Can Copepods Cope in Oxygen- Depleted Waters of Hood Canal?

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It's a leisurely Sunday afternoon in late summer, a perfectly sunny day for a stroll along one of Seattle's resident beaches. A zephyr cools the rare solar intensity as your bare feet sink into the sand with each step as--Ewww!!!—your feet squish upon a slimy surface and your eyes dart their way in horror down to a carcass washed up on shore. Dead marine animals such as fishes, octopuses, and jellyfish—to mention a few—are increasingly common in the Puget Sound's Hood Canal **(Figure 1)**. Scientists attempt to uncover the reasons behind such aquatic fatalities, and suggest that waters of this channel in the Puget Sound experience reduced levels of oxygen, stressing some organisms literally to death. But unlike you and I, who observe these palpable bodies on their sandy deathbed, scientists tackle this question of physical water quality from a microscopic level. Although we cannot see these tiny organisms with the naked-eye, microscopic animals often enable scientists to explain larger events, such as that dead squid you might have to avoid stepping on during your next visit to the beach.


Figure 1. Dead octopus and dead fish represent some of the organisms washing ashore dead in Puget Sound's Hood Canal. Scientists suspect that low oxygen levels are potential culprits for these, and other organisms', deaths.

We don't have to be scientists in order to understand why aquatic microscopic animals (called "zooplankton") are growing in recognition. We witness media reports of Red Tides and shellfish poisoning, both caused by these critters that are nearly invisible to the naked eye. But without the presence of zooplankton (derived from Greek for "free-floating animal"), our world would be a much less tastier place to live in! Not that we order zooplankton off restaurant menus or purchase them fresh at Pike Place Market, but we do love seafood and fish, which flourish thanks to our zooplankton friends. In the Puget Sound the most abundant type of zooplankton is the copepod, which loosely resembles crustaceous long-horn steers **(Figure 2)**. Copepods play a crucial role in the aquatic food web, linking minuscule algae to larger, more familiar, predators such as mussels, crabs, fish, and humans **(Figure 3)**. Some copepods also exhibit a fascinating predator-avoidance behavior by spending daylight hours hovering at lower depths, saving their foraging trip for the safer late-night hours when most fish are no longer feeding. For a copepod to ascend and descend the length of a football field on a daily basis is comparable to human traveling from Seattle to Chicago and back for the sole purpose of dining security! So how do scientists relate environmental condition ns such as reported declines in oxygen in the water to copepods? Do lower oxygen levels disturb copepods enough to alter their migration behavior and/or survival, thereby disrupting a key element in the entire marine food web?

Figure 2. Magnified copepod, as viewed beneath a microscope.

