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Biologic Oceanography off the Columbia River (Northeast Pacific) - Some Effects of a Large River

by

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Since January 1961, the Department of Oceanography, University og Washington, has carried out intensive studies of aspects of physical, chemical, geological, and biological oceanography in the region of the Columbia River effluent in the Northeast Pacific Ocean. Bimonthly 3-week cruises study the seasonal patterns of primary productivity, chlorophyll, and zooplankton from fine-mesh nets. Attempts have been made to demonstrate relationships of plankton distribution and activity to hydrographic and chemical conditions in and near the effluent. Seasonal and distributional studies will provide a foundation for future studies.

The primary objective has been to relate standing crop and production to seasonal variations in the Columbia River effluent. Most seasonal studies in other ocean areas have measured variation at a single station. In this study data from waters influenced by fresh-water discharge, in regions of coastal upwelling, and offshore beyond the Columbia River plume afford comparisons of areas with widely differing hydrographic conditions. It has been possible to establish the annual rates of primary production and seasonal cycles; some-idea of annual variations will eventually be obtained. Emphasis has now been turned to specialized studies of phytoplankton population growth which include measurements of short-term variations, both daily and diurnal, effects of experimental nutrient enrichment, and observations on Zooplankton-phytoplankton relationships.

Hydrography - The vertical distribution of salinity is characterized by a halocline 75 to 150 metres thick some 75 to 100 metres beneath the surface. In winter, temperature and salinity are uniform in the surface layer; in summer, thermal stratification develops.

During winter, the freshwater plume is held close along the coast north of the river mouth. A shift in wind pattern, from predominately south-westerly in winter to northerly in summer, results in a southerly distribution of the Columbia River plume in summer. The plume reaches maximum development in early autumn, extending southward and offshore about 350 miles. The plume is lost during autumn and early winter storms; the distribution of effluent returns to a narrow band along the coast north of the river mouth.

Upwelled water reaches the surface along the coast south of the river mouth in summer. The upwelling varies in magnitude with changes in wind speed and direction.

The Columbia River water is confined to a relatively thin surface layer during development of the summer plume. The vertical extent is marked by a well-developed pycnocline. In May, the layer ranges from less than 5 to 10 metres; it gradually thickens as the season progresses. By early autumn the pycnocline is at 30 to 40 metres. In waters offshore beyond Columbia River influence, vertical mixing extends to 70 to 80 metres during winter and early spring. By June, a thermocline is established at 10 to 20 metres; it increases to a maximum of 30 to 40 metres by early autumn. During summer, the depth of the mixed layer is generally 5 to 10 metres greater in waters offshore from the plume.

Nutrient Chemistry - Concentrations of nutrients in the mixed layer in winter are highcompared to summer. Nutrients are rapidly used by phytoplankton in spring and summer. Phosphate and silicate drop significantly in concentration, although they never become limiting to growth. In midsummer nitrate is scarcely detectable in offshore surface waters. Greater phytoplankton activity consumes nutrients more rapidly in the plum than offshore. The concentration of nutrients is high in upwelled water along the coast during summer.

Seasonal variations in nutrient content are correlated with phytoplankton growth, the hydrographic cycle, and addition from coastal sources. The hydrographic feature of major importance is the relatively shallow depth of the mixed layer in summer, resulting in nutrient depletion in the surface layer. Nutrients accumulated below the thermocline are not available to much of the euphotic zone until the onset of winter mixing. Significant quantities of nutrients are added to the system from the Strait of Juan de Fuca and coastal upwelling. The Columbia River contributes a great quantity of silicate, less nitrate, and negligible phosphate.

Primary Production. - The major influence of the Columbia River effluent appears to be on the timing of events rather than in total annual production. Typically, increased solar radiation in spring is accompanied by a major increase in phytoplankton populations and rapid nutrient depletion. A lesser autumn bloom may occur, and increased vertical mixing begins when incident light remains high. Production in the plume during early summer proceeds at a greater rate than in offshore waters because of the shallower mixed layer and somewhat higher temperature. Therefore, nutrient depletion is more rapid in the plume. In autumn, production is greater in offshore waters than in the plume, presumably because of more stable stratification in the plume which retards nutrient resupply by vertical mixing. The nutrient addition by the river is apparently spent in high production near the river mouth.

Annual photosynthetic production has been calculated for the areas studied:-

Area	Annual Production $gC/m^2/year$	Range
Offshore	61	43-78
Plume	60	46-73
River Mouth	88	
Upwelling	152	

There is a large margin of uncertainty in estimating annual production because of the infrequent sampling. During a cruise, measurements in the same areas on successive days were sometimes quite different. Variations in incident radiation and the physiological state of populations, especially during rapid growth or decline were believed to be important. In the plume and offshore areas where several measurements were made, a range of minimum to maximum production was computed.

Little or no difference in annual production is evident between the plume and offshore waters. More striking, the annual production appears to be quite low. It is similar to that reported from the Canadian Station Papa (45°N, 145°W; 70 $gC/m^2/year$), the Sargasso Sea (72 $gC/m^2/year$), Fladen Ground (57-82 $gC/m^2/year$), and Danish inshore waters (75 $gC/m^2/year$). All of these areas, except Station Papa, are impoverished in nutrients. Higher levels of annual production have been reported for the continental slope off New York (120 $gC/m^2/year$) and in Long Island Sound (180 $gC/m^2/year$).

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