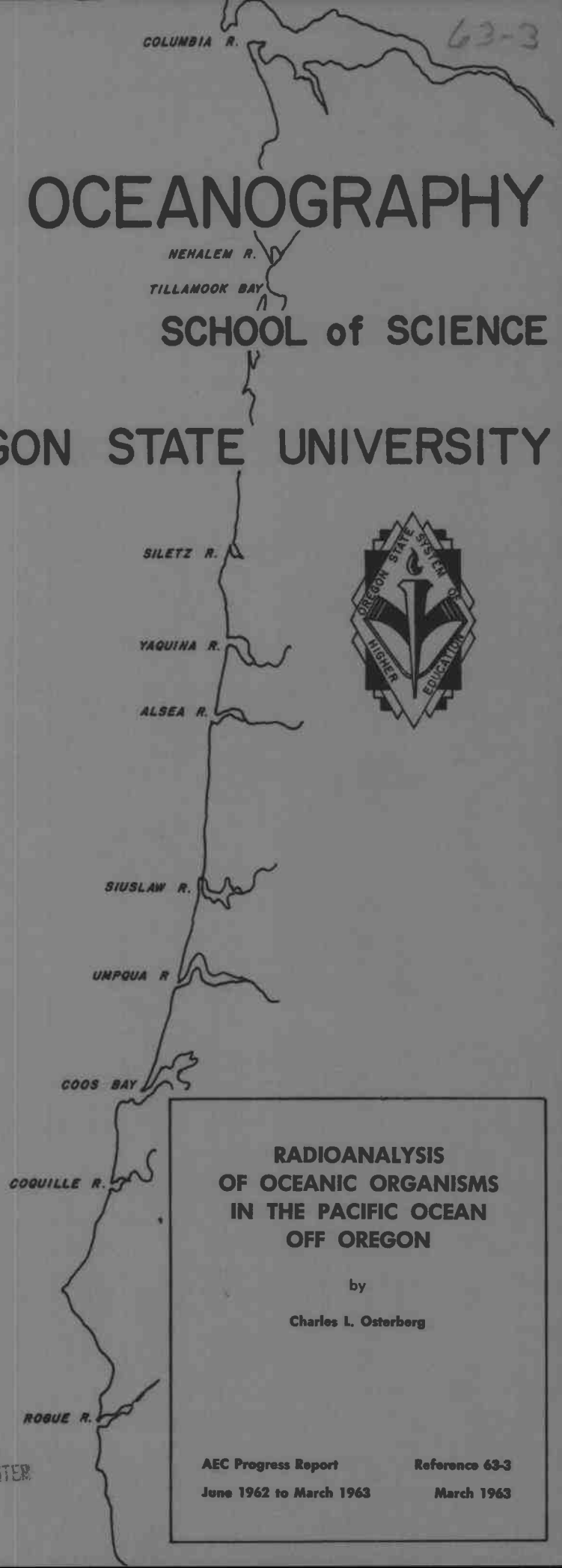

RADIOANALYSIS OF OCEANIC ORGANISMS IN THE PACIFIC OCEAN OFF OREGON

by

Charles L. Osterberg

AEC Progress Report
June 1962 to March 1963

Reference 63-3
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1 June 1962 through 28 February 1963

Submitted to the

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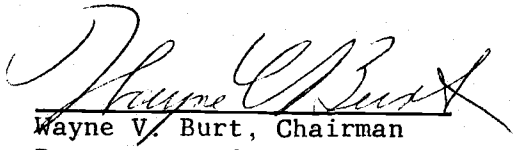


Wayne V. Burt, Chairman
Department of Oceanography

Reference 63-3
March 1963

RADIOANALYSIS OF OCEANIC ORGANISMS IN THE PACIFIC OCEAN OFF OREGON

INTRODUCTION

Our major effort since initiation of this contract has been directed toward (1) procuring the gamma-ray spectrometric equipment and integrating the components into an operational system, and (2) analyzing the samples obtained from the midwater trawl program of the Department of Oceanography and evaluating and interpreting the resulting data Analyses of samples at Hanford Laboratories were made possible through an agreement with the Atomic Energy Commission and General Electric Company.

