Understanding salmon survival in the ocean

September 2010

Salmon spend most of their lives in salt water. Most don't come back to the river to spawn. If just 1 to 2 percent more juvenile salmon survived through adulthood in the ocean, the number of adult salmon that came back to the Columbia River to spawn would more than double, National Oceanic and Atmospheric Administration Fisheries has estimated. Today, depending on the run, only one-tenth of 1 percent to 2 percent of the salmon that enter the Columbia River estuary as smolts return as adults.

According to NOAA Fisheries and Canadian researchers, there's a strong correlation between the ocean conditions salmon face and adult returns.[1] Conversely, NOAA has found no correlation between survival of juvenile salmon through the hydro system and adult returns.[2] Poor ocean conditions could override the benefits of improved fresh-water habitat and hydro system passage conditions for fish.

Scientists are just beginning to learn what happens to salmon during their life in the ocean. These efforts could help fish managers tailor salmon management in fresh water to produce the best possible survival prospect for the fish in the ocean and increase the likelihood of their successful return.

What we know: food, temperature and the Pacific Decadal Oscillation

Generally, more Columbia Basin salmon survive when cold water prevails off the coast of Oregon, Washington and British Columbia. Salmon need cold water. If the ocean warms slightly, salmon survival can be greatly reduced. Possible causes include reduction in food sources, increases in predation and changes to fish metabolism.

In 1996, scientists at the University of Washington identified a long-term pattern of cold/warm Pacific currents and temperatures that correlates to salmon survival patterns. Warm eras of this Pacific Decadal Oscillation see higher salmon returns in Alaska and poorer productivity off the West Coast of the contiguous United States, while cold eras produce the opposite effect. This correlation applies equally to rivers with and without dams.

One reason for this effect is coastal upwelling. In the cold-water phase, northern winds pull cold water from the ocean's depths to the surface off Oregon, Washington and British Columbia, bringing an abundance of plankton that feeds the entire food chain. During the warm phase, upwelling diminishes, reducing food sources for salmon, seabirds, anchovies, sardines, herring and other creatures.

Scientists' tracking of the Pacific Decadal Oscillation also shows a general trend toward warmer seas.

What we're learning

BPA has funded ocean research designed to improve Columbia Basin salmon management and enhance successful recovery of threatened and endangered runs. In the last five years, the science of salmon tracking and forecasting in the ocean has advanced substantially.

In the estuary: The Columbia River is influenced by the tide up to Bonneville Dam, so fish managers count everything below that point as estuary. Scientists are increasingly finding that the estuary is important to smolts' growth and adjustment to salt water and their subsequent survival. The combination of tides, ocean influences and fresh water makes a complex food web. BPA funds research on the role of the estuary in salmon survival. In 2009, BPA joined with the U.S. Army Corps of Engineers, the Bureau of Reclamation and the state of Washington to invest more than $40 million over the next decade in actions to improve salmon habitat in the Columbia estuary.

