DEPARTMENT OF OCEANOGRAPHY
UNIVERSITY OF WASHINGTON

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Nos. 214, 215, 216, 217, 218, 219, and 220

A COMPILATION OF ARTICLES REPORTING RESEARCH

SPONSORED JOINTLY BY

THE U.S. ATOMIC ENERGY COMMISSION

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THE OFFICE OF NAVAL RESEARCH

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RICHARD H. FLEMING
Chairman

CLIFFORD A. BARNES
Principal Investigator

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Technical Report No. 214

SERGESTES SIMILIS HANSEN AND *S. CONSOBRINUS* N. SP. (DECAPODA) FROM THE NORTHEASTERN PACIFIC, by Darrelyn S. Milne. Crustaceana *14*(1):21-34. 1968.

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SONAR REFLECTION PROFILING ON THE COLUMBIA RIVER AND IN LAKE WASHINGTON, by C. R. B. Lister, John T. Whetten, and Bates McKee. Northwest Science *41*(4):152-154. 1967.

Technical Report No. 216

DISTRIBUTION AND MOVEMENT OF RADIOACTIVE CONTINENTAL SHELF SEDIMENT, NORTHWESTERN UNITED STATES, by M. Grant Gross. Collected Preprints of the International Sedimentological Congress. 4 p. 1967.

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CONTINENTAL SHELF SEDIMENT, NORTHWESTERN UNITED STATES, by M. G. Gross, D. A. McManus, and H-Y Ling. Journal of Sedimentary Petrology *37*(3): 790-795. 1967.

Technical Report No. 218

MAZAMA ASH FROM THE CONTINENTAL SLOPE OFF WASHINGTON, by Chester F. Royce, Jr. Northwest Science *41*(3):103-109. 1967.

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A DEVICE FOR RELEASING A PISTON CORER AND DEACTIVATING THE PISTON, by James L. Woodruff. Deep-Sea Research *14*:309-310. 1967.

Technical Report No. 220

SINKING RATES OF RADIOACTIVE FALLOUT PARTICLES IN THE NORTH EAST PACIFIC OCEAN, 1961-62, by M. Grant Gross. Nature *216*(5116):670-672. 1967.

DISTRIBUTION AND MOVEMENT OF RADIOACTIVE CONTINENTAL SHELF SEDIMENT, NORTHWESTERN UNITED STATES

M.Grant Gross, Department of Oceanography, University of Washington, Seattle, Washington, USA.
and Division of Sedimentology, U.S. National Museum, Washington, D.C., USA.

Man's increasing release of radioactivity to the environment affords new opoortunities for studying the movement and deposition of newly deposited sediment. For example, certain radioactive elements with short half-lives may be used to identify recently deposited material, supplementing other more traditional techniques. Perhaps most important, the radioactivity in some instances is a useful time-dependent parameter, providing information about the rate of sediment movement.

This paper reviews the results of studies made from 1961 to 1963 on the radioactivity of sediment from the Continental Shelf near the Columbia River. This area has received more radioactive effluent over a longer period of time than any other portion of the United States and probably anywhere in the world (MAUCHLINE, Jr., TEMPLETON, W.L., 1964. In BARNES,H. (Editor). Oceanography and Marine Biology, Annual Review, v2, George Allen and Unwin Ltd., London, p. 239).

When sampled, the sediments contained radioactivity from three sources: naturally occurring radionuclides; radioactive fallout, primarily fission products, from atmospheric testing of nuclear devices; and radionuclides released to the environment by the Hanford Atomic Operations of the U.S. Atomic Energy Commission. Of the naturally occurring radionuclides, only K^{40} and Bi^{214} (decay product of Ra^{226}) were identified. Neither of these nuclides is useful for determining sediment movement or deposition in this environment and the data will not be discussed here.

After atmospheric testing of nuclear devices began in late1961, radioactive fallout was deposited over the area. Some fallout was deposited directly onto the ocean surface and virtually all the Continental Shelf sediments analyzed contained Zr^{95}-Nb^{95}, Re^{106} and Ce^{144}. Much of the fallout, however, was initially deposited on the land and when brought into the ocean was apparently associated with sedimentary particles. This material, deposited in part near the Columbia River and the mouths of the smaller rivers discharging into Willapa Bay, caused local maxima of fission products in the sediment. Because of the complicated mode of injection, the distribution of these radionuclides has not been exploited fully in sediment studies in this area.