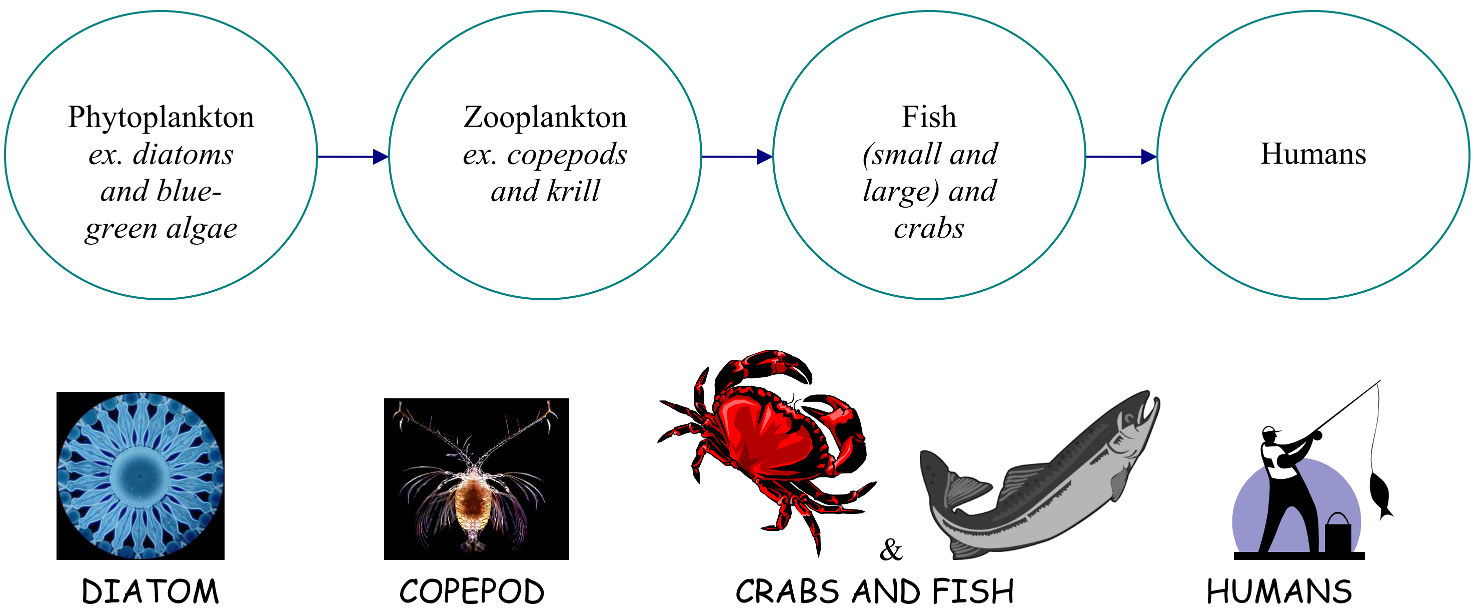


Figure 3. Example of an aquatic food web depicting zooplankton's (copepod) vital link in marine ecosystems.

Scientists at the University of Washington's Oceanography Department carry on investigations of how the physical and chemical components of the Puget Sound's waters influence marine plant and animal communities. A recent project has examine whether copepod populations are affected by lower oxygen levels, and if so, to what degree is this related to human activity. In order to explore this complex question, UW scientists set out for the waters of Puget Sound's Hood Canal **(Figure 4)**, a region of notoriously low oxygen concentrations in recent years. With the help of modern technology aboard the venerable research vessel, the RV Thomas G. Thompson, students surveyed copepod distributions in the water column in relation to dissolved oxygen concentrations at five different sites along the natural North–South axis of the fjord. Large nets capable of filtering these organisms from selected segments of the water column were deployed—and then towed up vertically—to obtain samples of zooplankton. Scientists determined deployment depths using an instrument called a "CTD" which measures physical characteristics (salinity, temperature, and dissolved oxygen) of the water column between the Sound's surface and its bottom. This information is necessary to ascertain trends in the water features, such as oxygen concentration at various depths. For example, surface waters differ from deeper waters in that they are less salty, undergo more circulation, and receive more sunlight. Deeper aquatic environments, on the other hand, tend to be colder, saltier, denser, as well as relatively dark. Oxygen concentrations are typically higher in the Northern segments of Hood Canal versus the Southern regions **(Figure 5)**. For this experiment, researchers sampled two water columns at each site utilizing dissolved oxygen data extracted from the CTD readings. The first water column sampled was near the surface (0 - 25 meters deep), or "photic zone", where oxygen levels were higher. A second tow was deployed in a deeper water column extending toward the bottom depths (0 - 130 meters deep) where oxygen levels were lowest. In undertaking this study, investigators embarked upon answering the question of how copepods are coping in the waters of Hood Canal.