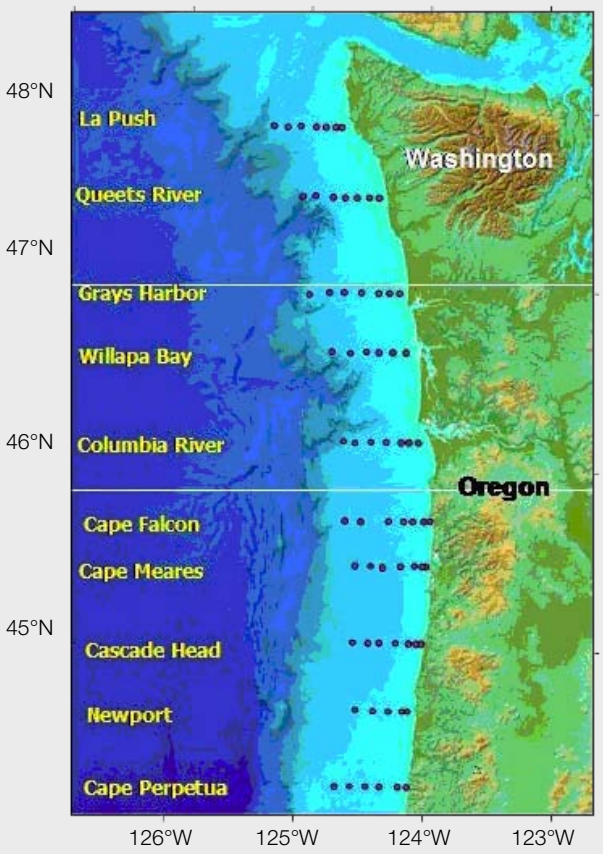
In the plume: The plume is the layer of fresh river water that lies on top of salt water in the estuary and extends into the ocean. It varies greatly in size and shape, depending on winds, tides and river flows. The plume front appears important to salmon survival when they first reach the ocean. Murky water may hide them from predators while they adjust to saltwater. BPA funds research on the plume's role in the salmon's life cycle.

Along the Oregon and Washington coast: As a result of BPA-funded research, scientists at NOAA's Northwest Fisheries Science Center have developed a new model for forecasting adult salmon returns that's proving more accurate than the traditional approach, which relied almost entirely on the number of immature male "jack" salmon returning a year early. The new system counts the jacks and adds whether the ocean is in the warm or cold cycles of the Pacific Decadal Oscillation and the La Niña/El Niño cycles. It then looks more closely at marine conditions off the coast of Oregon and Washington and whether the upwelling that brings nutrients from the bottom to surface areas is strong or weak.

Finally, it counts type and abundance of the small crustaceans called copepods that are the foundation of the food chain for young salmon and their prey. Taken together, these factors are providing a more reliable forecast of adult salmon returns that state fish managers can use in setting harvest limits. It also gives a better indication of expected ocean conditions for young salmon arriving in the ocean.

Following the salmon north to British Columbia and Alaska: BPA funds ongoing research by the Canadian Department of Fisheries and Oceans to sample how many Columbia Basin salmon

Scientists sample fish habitat regularly



From Cape Perpetua in southern Oregon to La Push at the top tip of Washington, Scientists from NOAA's Northwest Fisheries Science Center now regularly sample water temperature and salinity, nutrient abundance and other factors at intervals along the Northwest coast to get a better picture of how salmon (and other fish) may fare.
(NOAA Northwest Fisheries Science Center)

and steelhead appear, at what times, and in what condition at points along coastal waters off British Columbia and southeast Alaska. This Canada-USA Salmon Shelf Survival Study is helping scientists identify broad regions of good or poor salmon growth and survival in the ocean and has begun defining why growth and survival rates differ among regions. This is important because the region in which a fish stock spends its time at sea can be expected to influence its growth and survival rates and, therefore, its adult return rate. For example, Snake River chinook appear in a region of poor ocean growth off Vancouver Island in summer. Other stocks that are doing better, such as the Columbia River Hanford Reach chinook, have a more northerly ocean distribution that coincides with a region of higher growth.

The ocean has a significant effect on salmon survival.

