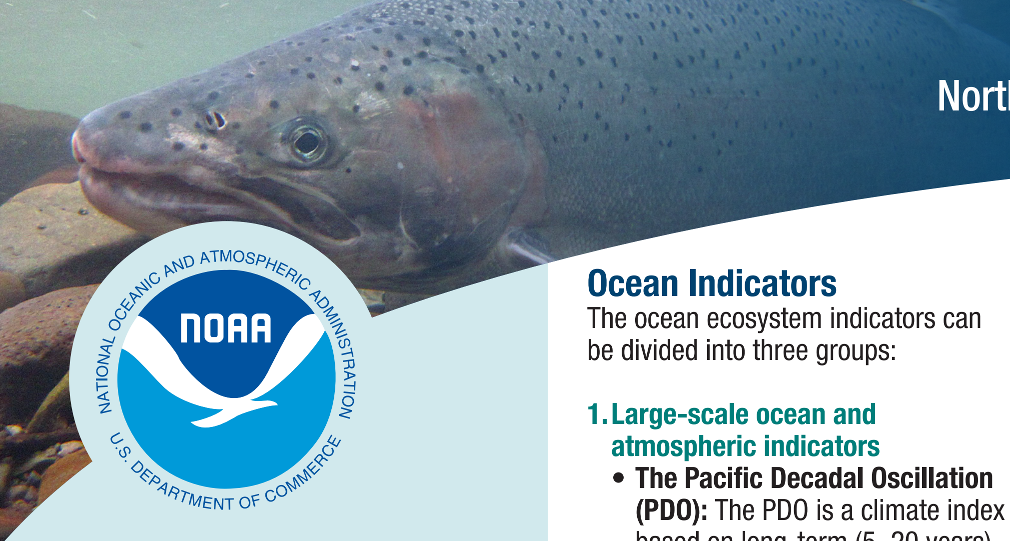
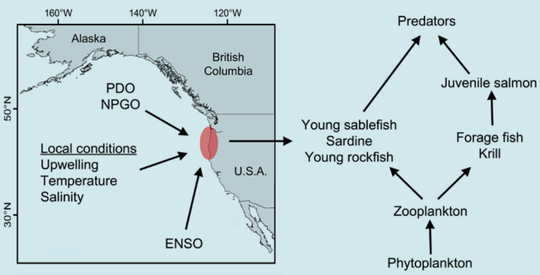


NOAA FISHERIES

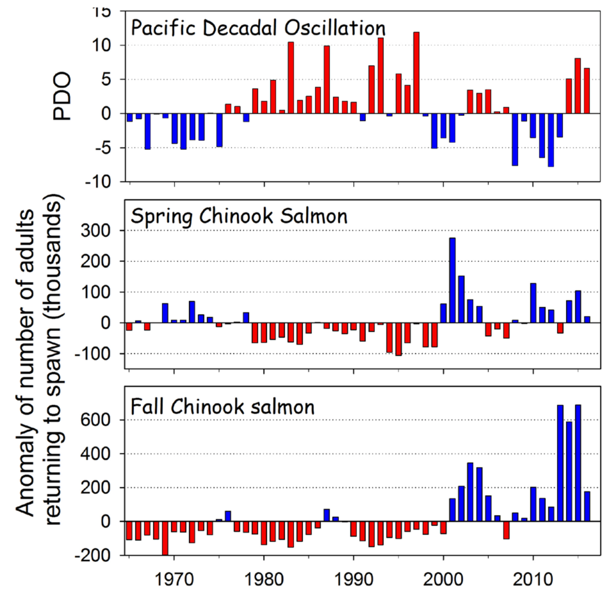
Salmon Returns and Ocean Conditions

Since 1996, scientists at the Northwest Fisheries Science Center have been monitoring the ocean environment off the coasts of Washington and Oregon, its interaction with the California Current, and how ocean conditions affect threatened salmon populations. We have identified a suite of ocean ecosystem indicators to help us better understand some key relationships between climate, oceanography, and biology, and offer new insights into the mechanisms that lead to success or failure for salmon runs.