The Hanford Atomic Products Operation at Richland, Washington is a major source of radioactivity to the environment and provided a quasi-steady state input for several nuclides during the period of this study (WILSON, R.H. (Editor) Evaluation of radiological conditions in the vicinity of Hanford for 1963. AEC Res. Develop. Rept. No. HW.80991. Office of Technical Services, Dept. of Commerce, Washington, D.C.; PERKINS, R.W. et al. 1966. Limnol. Oceanogr., 11, 235). The radioactivity released is due primarily to neutron activation of materials dissolved in the reactor cooling waters and to the corrosion products from the reactors.

For certain nuclides, such as Cr^{51} (half-life 28 days), the Columbia River is the only source. Although present in large quantities, Cr^{51} is not overly useful for sediment studies, because it tends to remain in the water (FOSTER, R.F. 1963. In SCHULTZ, V., KLEMENT, A.W., Jr. (Editors). Radioecology, Reinhold, New York). A small amount of Cr^{51} is deposited with the sediment in the river and in the adjacent ocean (GROSS, M.G. 1966. J. geophys. Res., 71, 2017).

For other nuclides, such as Zn^{65} and Co^{60}, the Columbia River is the major source. Both Zn^{65} and Co^{60} are primarily associated with riverborne particulate matter (PERKINS, R.W. et al. 1966. Limnol. Oceanogr. 11, 235). Thus these nuclides are especially useful for sediment studies.

The areas covered by recently deposited Columbia River sediment can be delineated using the distribution of radioactivity in the surface layer (approximately 1 cm thick) of more than 200 sediment samples collected during August 1963 (Figure 1). The data indicate that radioactive sediment is deposited on the Continental Shelf within approximately 30 km of the river mouth and extending northward early 70 km from the river mouth. Zn^{65} was not detected in sediment near the edge of the Continental Shelf or near the Oregon coast south of the river mouth. Apparently these areas presently receive little or no radioactive Columbia River sediment. This is consistent with the conclusions based on the distribution of other sediment properties that the Continental Shelf edge in this region is largely covered with relict sediment deposited during a previous sedimentary regime (GROSS, M. G. et al. this congress).

The distribution of sediment containing Cr^{51} and Co^{60} is generally similar to that of Zn^{65}, showing deposition near the river mouth of Columbia River sediment and northward movement along the Continental Shelf.(GROSS, M.G. 1966. J. geophys. Res, 71, 2017). Each nuclide is distributed somewhat differently because of the variations in the mode of association with the sediment and probably the type and size of particles involved.

The activity of Zn^{65} and Co^{60} decreases away from the river mouth. One can use this to estimate the rate of movement by assuming that little or no Zn^{65} and Co^{60} is added to the sediment after leaving the river, and that the changes in activity are due to radioactive decay during the time the particle is moving from the river mouth to the sampling site. Based on the Zn^{65} activities, the sediment appears to move 20-25 Km/yr parallel to the coast and 12 km/yr westward away from the coast. Based on the Co^{60} activity, the apparent rate of movement is 12 km/yr parallel to the coast and 2.5 km/yr westward away from the coast.

Such a simple calculation ignores the probable mixing of radioactive sediment with older, possibly nonradioactive sediment, which diminishes the activity of each nuclide in the surface sediment. As a result the estimated time is increased. Consequently the estimates based on the activity of a single nuclide probably give the minimum rate of sediment movement.

It is possible to eliminate the effect of mixing with older sediment by using the activity ratio of two sediment-associated nuclides as the time-dependent parameter. The ratio is unchanged by mixing with radioactive sediment whereas the activities of the individual nuclides are diminished. Such a calculation, using Zn^{65} and Co^{60} requires that the two nuclides be supplied to the river in relatively constant proportions for several years proceeding the sample collection and that the activity ratio of the riverborne particulate matter be relatively constant when it enters the ocean. The available data suggest that these requirements are reasonably well satisfied (GROSS, M.G., NELSON, J.L. 1966. Science, 153).

The ratio ($A_{Zn}65/A_{Co}60$) of the surface sediment is greatest near the river mouth and decreases with increasing distance from the river (Figure 2). The changes in the ratio (half-period approximately 280 days) indicate an apparent rate of sediment movement of approximately 30 km/yr parallel to the coast and 10 km/yr away from the coast.

Near the river mouth the activities of Zn^{65} and Co^{60} decrease markedly within a short distance although there is little or no change in the activity ratio ($\underline{A}_{Zn}65/\underline{A}_{Co}60$). This suggests that the recently deposited, radioactive sediment mixes with two or three equal volumes of older non-radioactive sediment in less than two months. Similar calculations suggest that the radioactive surface sediment farthest from the river (Figure 2) has mixed with 15 equal volumes of non-radioactive sediment within approximately two years.

