BEST PRACTICES

Salmon in a Changing Climate

The anadromous life cycle of salmonids subject them to the impacts of climate change in spawning rivers, estuaries, and the ocean. For the five species of Pacific Northwest salmon, the time spent in any one of these habitats can vary greatly. For example, immediately upon emerging from the gravel, chum fry migrate down-river before transitioning into marine waters. The time spent in freshwater habitat by chum fry is in stark contrast to coho fry, who spend a year or more in freshwater before becoming smolts and out-migrating to the marine environment. Understanding the effects of climate change on salmonids requires consideration of life history differences and knowledge about the amount of time spent in the various habitats.

Anadromous: migrating to fresh water from the sea to spawn

The primary climate drivers that will likely impact salmon include: temperature in the air, streams, and ocean; precipitation in high elevation areas, which will impact the snow pack and stream flow in spawning rivers; and oceanographic factors such as increased acidification and changes to the frequency and intensity of ocean upwelling. Perhaps the best way to describe how climate drivers will impact salmon is to follow a salmon on its life history journey from a fertilized egg buried within the gravel of a stream to the final return from the open ocean as an adult to spawn in its natal stream.

When salmon eggs are fertilized and buried underneath stream gravel, changes in climate can influence the survival of developing eggs. Increased temperatures can lead to more precipitation falling as rain as opposed to snow during fall and winter months. This can increase the frequency of flooding in streams and rivers If floods are strong enough, scouring can occur in-river where gravel deposited. As a result, eggs can be pushed downriver where the eggs may not survive. This appears to have occurred to pink salmon in 2015, when adults deposited eggs in drought conditions. Several significant flood events followed in the fall which scoured redds (egg nests) and contributed to very poor production throughout Puget Sound rivers. Further climate impacts at this early life stage may include increased in-stream water temperatures that can result in altered development periods and increased thermal stress.

For species that spend a longer amount of time in freshwater streams as juveniles, like Chinook and coho salmon, it is anticipated that they will be more susceptible to in-river low flows and increased temperatures relative to chum or pink salmon, who migrate downriver shortly after emergence from the gravel. Increased air temperatures will result in decreased mountain snowpack, a more rapid spring melt, lower summer flows, and increased in-river temperature. This can limit habitat availability, increase disease and alter fish behavior.

Upon migrating into the estuary, salmon fry and smolts make the transition to marine conditions. The current pace of sea level rise is outpacing the rate that estuarine plants can grow and colonize new habitat. This may result in a reduction of available estuary habitat over time. Sea level rise projections vary considerably, but based on observation, sea level rise has been under-predicted. While there is still a lot of uncertainty about how much sea level rise will occur throughout the 21st century, as sea level rise modeling advances, the outlook for estuaries which juvenile salmon rely on seems to be grim.

After rearing in estuaries, salmon fry and smolts make their way into Puget Sound and further into the open ocean. In the ocean, they need to feed and grow rapidly before they return to their natal streams 1 to 5 years later. In the open ocean, rapid large-scale changes might seem unlikely. During the 'Warm Blob' in 2014-2016, average sea surface temperature (SST) rose 4°C above average. This illustrates just how quickly entire ecosystems can respond to changes in SST. The "Warm Blob" event was unprecedented and resulted in drastic changes to the food web that salmon depend on. We know from historical salmon returns that when SST in the Pacific Ocean is warm, the survival of most salmonids to the Pacific Northwest is lower compared to cooler years. The decreased survival in warm years is attributed to a shift in the food web with less abundance of lipid-rich zooplankton upon which salmon and their prey depend. This food web shift was observed in 2015-16 and correlates when Puget Sound had extremely poor returns of pink and coho salmon.

Ocean acidification (OA—reduced ocean pH from CO2 dissolution) also has the potential to alter the food web salmon depend on. OA can reduce the ability for many organisms such as urchins, clams, and corals to create calcium carbonate shells. A key organism in many North Pacific f ood webs that many salmon depend on is a zooplankton known as pteropods. Pteropods also create shells of calcium carbonate and are negatively impacted by ocean acidification when tested in the aboratory. The impact this will have on the food web that salmon depend on remains unknown but is of keen interest to researchers and fisheries managers.

Finally, after spending their time in the open ocean, salmon return as adults to complete their life cycle and spawn in-river. Similar to the impacts of temperature and flow experienced by juvenile salmon, returning adult salmon will incur added thermal stress. Increasing their susceptibility to disease. Reduced summer flows may also limit spawning habitat availability.

Following salmon through their life cycle demonstrates the unique challenges they will have to overcome in the coming century with climate change. Puget Sound salmon will need our continued efforts to recover current habitat so that they may be best equipped to deal with trials ahead.

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