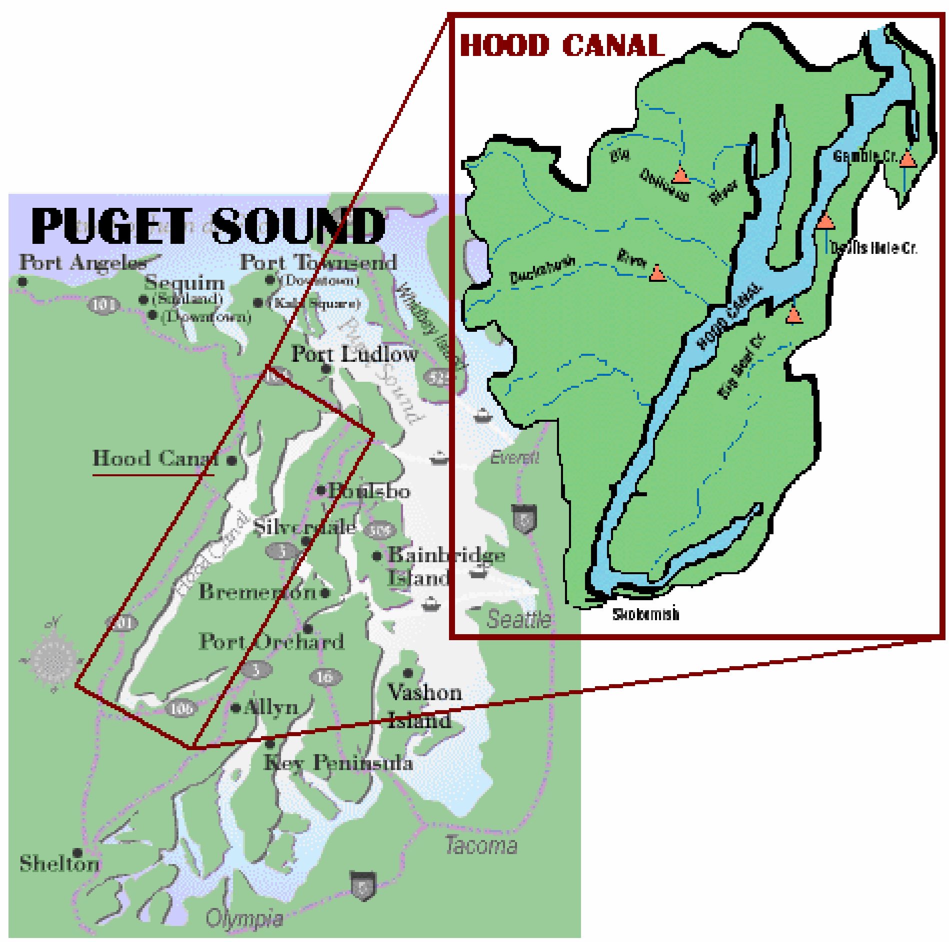


Figure 4. Hood Canal's location in Washington State's Puget Sound Region. Dissolved oxygen levels have waters have significantly declined since the 1990s, particularly in the south Hood Canal.

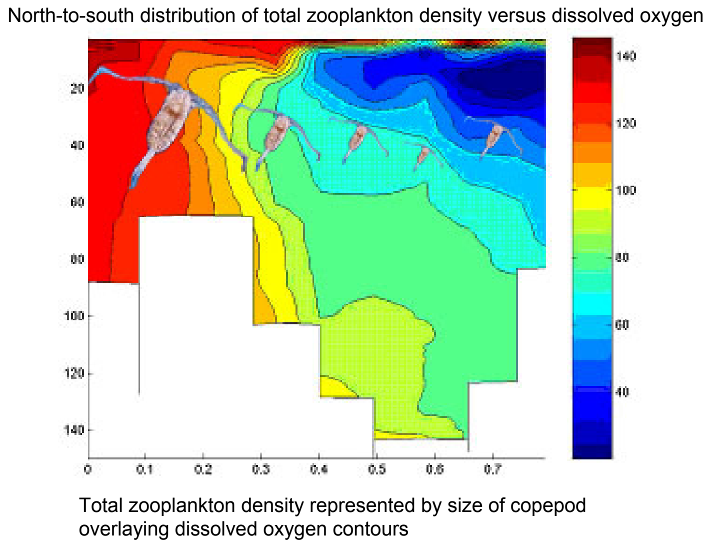


Figure 5. Larger communities of copepods are supported in north Hood Canal than in south Hood Canal where oxygen concentrations are higher.

Scientists hypothesized that fewer copepods would thrive in areas where dissolved oxygen levels were lower in, such as in south Hood Canal. This, in turn, could have a detrimental domino effect on the food web: since all respiring animals require oxygen, diminution in oxygen could disrupt the bottom levels of the food web (copepods) but also larger organisms such as fish that rely upon, or starvation on top of suffocation! These factors would predictably result in a slow, deathly dance towards depletion of Hood Canal's fauna, affecting human quality of life in turn. Results, however, indicate that copepods are currently not experiencing enough oxygen stress to alter their daily forage migration **(Figure 6)**.

