UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
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February 22, 2008

MEMORANDUM TO: D. Robert Lohn, NWR
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FROM: Usha Varanasi, NWFSC Norm Bartoo, SWFSC

SUBJECT: Evaluating Causes of Low 2007 Coho and Chinook Salmon Returns

Returns of several West Coast Chinook and coho salmon stocks were lower than expected in 2007. In addition, low jack returns in 2007 for some stocks suggest that 2008 will be at least as bad. Here, we consider possible causes of unexpectedly low returns and make recommendations to address the issue technically.

The most prominent example is Central Valley (CV) fall Chinook salmon, for which spawning escapement is estimated to have been less than 25% of predicted returns and below the escapement goal (122,000 - 180,000) for the first time since the early 1990s, continuing a declining trend since recent peak abundance (near 800,000 spawners) in 2002.. Similar low returns have been documented for coastal coho salmon. For California populations, data compiled by the SWFSC indicate that coastal coho salmon returns this season averaged 27% of parent stock abundance in 2004, with a range from 0% (Redwood Creek) to 68% (Shasta River). In Oregon, spawner estimates for the Oregon Coast natural (OCN) coho salmon were less than 25% of predicted returns and 30% of parental spawner abundance. These returns are the lowest since 1999, approaching the low abundances of the 1990s. Columbia River coho and Chinook stocks experienced mixed returns, with some stocks near predictions and others well below predictions.

For coho salmon there is a clear north-south gradient, with returns improving to the north. California and Oregon coastal returns were down sharply, while Columbia River hatchery coho were down only slightly (82% of prediction). Washington coastal coho returns were similar to 2006, and British Columbia coho returns exceeded expectations by a moderate amount. Even within the OCN region, there was a clear north-south pattern, with the north coast region (predominantly Nehalem River and Tillamook Bay populations) returning at 46% of parental abundance while the mid-south coast region (predominantly Coos and Coquille populations) returned at only 14% of parental abundance. The Rogue population was at only 21% of parental abundance.

Low 2007 returns of jacks for three stocks suggest a continuing severe problem in 2008. Jack returns were at record low numbers for fall Chinook salmon in the Klamath Basin and Central Valley. In addition, coho salmon jack returns to the Columbia River were near record lows.

Potential Causes

There are two interrelated questions to answer: First, what caused the observed low salmon returns, and second, why did current stock abundance predictors fail to anticipate the problem? A full assessment of the problem would be premature at this time, while return data are still being processed. However, we can look at general patterns to draw some tentative conclusions.

To answer the first question, we need to recognize that salmon exhibit complex life histories, with potential influences on their production at a variety of life stages in freshwater, estuarine, and marine habitats. Thus, salmon typically have high variation in adult returns, which may be explained by a variety of human and environmental factors. However, when short-term patterns are coherent over broad geographic areas, it is likely that they are caused by regional environmental variation. This could include such events as widespread drought or floods affecting river flow and temperature, or regional variation in ocean conditions (temperature, production, predator abundance). Given the observed pattern of widespread low returns for two species this year, and a gradient from California to British Columbia, this type of regional environmental variation is the most likely cause.

In freshwater, the major recent regional event that would likely affect river flows or temperature in a number of basins was the severe California drought in 2007, which extended (with less severity) into southern Oregon. The geographic extent of this event is consistent with observed low returns, but its timing is not: the drought occurred after this year's returning salmon had migrated to the ocean. (It may, however, be a factor in future returns.) At this time, we are aware of no other widespread events in freshwater that would explain this year's returns, but it would be prudent to look more closely at river flow and temperature data throughout the region before dismissing freshwater causes.

For ocean factors, two efforts are underway by the two Centers to develop and use ocean environmental indicators to explain variations in salmon marine survival. The Northwest Fisheries Science Center is using a number of physical and biological indicators for the Oregon and Washington coasts to provide qualitative predictions of coho and Chinook salmon returns (described at http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/a-ecinhome.cfm). At the Southwest Fisheries Science Center, estimates of zooplankton, rockfish, seabirds, and 15 other ocean variables have been combined into a composite productivity index to describe variation in ocean production for the central California coast. Although the relationship between this index and California salmon population dynamics has not yet been fully tested, preliminary analyses indicate it tracks the CV Chinook population index (CVI) fairly well over the past 15 years.