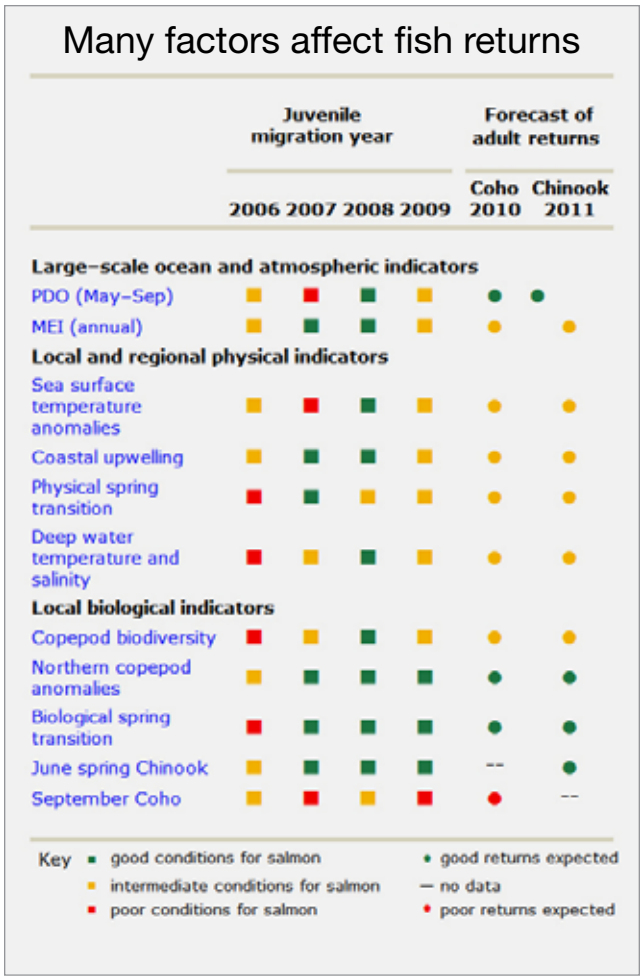
BPA is also an early funder and ongoing user of the Pacific Ocean Shelf Tracking Project, which uses new acoustic technology to track tagged fish (and other marine animals) as they move along the West Coast of North America. Salmon are implanted with acoustic tags. Each tag sends out a unique signal picked up by long rows of receivers on the ocean floor. So far, arrays of receivers have been deployed at intervals from Point Reyes, Calif., to Prince William Sound, Alaska.

The POST arrays provide previously unavailable data on fish survival as individuals move through different portions of their migration in the ocean and in the Columbia River itself.

How ocean studies can help freshwater fish managers

Understanding what happens to salmon in the ocean can help managers choose the most effective strategies for improving salmon survival in fresh water. For example, hatchery releases could be timed so that salmon arrive in the ocean when food is plentiful. If the migratory behavior of certain stocks exposes them to regions of poor ocean survival, that information can be incorporated in management plans.

The ocean has a significant effect on salmon survival and productivity. Changes in ocean conditions can mask the effectiveness of human efforts to help salmon in fresh water. Where annual changes in salmon survival in fresh water may double or halve, changes in ocean survival may change up to one hundred-fold.



Scientists now examine many factors that can affect salmon survival in the ocean to predict each year's adult salmon returns to Northwest rivers. (Northwest Fisheries Science Center)

Tracking fish through their long travels

Researchers now literally track tagged fish through their downstream river migrations, along their oceanic travels and back up the rivers as adults. Identifying where different fish runs go during their ocean sojourns may help fish managers improve adult survival and return rates.

Understanding how to address the ocean's vagaries can help fish managers improve the effectiveness of freshwater efforts and improve salmon survival.

For more information

To learn more, go to the following websites:

- Pacific Ocean Salmon Tracking Project: *www.postcoml.org/*
- Lower Columbia River Estuary Program: *www.lcrep.org/*
- Bonneville Power Administration: *www.bpa.gov*
- Columbia Basin Fish and Wildlife Program: *www.cbfish.org*
- NOAA Northwest Fisheries Science Center: *www.nwfsc.noaa.gov/* (look for "salmon forecast 2010")
- North Pacific Anadromous Fish Commission: *www.npafc.org*

[1] Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon. Scheuerell, Mark D. and Williams, John G. Fisheries Oceanography. Sept. 2005. Pgs. 448-447. See: *www3.interscience.wiley.com/journal/1186637 16/abstract*

[2] Survival Estimates for the Passage of Spring-Migrating Juvenile Salmonids through Snake and Columbia River Dams and Reservoirs, 2006. Faulkner, James R., et al. Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration. June 2007. *www.pisces.bpa.gov/release/documentsdocument viewer.aspx? doc=P10 3914*