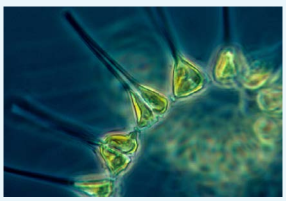
Oil Spill Impacts on Plankton

RRT/NWAC
REGION 10 REGIONAL RESPONSE TEAM and the NORTHWEST AREA COMMITTEE

What are plankton?

The term *plankton* refers to a broad group of drifting aquatic organisms found in various water bodies, ranging from open ocean to nearshore waters, estuaries, rivers, and lakes. These tiny creatures inhabit waters from the surface down to depths where sunlight can still penetrate, typically around 650 feet, depending on environmental conditions. Many aquatic species, including fish, begin life as temporary members of the plankton community, drifting in the water during early life stages.

Plankton are divided into two main groups:



Phytoplankton (plants) tend to stay closer to the surface where they can soak up the sunlight they need for energy through photosynthesis.

Zooplankton (animals) migrate through the water column to deeper depths for nutrients and shelter during the day and rise toward the surface at night to feed on phytoplankton.

Why are plankton important?

Plankton are the foundation of most aquatic food webs. Nearly all life in the ocean depends on plankton. For example, the Southern Resident Killer Whales are connected to plankton through their main food source, chinook salmon. Salmon feed on plankton and other small animals that eat plankton, like small fish, shrimp, and squid. Declines in the abundance and productivity of plankton can have ripple effects up the food web.

Plankton also play a vital role in deeper parts of the ocean as well. When plankton die, or when zooplankton drop their waste, it all sinks toward the ocean floor, dragging along other organic material that scientists call marine snow. Marine snow is a source of nutrients for organisms found deeper in the ocean as it settles on the ocean floor (4). Additionally, phytoplankton turn carbon dioxide into oxygen through photosynthesis, and due to their abundance, produce much of the oxygen in the air we breathe.

Are plankton always present?

The abundance and species composition of plankton is not constant throughout the year. Plankton blooms are periods of increasing concentrations of plankton in the water. While plankton blooms can occur almost any time of the year, there are recurring patterns. Typically, in Northwest waters, the concentration of plankton is low during the winter when light levels are low. In the spring as day length increases phytoplankton species numbers can greatly expand. The zooplankton, larval fish, and invertebrates also increase to take advantage of this abundant food source. Later in the summer, the surface waters may become nutrient limited and the production of phytoplankton and the planktonic species that feed on it may decrease. Also, at this time larval fish and invertebrate species may either settle out of the plankton to take up to live life on the bottom of the ocean, or outgrow the planktonic phase in the case of fish. Finally, in the fall there may be a second bloom of plankton as early storm and other oceanographic processes restore nutrients to the surface waters. As a result, the timing of a spill can have different potential for impact depending on the season.

How are plankton impacted by oil spills?

Researchers have looked into how oil affects plankton both in controlled lab settings and during oil spills. In most spills, oil is typically found in persistent slicks on the ocean surface, mixed into the water under the surface, and attached to particles in the water. Since plankton generally live close to the ocean's surface, they are particularly vulnerable to most types of oil spills. Plankton can ingest oil and can also become coated in oil, which may lead to suffocation. Plankton in the form of early life stages of fish and other organisms are particularly sensitive to the toxic effects of oil. In addition, natural sunlight can increase the toxicity of oil by 10 to 100-fold. This is known as photo-induced toxicity (8). When plankton are exposed to oil, they may die. Some may survive, but can have health effects that reduce their life span. Following a spill, the amount of plankton may decrease and the types of plankton present may also change.

The toxic effects of oil on plankton may vary because there are many different types of oil, each with its own chemical composition. Studies generally find that lighter weight compounds in oil can be more toxic than heavier components of oil. Additionally, different types of plankton have varying levels of sensitivity to these toxic substances.

If plankton are oiled or impacted, are there associated impacts to other aquatic organisms?

Plankton play a crucial role as the foundation of the ocean's food web. When plankton are exposed to oil, it can disrupt marine life throughout the entire food chain. If an oil spill results in a significant die off of plankton, larger organisms will lose this important food source. Some of the plankton includes early life stages of fish and other organisms that will not grow into adults, resulting in a significant loss of productivity in the food web. Organisms feeding on oiled plankton may be directly impacted by the ingestion of oil. As contamination in organisms moves up the food chain, larger animals may be exposed, increasing the potential impact. When oil mixes into the water, it can attach to marine snow and sink through the water. Organisms can feed on the oiled marine snow. In addition, when oiled marine snow settles on the ocean floor, it can have lasting effects on the deep-sea environment.

Does the use of chemical dispersants in oil spill response create additional impacts to plankton?

When dispersants are deployed, they help break up oil slicks on the ocean's surface, causing the oil to disperse or blend into the water. When dispersants are used, plankton could end up with heightened exposure to oil for a time afterward. This means that despite the intention to mitigate the immediate impact of the spill, plankton may still face increased vulnerability due to the dispersants' effects.

How quickly do plankton communities recover from oil spill impacts?