There is no evidence of a progress change in the abundance of clay- or silt-sized material, organic matter or other sediment properties that would cause the observed variations in radioactivity. The muddy sands having both Zn^{65} and Co^{60} contain more than 30% silt- and clay-sized particles and more than 0.5% organic carbon.

The results of these studies do not indicate whether the entire sediment mass is moving at these rates or only certain size fractions. Much of the radioactivity on sediment in the river is associated with clay- and silt-sized fractions (NELSON, J.L. et al. 1966. Symposium on Disposal of Radioactive Wastes into Seas, Oceans and Surface Waters. 16-20 May 1966, International Atomic Energy Agency, Vienna); this also appears to be true for the marine sediment near the Columbia River mouth. Thus, it is conceivable that the variations in the activity ratio result from the movement of only certain size fractions rather than the entire sediment mass.

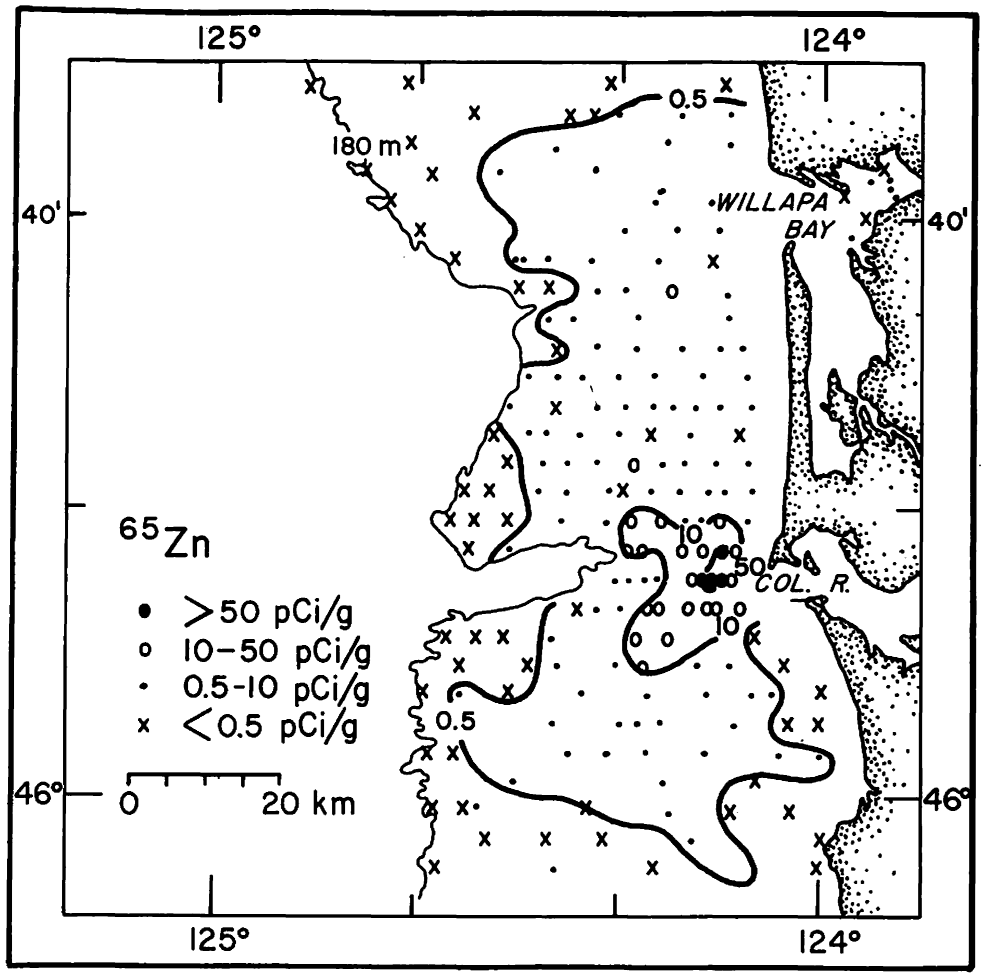
Presently there are no data available on the velocity of near-bottom currents in the area to check these results. The velocities of the weak and variable surface currents are, however, relatively well known. During late Spring and Summer, the surface ocean waters near the river mouth move generally southwestward at speeds between 5 and 20 cm/sec, averaging 8 cm/sec. During the remainder of the year, the coastal surface waters move northward at speeds between 10 and 20 cm/sec (BARNES, C.A., GROSS, M.G. 1966. Symposium on Disposal of Radioactive Wastes into Seas, Oceans and Surface Waters, 16-20 May 1966, International Atomic Energy Agency, Vienna). By comparison the radioactive particles apparently move at speeds estimated to be 0.02 to 0.01 that of the surface waters.