EQUIPMENT

We have received a Nuclear Data Model 130A (512 channels) spectrometer and auxiliary equipment including an IBM typewriter readout, Talley paper tape readout, and an oscilloscope for visual presentation. Data on punched tape can be read into the instrument by the Talley reader. This permits storage of spectra and/or spectrum "stripping."

The principal detector is a specially constructed 5" x 5" Harshaw NaI(Tl) crystal with 3/4" x 3" well (15 cc) mounted with its phototube in a low-background assembly. Samples (13 cc) are inserted in the well for analysis. A four-inch thick lead pig (16" x 16" x 30"), weighing about two tons, shields the crystal. A one-inch bismuth (99.999% pure) inner shield, which will enclose the crystal and further reduce the background (Crouthamel, p. 83, 1960), has been designed and is being fabricated. The second detector is a 3" x 3" Harshaw NaI(Tl) crystal with low-background assembly, as above. This solid crystal is "surrounded" by the sample, which is placed in a one-liter Marinelli beaker, calibrated for 500 ml and one-liter samples. A larger Marinelli beaker will be used for two-liter samples. Shielding is a four-inch thick (30" x 30" x 36") lead pig, weighing about five tons. The large cave serves two purposes: its size permits analyses of large samples and reduces back scatter. (Back scatter is no problem with the 5" x 5" detector because of the internal samples--i.e., in the well). Both lead pigs have six-inch thick lead doors.

The detectors can be used simultaneously by means of an ND 500 dual-channel amplifier. High voltage to the photomultipliers is supplied by a John Fluke Model 412 Power Supply, with individual adjustment to each tube permitted by a Hamner dual-channel voltage divider.

Qualitative analyses have been carried out with both detectors, and results are encouraging. Calibration for quantitative analysis is proceeding.

The equipment purchased is different from the equipment specified in our original proposal. The cost of an anticoincidence detector was considerably more than we had estimated, and we therefore looked for equipment that would do our job but would be within our budget. Talks with R. W. Perkins, Hanford Laboratories, Dr. Theodore Folsom, Scripps Institution of Oceanography, and Dr. Allyn Seymour, University of Washington, led to the detector arrangement described herein.

SAMPLE ANALYSIS

Much of the research carried out under this contract is an extension of a thesis problem. Gamma-ray spectrometry for this study was carried out at Hanford, Washington, under an agreement involving the Graduate School of Oregon State University, the General Electric Company and the Atomic Energy Commission, Richland, Washington. After the Ph.D. program was completed, we requested permission to continue using Hanford facilities until the ND 130A spectrometer in Corvallis was calibrated. The spectrographic equipment under the supervision of Mr. R. W. Perkins was made available and we were able to continue the program without interruption. Ken Englund (AEC) and his staff assisted with the necessary arrangements.

PAPERS PREPARED

Using the counting facilities at Hanford, it has been possible to complete a number of analyses and to present the results in papers for publication. Some of the work was completed prior to receipt of this contract, but the following abstracts all describe research closely related to the work now being carried out under AEC sponsorship.

Zn^{65} Content of Salps and Euphausiids (Reprint appended)

Salps and euphausiids some distance offshore were shown to concentrate zinc-65. Although this isotope is present in fallout, the quantities present in marine plankton off Oregon indicate that the Columbia River is the principal source (Osterberg, 1962a).

Fallout Radionuclides in Euphausiids (Reprint appended)

Euphausiids, which are filter feeders, concentrate particulate fission products and sometimes show high concentrations of zirconium-95, niobium-95 and cerium-141. A series of observations made off the Oregon coast in November 1961 showed the presence of a "hot spot" of fallout radioactivity in euphausiids collected 45 miles off Astoria, where a maximum of 618 picocuries of Zr^{95}—Nb^{95} per gram dry weight of euphausiid was recorded. Later observations indicated a gradual diffusion of the "hot spot" (Osterberg, 1962b).

