UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
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MEMORANDUM FOR: Michael Tehan, Assistant Regional Administrator, Interior Columbia Basin Office

FROM: Kevin Werner, Science Director, Northwest Fisheries Science Center
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SUBJECT: Ocean Conditions and Salmon Returns for 2017-2018

Since it is part of the Northwest Science Center's mission to provide relevant information to help build sustainable fisheries, recover endangered and threatened species, and assist stewardship of marine resources, we are providing a summary of recent ocean survey results that we feel may have important implications for future returns of adult salmon. Our data, collected during summer 2017, suggests very poor ocean conditions for salmon, which follows on the heels of unusually warm surface temperatures ('the warm blob') and a strong El Niño event. There is a high potential for these adverse conditions to negatively impact salmon returns to the Columbia River over the next few years.

For the past 20 years, staff from the NWFSC have been studying the ecology of young salmon when they first enter the ocean to better understand marine growth, migration, and survival. This study informs salmon conservation and recovery efforts and

harvest management, as well as a broader understanding of marine ecology and salmon dynamics. By sampling off the coast of Washington and Oregon each spring and summer, we are able to annually describe a suite of biological and physical conditions in the Northern California Current (NCC) ecosystem, with a particular focus on juvenile salmon dynamics. These data provide an 'early warning indicator' of ocean conditions that affect salmon survival. In 2017, we found highly anomalous conditions, suggesting that the NCC could have negative impacts on salmon returns over the next few years.

Our catch per unit effort (CPUE) of juvenile coho and Chinook salmon during our June survey has been correlated with adult return rates. This year, CPUE was among the three lowest observed in the last 20 years (**Figure 1**), suggesting that early ocean survival may have been anomalously low. Several other data sources support this conclusion. First, catches of almost all of the species we regularly catch were low. This includes many forage fish species, such as herring, anchovy, and smelt. If prey fishes such as anchovies and smelt were scarce, predators may have been forced to feed at higher rates on salmon. For avian predators, such as common murre and sooty shearwater that aggregate just north of the Columbia River mouth, an increased reliance on salmon might have resulted in substantial mortality for juvenile salmon just as they entered the ocean.

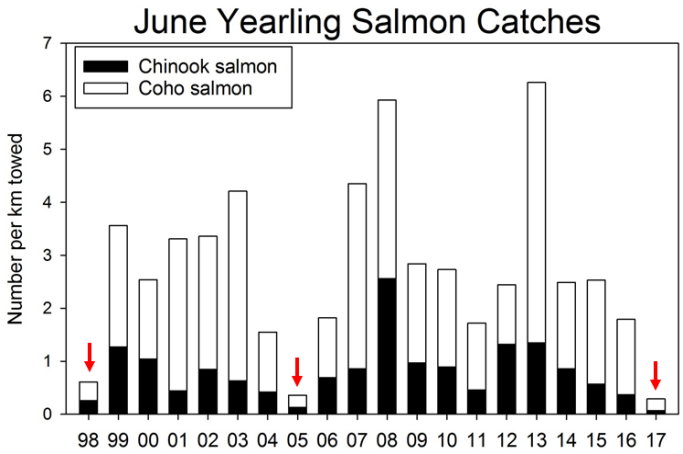

Figure 1. Juvenile Coho and Chinook salmon CPUE during the NWFSC June survey, 1998-2017.

Low salmon abundance was not the only anomalous observation in 2017. Much of the northeast Pacific Ocean has been extremely warm since the fall of 2013 (**Figure 2**). Although it has recently cooled to average or slightly warmer than average conditions, the biological responses to these warm waters are likely to be evident for a longer period. For example, warm water fish species such as Pacific Pompano and Jack Mackerel (a potentially important salmon predator) were caught regularly in our trawls over the last few years (**Figure 3**).