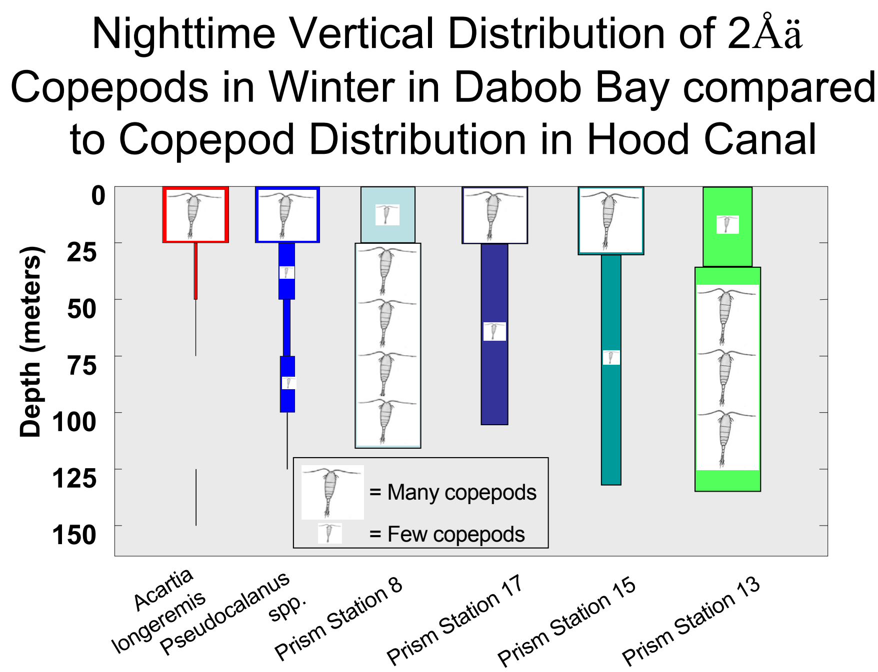
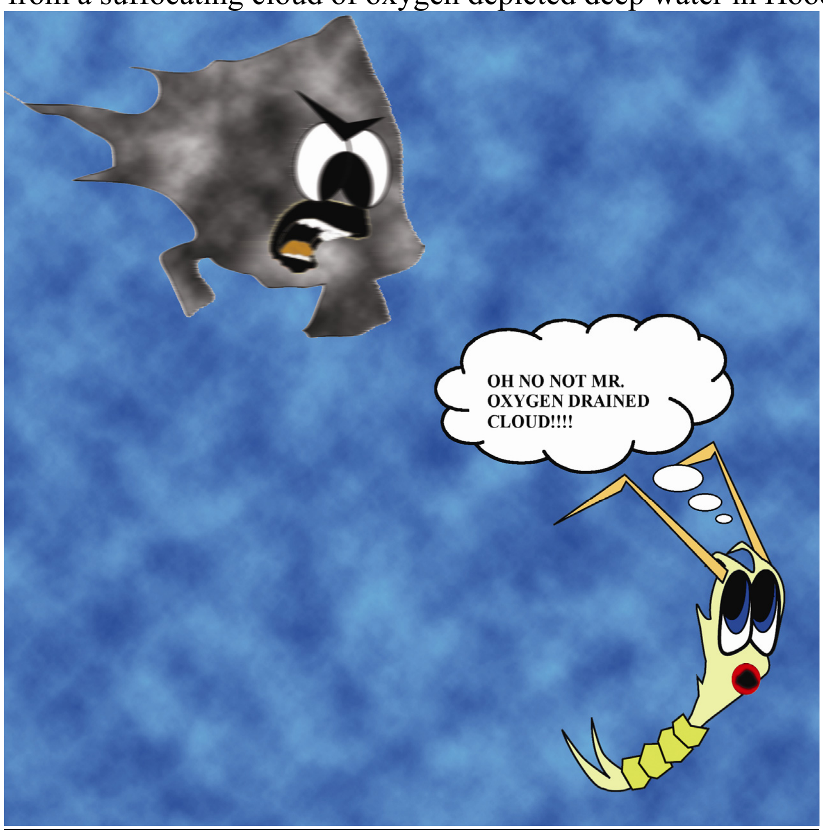


Figure 6. Copepod daily migratory behavior was not found to be significantly altered in areas experiencing lower dissolved oxygen levels.