Gamma Emitters in Marine Sediments near the Columbia River (Reprint appended)

Samples from sediment cores collected at 26 different locations 5 to 35 miles offshore in and around Astoria Submarine Canyon were analyzed for gamma emitters. Chromium-51 and Zn^{65} were the principal isotopes found, although several fission products and natural potassium-40 were also present. Radioactivity fell off sharply with distance from the mouth of the Columbia River, indicating that the river serves as a common source of the artificial radionuclides (Osterberg, et al , 1963b).

Radioactivity in Large Marine Plankton as a Function of Surface Area

Our studies of oceanic organisms collected off Oregon indicated the presence of both fission products and neutron-induced radionuclides and an abundance of plankton with considerable distribution in size. This information led us to a study to determine whether the specific activity (per gram dry weight) would increase for organisms having greater surface area per unit weight, as would be expected if adsorption is an important means of uptake. Comparisons were made between small euphausiids and large euphausiids, between euphausiids and copepods, and between the "nuclei" (digestive apparatus) and the exterior body of salps. Six gamma emitters were counted for the three cases. We concluded that surface adsorption is not an important factor in uptake of these gamma emitters, except possibly Cr^{51} (Osterberg, et al., 1963 c).

Radioactivity and its Relationship to Oceanic Food Chains

The gamma-ray spectra of a variety of marine zooplankton and nekton and of filterable particles, representing several trophic levels, were prepared from organisms taken from the ocean off the Oregon coast. These samples had been exposed to radioactivity in their environment, both from fission products from fallout and neutron-induced radionuclides from the Columbia River. Comparisons of the spectra of organisms from different trophic levels, as determined by stomach contents, suggest that Zr^{96} - Nb^{95} and Ce^{141} are concentrated

at the first and second trophic levels (primary producers and herbivores) but are not concentrated at higher levels (carnivores). Chromium-51 was abundant only in filtered samples (trophic level I). Manganese-54, cobalt-60, and cesium-137 were found only at higher trophic levels. Zinc-65, however, was found in every marine organism examined, regardless of trophic level (Osterberg, et al., in press).

Seasonal and Geographic Variations of Zn^{65} from the Columbia River in Euphausiids from the Oregon Coast

Most of the Zn^{65} in the northeast Pacific Ocean originates in the Columbia River as a result of the nuclear reactor operations at Hanford. Seasonal changes in the amount of Zn^{65} in euphausiids were compared to seasonal changes in the salinity distribution off the Oregon coast, where the euphausiids were collected. Some correlations are apparent, although seasonal changes in Zn^{65} in euphausiids are small and the level remains fairly high, even in organisms not collected from the low salinity plume of the Columbia River. This seems to indicate that either the radioactivity in the water built up off Oregon when the plume is present remains after the plume has vanished, or that the levels of Zn^{65} remain high in euphausiids because of the long biological half-life of this isotope (Osterberg, et al., in preparation).