For the spring and summer of 2005 (the ocean-entry year for 2004 brood fall Chinook and 2003 brood coho), both approaches indicated very poor conditions for juvenile salmon entering the ocean, indicating poor returns for coho in 2006 and age 3 fall Chinook in 2007. Coast-wide observations showed that 2005 was quite an unusual year for the northern California Current, with delayed onset of upwelling, anomalously high surface temperatures, and very low zooplankton biomass (Peterson et al. 2006, CalCOFI Reports 47:30-74; see also the special issue "Warm Ocean Conditions in the California Current in Spring/Summer 2005: Causes and Consequences" in Geophysical Research Letters, Vol. 33, No. 22, 2006). For the 2006 ocean-entry year, the SWFSC index was also poor, while the indicators used by the NWFSC provided a mixed assessment, which may explain the north-south trend observed in coho returns in 2007. Taken together, these poor ocean conditions, reflected in the indicators, provide a plausible explanation for the observed low returns of coho salmon in 2006 and 2007, and the low CV fall Chinook adult returns in 2007. Consistent with the CV fall Chinook record low jack return in 2007, the ocean indicators also would predict very low CV fall Chinook adult returns in 2008.

The second question is why current stock abundance predictors for coastal coho and CV Chinook salmon failed to capture this environmental signal. The answer is probably different for the two predictors, given the different methods employed. The CVI predictor uses a sibling-type regression to predict ocean stock abundance (predominantly age-3 fish) from the return of age-2 jacks the previous year. However, this regression has overestimated the CVI for the past three years, and the PFMC Salmon Technical Team is currently re-examining the data and statistical methods used for this predictor. A sibling-type regression should account for any variation in freshwater or early ocean mortality, but does not ordinarily account for variation in the maturation schedule. Research has shown that the maturation schedule in Chinook salmon is determined in part by coincident ocean conditions. Thus, incorporating an appropriately defined index of ocean conditions in a sibling regression has the potential to improve its predictive power. The SWFSC recently received NMFS funding to evaluate the merits of this approach for forecasting Klamath River fall Chinook ocean abundance, and this work will be extended to include forecasting of the CVI. In contrast, in recent years the OCN rivers coho salmon predictor has been based on a regression that does include two environmental indices (January sea-surface temperature and spring upwelling anomalies) that has a moderately good statistical fit using data from 1970 to the present. However, for 2008 predictions, the OPI Technical Team (OPITT) adopted a revised data series starting in 1986. The environmental relationship was not statistically significant using the shorter time series so OPITT adopted an alternative method. The poor statistical fit of this predictor in recent years may indicate that the processes controlling early ocean survival for coho are no longer adequately reflected by these two variables. More inclusive indices may provide improved prediction. The multivariable approaches cited above, incorporating biological and environmental data, may more completely characterize ocean ecosystem conditions of the California Current at the appropriate scale affecting salmon early marine survival and their maturation schedules.

In summary, pending further analysis, it appears that unusual ocean conditions are the most likely cause of the low returns examined here, and that continued efforts to quantify the affects of ocean conditions on salmon population abundance should be supported.

Recommendations

We recommend that two technical tasks be undertaken to address the problem:

1) A cross Center team should be tasked to evaluate the likelihood of various causal factors for these events on a coast-wide basis for both coho and Chinook salmon stocks. It is important to have an integrated regional perspective, rather than a localized stock-by-stock analysis. The team should also make recommendations about data needs beyond what is currently available.

2) A program to re-examine predictors for these stocks should be initiated. This should focus on evaluating the statistical methods employed, the potential utility of incorporating environmental indicators into predictors, and evaluating uncertainty in predictors and the management consequences of that uncertainty.

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