Ocean Indicators

The ocean ecosystem indicators can be divided into three groups:



1. Large-scale ocean and atmospheric indicators

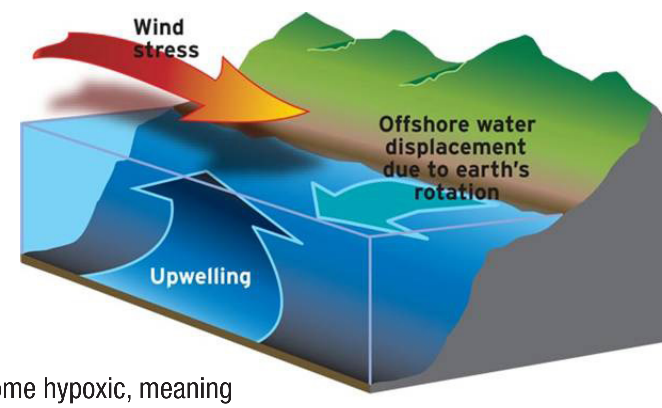
- **The Pacific Decadal Oscillation (PDO):** The PDO is a climate index based on long-term (5–20 years) average sea surface temperature variations in the North Pacific, which has warmer and colder phases. More abundant adult salmon catches are correlated with the colder phases of the PDO.

- **The Oceanic Niño Index (ONI):** The ONI is an index of warm equatorial Pacific waters. They are affected by El Niño events and can be transported northward along the U.S. West Coast. Generally, a change in the ONI is often followed by a corresponding change in the California Current ecosystem.

2. Local and regional physical indicators

- **Temperature:** Local sea surface temperatures change in response to changes at larger spatial scales and regional dynamics such as wind strength and direction. In general, cold conditions tend to be better for Chinook and coho salmon than warm conditions.

- **Upwelling**: The movement of deep, cold, nutrient-rich water toward the surface (where the water is warmer and depleted of nutrients) is necessary to stimulate the production of plankton. The impact of upwelling on salmon survival rates is most noticeable during the cold phases of the PDO.



- **Hypoxia:** Deep water can become hypoxic, meaning that there is not enough dissolved oxygen for fish and plankton to survive. Juvenile salmon live near the surface and are not directly affected by these conditions, though their food sources can be, which creates the possibility of an indirect impact on salmon growth and survival.

- **The spring transition (physical):** This term describes the change, usually between March and June, from a downwelling to an upwelling state along the coast. Generally, the earlier in the year upwelling begins, the more productive the ecosystem will be.

- **Deepwater temperature and salinity:** During the summer, when Chinook and coho salmon first enter the ocean, if deep waters are relatively cold and salty, we can expect generally good survival.

3. Local biological indicators

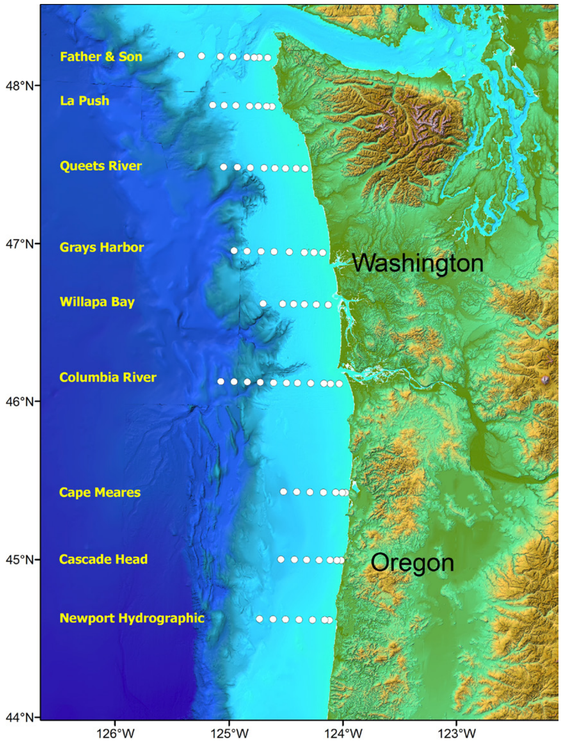
- **Copepods:** These tiny crustaceans can be found in plankton. Subtropical copepod species indicate the transport of warm waters from the south (not as good for salmon); coastal, sub-Arctic species indicate the transport of cold waters from the north (better for salmon). Two northern species are especially rich in lipids (wax esters and fatty acids), which transfer up the food chain, while the southern copepods are smaller and have less fat. Salmon eat herring, smelt, and other pelagic fishes that feed on copepods. If these forage fish have been eating a primarily "fat-free," warm-water copepod diet, this can negatively affect salmon return rates.