NEW STUDIES

Gamma Emitters in Natural Waters

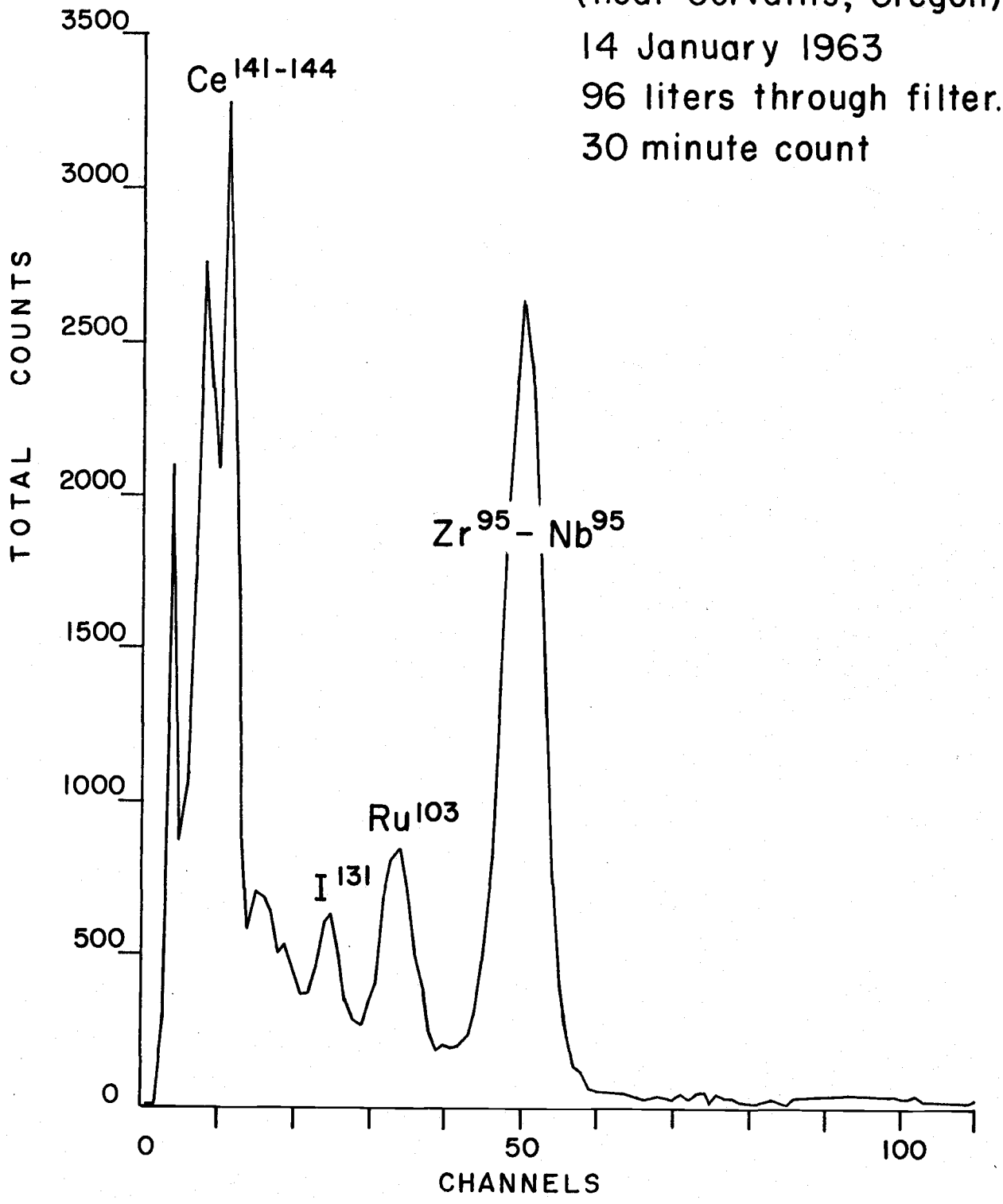
From the study of gamma emitters in marine sediments, it was learned that radionuclides from fallout as well as neutron-induced radionuclides were concentrated near the mouth of the Columbia River. Therefore, a study of the radionuclides in Oregon rivers was begun to determine the role played by these rivers in the transport of radioactivity into the sea. Measurable quantities of Zr^{95}—Nb^{95}, ruthenium-103, and Ce^{141} were detected. The spectra from some stations on the Willamette River showed a peak which appears to be iodine-131. Decay studies should make verification possible (see Figure 1).

The Columbia River has been sampled on three occasions, mostly to perfect our techniques and field collecting gear. Studies of Columbia River water have been made using filtration techniques, cation resins, anion resins, and chelating resins. These will be tested at sea in the near future. Dr. Park and Dr. Curl are assisting in the planning of these experiments.

A rain collector has been built and placed on the roof of our building so that we can compare the ratio of radionuclides in the rain, the rivers, and the ocean. Our tests of a recent snowfall (30 January 1963) showed large peaks in the spectra due to fission products (Figure 2).