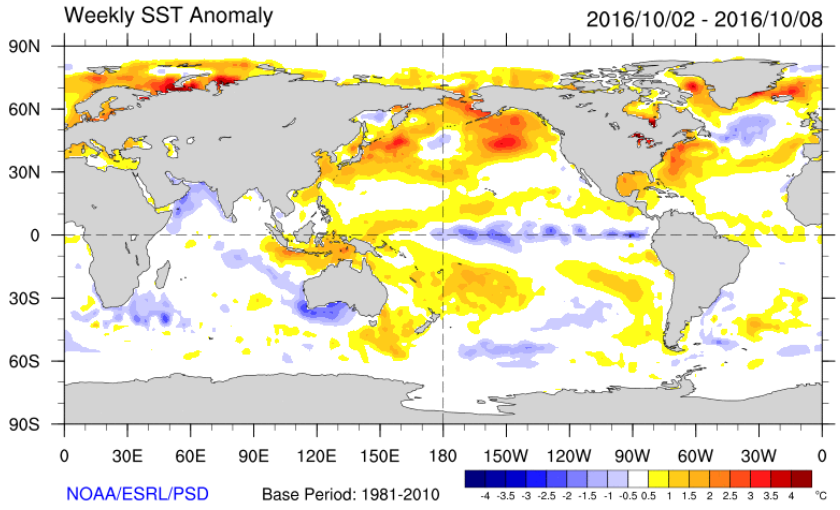

Figure 2. Sea surface temperature anomalies for the first week of October, 2016. Image from: http://www.esrl.noaa.gov/psd/map/clim/sst.anom.anim.html

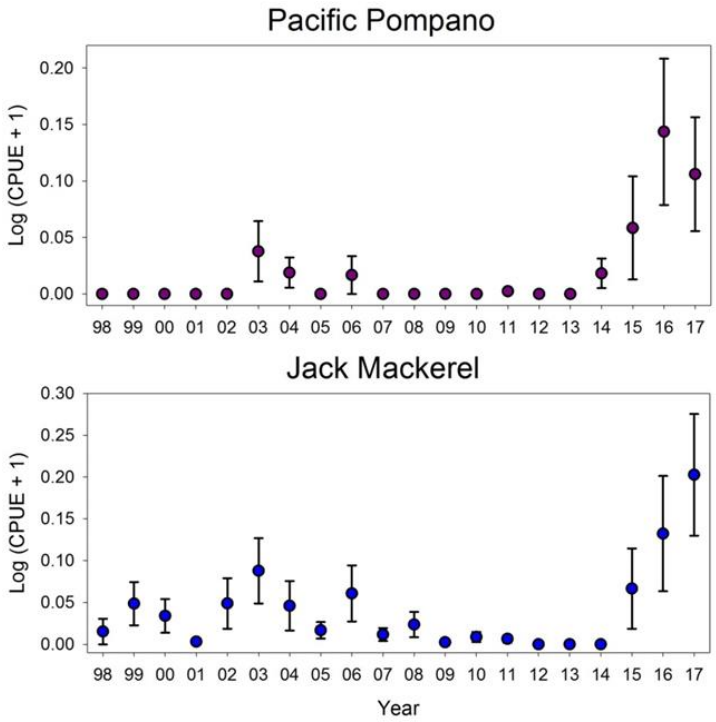

Figure 3. Time series of catches of Pacific Pompano and Jack Mackerel (1998-2017).

At the lower end of the food web, conditions were also anomalous. Chlorophyll, which is a proxy for phytoplankton, was at the lowest levels we have observed in 20 years. Pyrosomes, which are colonial tunicates usually found in warmer and offshore waters, were in extremely high abundance this year, often to the point of interfering with scientific and commercial fisheries (https://www.nwfsc.noaa.gov/news/features/pyrosomes/index.cfm). The biomass of the northern species of copepods (that correlate well with high growth and survival of salmon) has been low since mid-2014. And for the past 3 years, the jellyfish community has shown a complete shift from predominantly Pacific sea nettle to the much smaller water jelly.

Our results are still in the preliminary stage, with several next steps. Zooplankton and salmon samples that we collected at

sea still need to be processed to estimate important biological metrics, such as copepod biomass, salmon condition and stomach contents, and salmon growth hormone levels. All results will be placed into a broader context by integrating them with oceanographic data derived from satellites and ocean buoys. We will also corroborate our results with other coastal ecosystem surveys (e.g., Gulf of Alaska) that regularly catch Columbia River salmon. Finally, each year we synthesize results of this work, including an estimate of adult salmon returns to the Columbia River (see https://www.nwfsc.noaa.gov/oceanconditions).