Preliminary conclusions from the Hood Canal Dissolved Oxygen Program Integrated Assessment and Modeling Study
30 June 2008

There have been many new revelations gained about the unique nature of Hood Canal from this research. A clear understanding of these physical, biological, and chemical processes was necessary before models and other analyses could be used to evaluate the causes for the low dissolved oxygen.

The oxygen picture is complex, with both natural and human factors contributing, but with differences in the balance depending on location and time. The overall conclusion is that several natural factors, such as sunlight, wind, and external ocean conditions, affect Hood Canal oxygen conditions substantially and are the major factors in the interannual variation of 1-2 mg/L in minimum oxygen concentrations. Both the mainstem of Hood Canal and Lower Hood Canal are affected by these factors. However, we also find that human factors can be of sufficient magnitude to reduce minimum oxygen concentrations on the order of 1.0 mg/L in Lower Hood Canal over the course of the summer.

In a given year, the human impact from anthropogenic N loading will be greatest at Lower Hood Canal during years with mild and sunnier winters and springs. However, the effect from natural or externally forced variation may either add to or negate this effect, so that the overall oxygen concentration can vary widely.

More details:

-- External factors, such as climatic variation in atmospheric and ocean conditions, controlling oxygen in Hood Canal are very important, in terms of both the observed interannual and interdecadal variations. For instance, the period of the 1950's when more oxygen was observed was associated with lower air and ocean temperatures as well as stronger winds.

-- Hood Canal is an area within Puget Sound where the growth of algae is particularly sensitive to addition of nitrogen (N). Phytoplankton growth during summer in Lower Hood Canal is limited by the availability of N. An input of N at this time fuels more growth, which in turn decays at depth, consuming oxygen.

-- Marine N is the dominant nutrient source to Hood Canal, but loading of N from anthropogenic sources is significant and measurable through observations.

-- Previous estimates of the marine input of N to Hood Canal were based on the flux of nitrate over the sill. We have found that this greatly overestimates the flux of N into the surface layer of Lower Hood Canal. A large amount of this N does not reach the surface layer in Lower Hood Canal because some of this becomes part of the seaward return flow beneath the sunlit surface layer (measured at 25-45% of the influx) and some (not quantified) upwells to the surface layer in northern Hood Canal . This N does not contribute to primary production in the surface layer of Lower Hood Canal.

-- Anthropogenic N sources, predominantly alders and septics, are a significant part of terrestrial inputs to Hood Canal.

-- The timing of N loads from alders is skewed to Nov-Feb, when sunlight and temperature are not conducive to phytoplankton growth; in contrast the timing of N loads from the most heavily populated watersheds is less seasonally variable. Groundwater N loading is appreciable during summer.

-- The relative contribution of anthropogenic N to the marine water column is greatest in Lower Hood Canal.

--Human loading of N into Lower Hood Canal is of sufficient magnitude that it can cause lower oxygen concentrations on the order of 1.0 mg/L over the course of the summer.

-- There appears to be export of low oxygen water from Lower Hood Canal towards the Hoodsport area during late summer, which could lower ambient oxygen levels in a critical time of the year.

-- The physical processes that result in fish kills in southern Hood Canal are better understood. A combination of the annual late-summer intrusion of new bottom waters that forces low oxygen waters towards the surface and favorable wind conditions that can bring these low oxygen waters rapidly to the surface results in the high-mortality events in southern Hood Canal.

-- The bacterial mats that develop in Lower Hood Canal due to low oxygen conditions provide a positive effect for other biota because they prevent dangerous sulfide from reaching the water column, but they also may result in even more eutrophication because of their contribution of ammonium, a N nutrient.

-- The dissolved oxygen concentrations affect the distribution of biota in Hood Canal, although there is a large amount of complexity to the spatial patterns and temporal responses of individual species.

-- There are many biological events that we still do not understand regarding Hood Canal biota populations. For instance, we cannot conclude what caused the recent krill beachings, although we can rule out oxygen stress. We cannot conclude whether oxygen or other factors are the primary cause of the reduced number of crabs.

--These conclusions are for present conditions and do not take into account potential increases in human population or future climate change.

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