Figure 1

Willamette River
Buena Vista Ferry
(near Corvallis, Oregon)
14 January 1963
96 liters through filter.
30 minute count



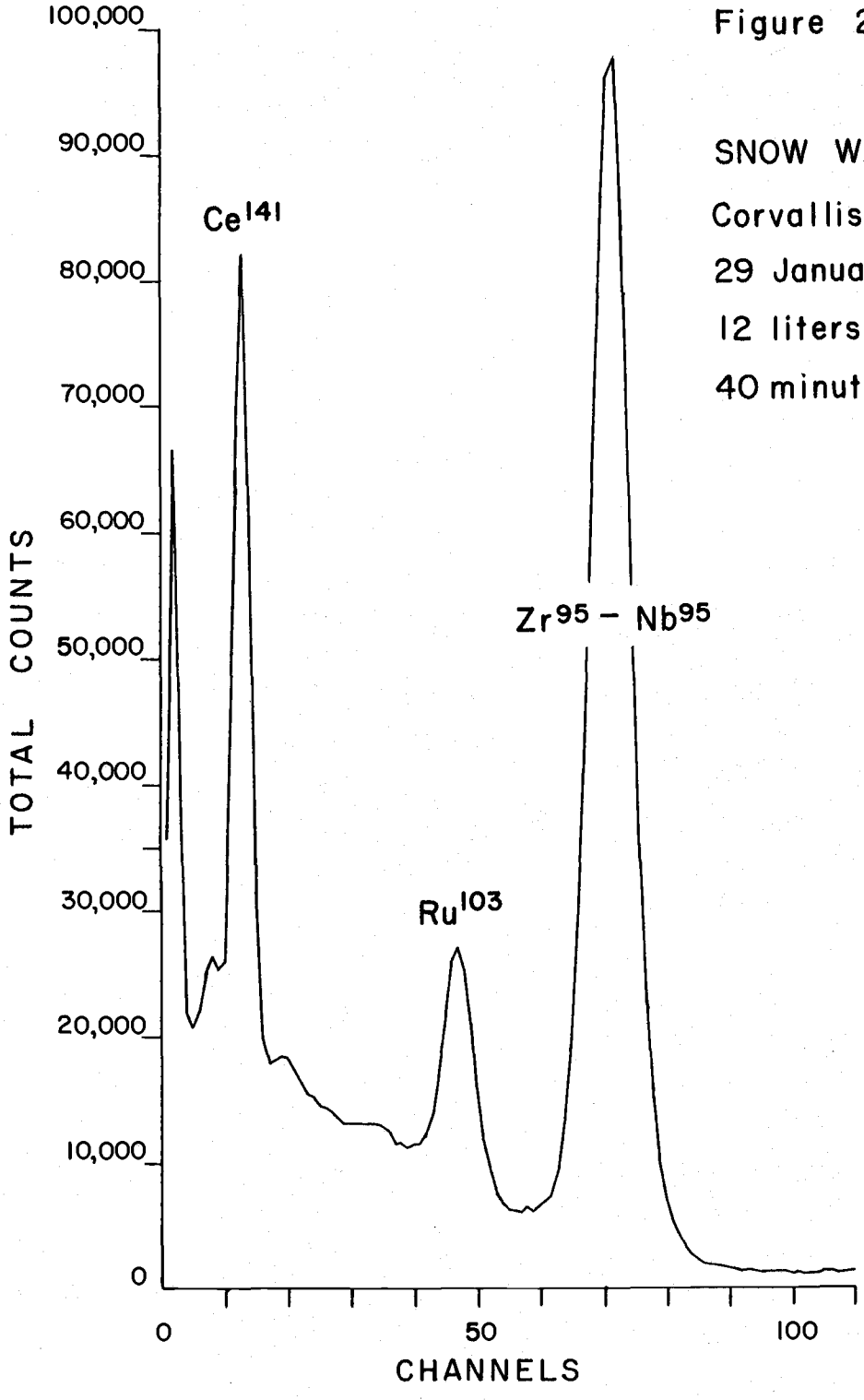


Figure 2

SNOW WATER

Corvallis, Oregon

29 January 1963

12 liters through filter.

40 minute count.

Trace Element Studies

Arrangements have been made to do trial activation analysis work on an ashed sample of Euphausia pacifica using the reactor facilities at Hanford. Our first test of this sensitive method of trace element analysis was carried out in late February. Gamma spectrometry will be used to measure the gamma emitters with long half-life, after there has been sufficient time for the decay of radionuclides with short half-lives.