According to this study copepods have not adjusted their ecological behavior at sites with reduced oxygen concentrations; they continue to hide out during the daytime while feeding at night near the surface waters while predators slumber. Copepod numbers, however, reveal an observable pattern related to oxygen concentrations: survey sites in the northern part of Hood Canal, where overall levels of dissolved oxygen are higher, supported more copepod individuals. In contrast, zooplankton abundance was half the amount in south Hood Canal, where lowest dissolved oxygen levels were found. While dissolved oxygen levels are not severe enough at this point to have eliminated copepods, marine animals may be reaching a threshold. Incoming ocean water is already slightly depleted with respect to dissolved oxygen at ~6.5 (?) mg/L. Some animals display stress when oxygen levels decrease to 5 mg/L and can die when concentrations lower to 3 mg/L (a condition referred to as "hypoxia"). The implication that copepods are unable to modify genetic behavior quickly enough to adapt to these conditions suggests that water quality is worse than what humans can currently measure. Some areas of Hood Canal, for example, experience anoxic (quasi-null oxygen) concentrations of oxygen as low as 1 mg/L. Will the waters of Puget Sound become increasingly depleted in oxygen in the future, and if so, will copepods weather these underwater, oxygen-drained clouds **(Figure 7)**?

The environmental changes taking place in the Puget Sound are not esoteric enigmas that only well-equipped scientists can unravel. You and I have the power to make a difference not only in the lives of the aquatic ecosystems, but for ourselves and future generations as well. All of earth's habitats are linked together within an overarching macrocosm, therefore even one person's daily activities can affect the general health of these cherished communities. Organisms inhabiting the Puget Sound waters may be up against a threshold due to expanding anthropogenic pressures, but our awareness and action can reverse a potentially dangerous outcome. Volunteering with local environmental groups and educating yourself about local ecological issues are a few of the things that you can do to ensure the livelihood of our beloved Puget Sound **(Figure 8)**. Simply recognizing the fact that we are all interconnected with and interdependent of these precious resources may serve as catalysts for mounting positive action. So the question in Hood Canal waters is not only whether copepods can withstand degraded g oxygen levels, but also whether or not humans are willing to allow water quality to worsen.

Figure 7. Copepod Cartoon: A documented, real life account of a copepod fleeing for his life away from a suffocating cloud of oxygen depleted deep water in Hood Canal



"I barely made it home yesterday after ascending to the surface to grab some food and a drink with the guys. As I was heading home, slowly making my way down through the stratified waters. The traffic was horrible, it seemed like everyone was at a complete stop and it wasn't even the weekend! I impatiently joined my fellow kin merging into a single file line, finally realizing why everybody was backed up: they couldn't breathe! Instinctively I gasped and swam away from this oxygen-devoid zone, sickened by the anoxic cloud I had just inhaled. After making it to a well-oxygenated layer, I I got through this area I gasped for a deep breath, but I definitely learned a lesson; traveling through water like that could even kill a copepod like me."

-Cornelius Copepod

Figure 8.
Things YOU can do to alleviate pressure to help ameliorate the quality of Puget Sound's environment:

1. Volunteer with community outreach groups such as People for Puget Sound. (http://www.pugetsound.org).
2. Eliminate or reduce household fertilizers, dumping of organic material, and spilling of household oils/fuels.
3. Stay informed about important decisions are being made about the health of Puget Sound and communicate your values to Federal, State, and local governments!
4. Educate others around you, especially children, by relating the importance of human interconnectedness to our natural environments.
5. "Adopt" a piece of Puget Sound to help ensure its health in the future.