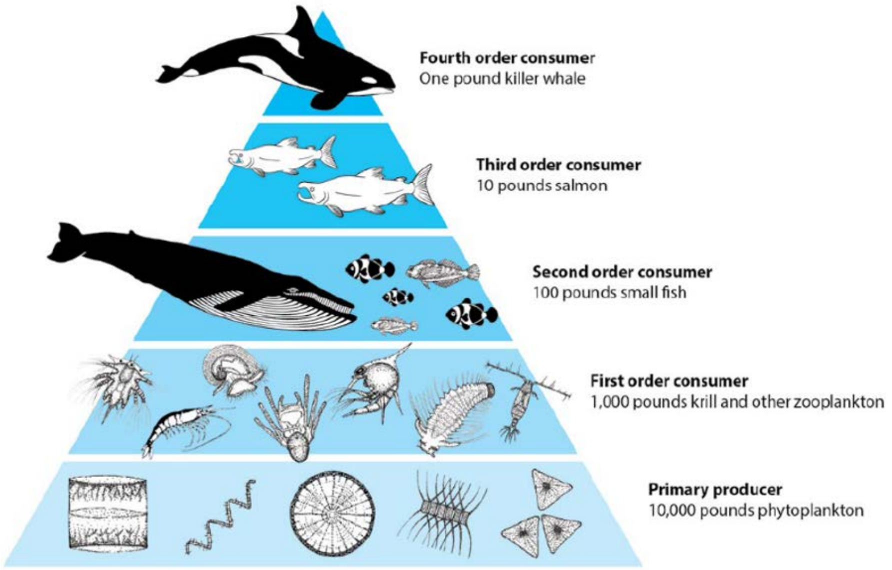
There are several important factors to consider in terms of the oil spill that influence effects and recovery time. The amount of oil spilled and the duration it remains in the environment, both will play a significant role in the time to recovery. The rate at which plankton communities recover from impacts from oil spills has not been studied extensively, but what we do know suggests that areas with good water circulation generally recover quickly. This is due to constant replenishment of healthy plankton from non-impacted areas, coupled with generally high rates of reproductivity in many planktonic species. However, if these areas are nutrient poor, the recovery can be slower. Areas with low water circulation, such as bays, harbors, and lakes, might experience longer recovery times (2).

Can we monitor or assess impacts to plankton during an oil spill?

In the event of a significant spill, monitoring may be conducted to assess impacts to plankton as part of a natural resource damage assessment. Monitoring of plankton communities can be conducted before, during, and after an oil spill. These studies may involve collecting plankton samples, analyzing water quality, and tracking changes in plankton abundance and diversity throughout a response. Studies may continue following the response to evaluate longer term impacts and the amount of time for the plankton community to recover. Information from plankton monitoring informs direct impacts to the plankton and can be used to assess larger ecological impacts. This type of monitoring is typically outside the scope of response efforts. Information collected by the response such as oil type, oiling extent, and the duration of oiling can help inform the monitoring.

Food Pyramid Caption

Food webs are made up of interlocking food chains. The flow of energy through such chains is best visualized through a simplified pyramid. This pyramid shows the relationship of plankton to the highest level in the food web, the killer whale. In this food web pyramid, 10,000 pounds of phytoplankton are needed to produce 1,000 pounds of zooplankton which produces 100 pounds of small fish. The 10 pounds of salmon produced by feeding on small fish will yield only one pound of killer whale. Each pound of whale is supported by 10,000 pounds of phytoplankton. Therefore, reductions in the abundance of organisms lower in the food web will negatively impact those higher in the food web.



Resources and References

1. Aurand, D., G. Coelho, and M. A. Slaughter (2009). T*he Relationship Between Acute and Population Level Effects of Exposure to Dispersed Oil, and the Influence of Exposure Conditions Using Multiple Life History Stages of an Estuarine Copepod, Eurytemora affinis as a Model Planktonic Organism*. University of New Hampshire, Coastal Response Research Center. Version 4.0.

2. Dilworth Chamberlain, Scott Robertson (1999). *Guidelines for the Scientific Study of Oil Spill Effects – Plankton*.

3. Hjorth, M., and T. G. Nielsen (2011). *Oil exposure in a warmer Arctic: Potential impacts on key zooplankton species.* Marine Biology 158(6):1339-1347.

4. National Academies of Sciences, Engineering, and Medicine (NASEM). 2020. *The Use of Dispersants in Marine Oil Spill Response*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25161.

5. Koray Ozhan, Michael L. Parsons, Sibel Bargu (2014) *How Were Phytoplankton Affected by the Deepwater Horizon Oil Spill*. BioScience 829 Vol. 64 No. 9.

6. Özhan, K., S. M. Miles, H. Gao, and S. Bargu. (2014). *Relative Phytoplankton Growth Responses to Physically and Chemically Dispersed South Louisiana Sweet Crude Oil. Environmental Monitoring and Assessment* 186(6):3941-3956.

7. Sutton TT, Milligan RJ, Daly K, Boswell KM, Cook AB, Cornic M, Frank T, Frasier K, Hahn D, Hernandez F, Hildebrand J, Hu C, Johnston MW, Joye SB, Judkins H, Moore JA, Murawski SA, Pruzinsky NM, Quinlan JA, Remsen A, Robinson KL, Romero IC, Rooker JR, Vecchione M and Wells RJD, (2022). *The Open-Ocean Gulf of Mexico After Deepwater Horizon: Synthesis of a Decade of Research*. Frontiers in Marine Science - Marine Pollution Volume 9.

8 Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement - *Injury to Natural Resources*.