A second sample of freeze-dried (but not ashed) euphausiids has been sent to Dr. Harold Dodgen, Washington State University, for irradiation in the "swimming pool" reactor. The initial test at Hanford indicated that a lower neutron flux would be sufficient. The WSU facility operates at a much lower temperature than the Hanford reactor, eliminating some of the expensive operations (such as sealing the sample in quartz). Security problems, of course, are eliminated by using a reactor on a university campus.

Radioanalyses of Arctic Specimens

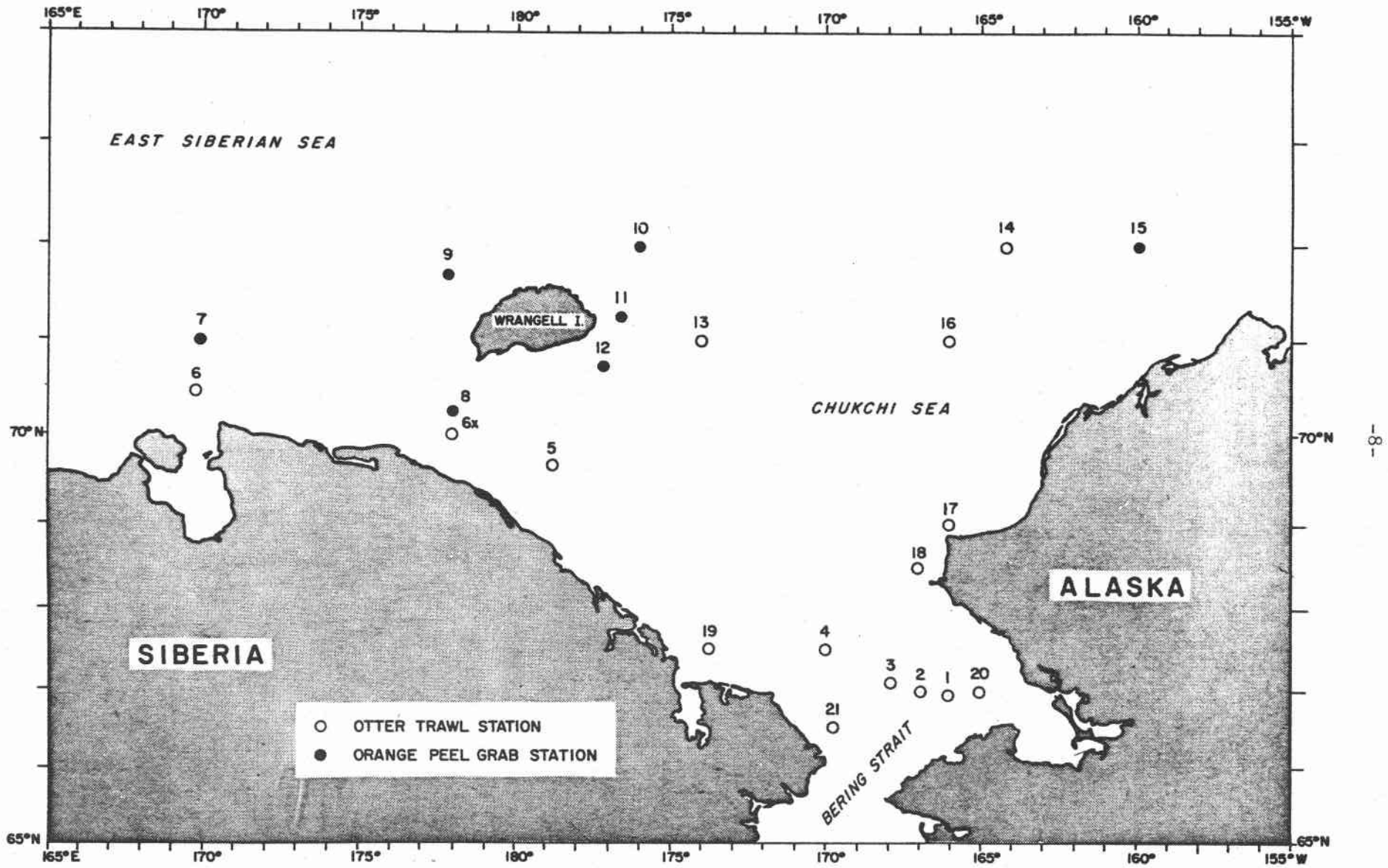
Radioanalyses of material collected by Dr. James McCauley, Department of Oceanography, OSU, on a cruise in the Arctic have been completed. Spectra of animals taken in biological tows by the NORTHWIND show peaks, due principally to fallout. At the four stations listed below (see Figure 3), where sufficient quantities of Eualis gaimardii belcheri were collected, the shrimp was found to contain fission products, with Zr^{95}—Nb^{95} most abundant.