- **The spring transition (biological):** This transition is defined as the date that a northern copepod community first appears at our Newport, Oregon, Research Station, replacing a southern copepod community. The arrival of these cold-water species signals that the ecosystem is primed to begin a productive season. Although this transition usually occurs from March through July, in both 2015 and 2016, this biological transition never occurred at Newport.

- **Winter ichthyoplankton:** After moving into the ocean for their first winter, juvenile Chinook and coho salmon primarily eat juvenile rockfish, anchovies, smelts, and other winter-spawning fishes. As an index of this juvenile fish prey base, we collect ichthyoplankton (larval fish) in the winter before salmon enter the ocean. Our annual biomass estimates of key salmon prey are another indicator of salmon survival.

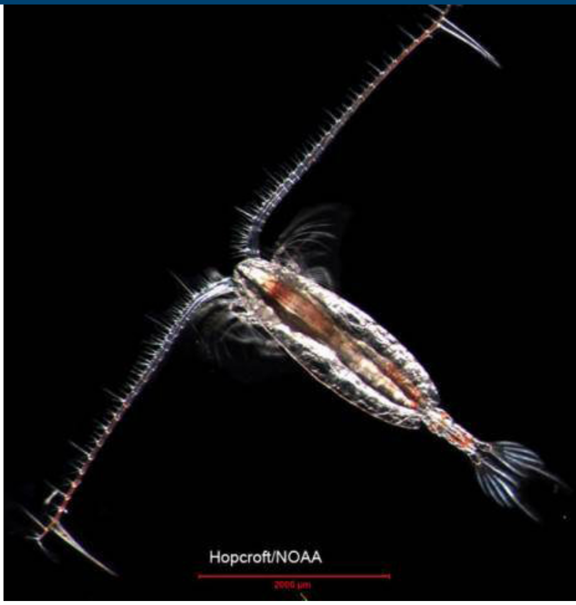
- **The juvenile salmon catch:** We sample pelagic fishes from the upper 20 m of the water column from Newport to Father and Son, Washington. Up to 60 individuals of each species are measured and categorized. The number of juvenile salmon can serve as an index or surrogate measure of ocean survival for spring Chinook and coho salmon.

- **IGF1:** Salmon growth rates in the ocean are estimated by measuring levels of the hormone Insulin-like Growth Factor 1 (IGF1) in their blood. This hormone directly stimulates growth and serves as a good proxy for recent growth rates. Higher growth during early ocean residence is generally correlated with increased survival and adult return rates.



Salmon Returns

By capturing the dynamics of the ecosystem, these indicators provide a weight of evidence approach for estimating the relative state of adult Chinook and coho salmon returns. This evaluation occurs far enough in advance for decision-makers to plan for good, average, or poor yield years. These estimates are invaluable to state and federal fishery managers in setting harvest limits and allocations, and for tracking recovery of these threatened species.



For more information on salmon returns and ocean conditions, please visit our website at www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/index.cfm

Brian Burke, Ocean Team Lead
David Huff, Program Manager
Estuarine and Ocean Ecology Program
Fish Ecology Division
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, Washington 98112
(206) 860-3334

All photos and figures: NOAA Fisheries.

Learn more:

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