Obviously more data on the near-bottom currents in the area and the abundance and distribution of particulate matter in coastal waters are needed to check these results. In the meantime these studies of the radioactive sediment distribution provide a working hypothesis which is consistent with the distribution of other sediment properties. In addition it provides the first available data on the rates of sediment-movement in this region.

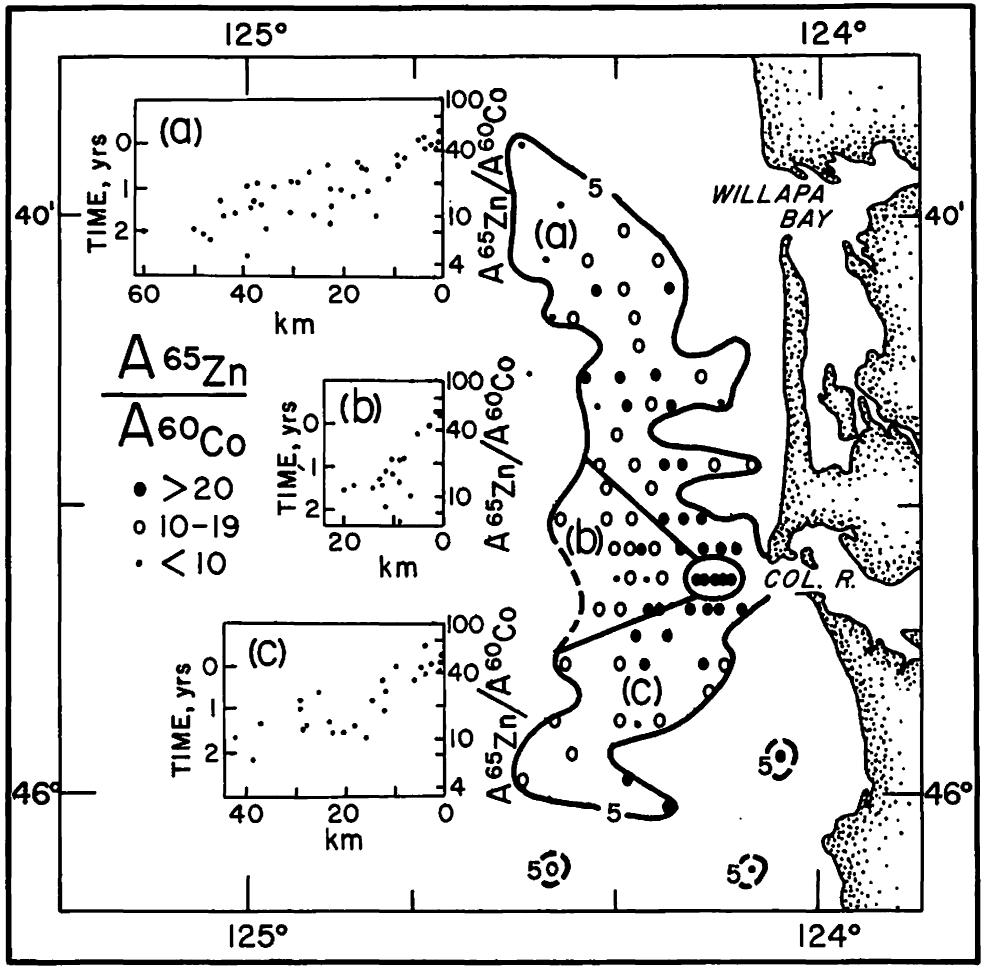
ILLUSTRATIONS

Fig. 1. Distribution of surface sediment containing Zn^{65} in summer 1963.

Fig. 2. Activity ratio ($\underline{A}_{Zn}65/\underline{A}_{Co}60$) in sediment containing both radionuclides. The change in the activity ratio with increasing distance from the Columbia River is shown for sediment north (a), west (b), and southwest (c) of the river mouth.


125°
124°
40'
46°
0.5
180 m
WILLAPA
BAY
COL. R.
10
50
^{65}Zn
> 50 pCi/g
10–50 pCi/g
0.5–10 pCi/g
< 0.5 pCi/g
0
20 km

1


125°
124°
40'
46°
(a)
(b)
(C)
TIME, yrs
km
$\frac{A^{65}Zn}{A^{60}Co}$
• > 20
o 10–19
• < 10
WILLAPA
BAY
COL. R.
5
50

2