STATION	PICOCURIES ZR^{95} -NB^{95}/GRAM ASH OF SHRIMP
2	7.5 ± 1.2
17	5.9 ± 0.5
18	20.4 ± 0.7
19	12.4 ± 0.6

The sessile tunicate Boltenia echinata from Station 17 contained 19.3 picocuries of Zr^{95}- Nb^{95}. This tunicate also contained more Ce^{141} and Ru^{103} than any of the other animals examined.

Zn^{65} was present in trace amounts. The spectrum of the tom cod, Boregadus saida showed a small but distinct peak of Zn^{65}.

Since none of these organisms have been taken off Oregon, direct comparisons of the radioactivity are not possible. Closely related species from off Oregon certainly have much higher levels of Zn^{65} (Osterberg 1962a; Osterberg 1963a), and much higher values of fission products have also been reported in euphausiids from the Oregon area (Osterberg 1962b).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CHUKCHI SEA
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Figure 3.

PAPERS PRESENTED AND MEETINGS ATTENDED

The results of the radioanalysis of material collected in the Arctic were presented by I. Lauren Larsen, Assistant in Oceanography, at the February meeting of the Oregon Academy of Science in Corvallis. The title of this paper was "Gamma-ray analyses of marine arctic specimens." Dr. Osterberg presented a paper, "The effluent of the Columbia River as a source of radioactivity" at the November meeting of the American Geophysical Union in Seattle. An abstract, which will be printed in the AGU abstracts, follows.

Abstract

The presence of relatively large equilibrium values of chromium-51 and zinc-65, introduced into the Pacific Ocean as a result of the nuclear reactors at Hanford, Washington, has been used to carry out several studies.

The level of zinc-65 in the ocean off the Oregon coast, as measured by radioanalyses of euphausiids, has been followed for more than a year. The data show that Zn^{65} is present in this part of the ocean during all seasons, but is somewhat influenced by the location of the Columbia River plume in that the highest levels off southern Oregon occur in the summertime. The maximum value, 150 picocuries/gram dry weight of euphausiid, was found in the springtime (1962) 15 miles off the mouth of the Columbia River. The minimum, about 4 picocuries/gram, was found in euphausiids from off Coos Bay in January 1962.

Zn^{65} and the fission products have been followed through several trophic levels. Although the fission products zirconium-95—niobium-95, ruthenium-103, and cerium-141 are present at the first and second trophic levels, they are discriminated against by predaceous animals. Zn^{65}, however, has been found at all marine trophic levels. Chromium-51 was only abundant at the first trophic level, as measured on membrane filters through which sea water had been passed.

Euphausiids, which are second trophic level filter feeders, have been found to be excellent concentrators of most radioisotopes. Because of their great numbers, their use as forage by many marine organisms, and their diurnal vertical migrations, they may prove to be important agents in the vertical transport of radionuclides in the sea.

Dr. Osterberg discussed "Radioactivity in Plankton" and the role of Oregon State University in this study at a round-table discussion in Victoria, British Columbia, at the annual meeting of the Pacific Northwest Oceanographers in February.

Dr. Burt and Dr. Osterberg attended a meeting of the Columbia River working committee in Richland, Washington, in September 1962. Dr. Osterberg was also present at the January 1963 meeting of the same committee. These meetings were sponsored by the AEC and were to coordinate work on the Columbia River.

DEGREE COMPLETED

Dr. Osterberg completed requirements for the Ph.D. degree in October 1962.

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