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Bloom or Bust: The Bond Between Fish and Phytoplankton [1]

by Laurie J. Schmidt

Ocean color data from the SeaWiFS and MODIS sensors enable researchers to examine the link between phytoplankton blooms and fish and bird health.

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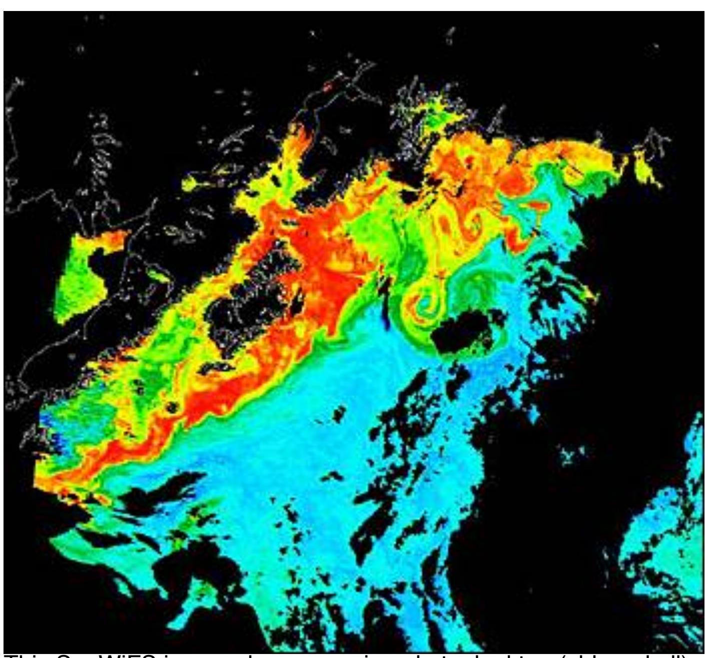
When you're a juvenile salmon trying to survive into adulthood, timing is everything. If you're lucky enough to be born in a year when there's an ample supply of zooplankton, then this food source helps keep your predators at bay. If, however, you're born during a lean plankton season, there's a good chance you might become a snack for fish like pollock and herring.

Oceanographers have long known that food web dynamics influence fish and bird populations in marine coastal areas. But new evidence has led some researchers to suspect that Mother Nature may have a unique way of sustaining populations by bringing young fish, like salmon, into the world when food sources are at their maximum.

The marine food chain starts with microscopic plants called phytoplankton, which typically float close to the surface where there is sunlight for photosynthesis. Phytoplankton are eaten by slightly larger, more mobile, herbivores called zooplankton, which range in size from single-celled organisms to jellyfish. In turn, zooplankton provide food for krill and some small fish.

Sudden explosive increases in phytoplankton, called "blooms," occur in the ocean when nutrient and sunlight conditions are just right. The timing of these blooms plays a large role in maintaining marine ecosystems, and is crucial to the survival of certain fish and bird species. "In theory, you have to have high levels of phytoplankton to support a high abundance of zooplankton, which then supports an abundance of small feeder fish," said oceanographer Scott Pegau.

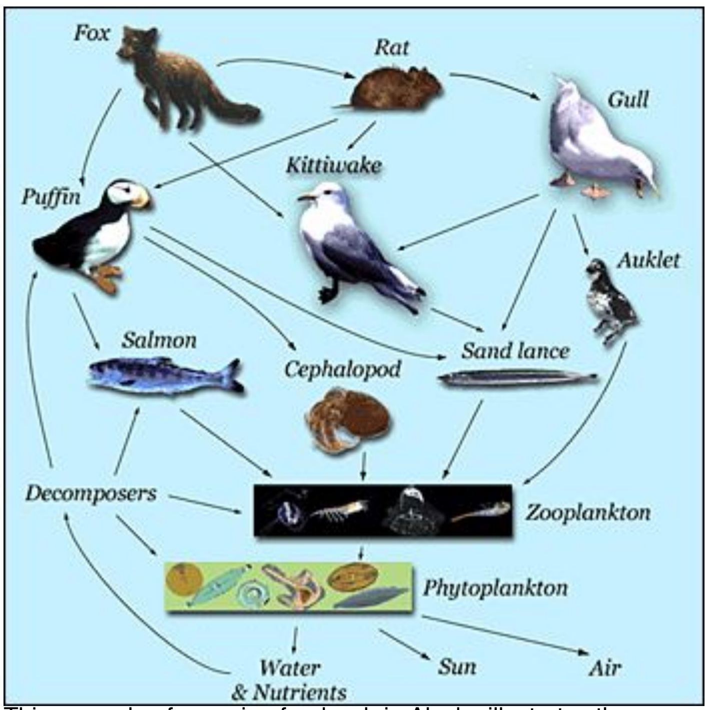


This SeaWiFS image shows a spring phytoplankton (chlorophyll) bloom over the Gulf of Alaska. Red represents high chlorophyll levels and blue represents low concentrations. The timing and location of these blooms are crucial to fish and bird populations. (Image courtesy of Scott Pegau, Kachemak Bay Research Reserve)

Pegau, a researcher at the Kachemak Bay Research Reserve in Homer, Alaska, has been using satellite data to look at the possible link between phytoplankton blooms and fisheries and bird health. By analyzing imagery from ocean color sensors, like the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and the Moderate Resolution Imaging Spectroradiometer (MODIS), Pegau and his colleagues can get a good look at both the timing and location of phytoplankton blooms and, hopefully, identify significant patterns that might lead to better fisheries management. "All fish are tied back to phytoplankton somewhere along the line," said Pegau. "So, most of the coastal fisheries could benefit from understanding bloom patterns and being able to make inferences to survival rates."

Kachemak Bay is located off the shores of Homer, Alaska, on the southwest side of the Kenai Peninsula — a region dependent on recreational and commercial fishing for its livelihood. "Fisheries are extremely important to coastal Alaska," said Pegau. "Many of the communities are strictly fishing communities — it's the sole dimension to their economy."

But during the past 10 years, several fisheries have collapsed in the Kachemak Bay area, including king crab, tanner crab, Dungeness crab, and shrimp. According to Pegau, these collapses are due partly to ocean circulation changes, but they also can be traced to a poor understanding of the variables that can influence fish populations in a given year. "We're still getting millions of pounds of salmon from this area, but better fishery management techniques could help ensure that the industry as a whole survives," said Pegau.



This example of a marine food web in Alaska illustrates the relationships between producers (plants that make their own food using chlorophyll and the Sun's energy) and consumers (animals that eat producers and other animals). It also shows the relationship between predators (animals that hunt and eat other animals) and prey (the animals that are hunted). (Image courtesy of U.S. Geological Survey)

Understanding phytoplankton bloom patterns and their effects on fish populations could spawn new management practices that help safeguard the future of the Alaska fishing industry. But without satellite data, Pegau and his team wouldn't be able to see an area large enough to detect any clear trends. "Kachemak Bay has 320 miles of coastline, and it's just a small dot on the Alaska map," said Pegau. "There is no way we can monitor what's happening in coastal Alaska without ocean color sensor data — SeaWiFS gives us the opportunity to see the big picture."

In the world's oceans, color varies according to the concentration of chlorophyll and other plant pigments in the water. Satellite sensors that detect these subtle changes in ocean color are critical tools for scientists studying ocean productivity. By analyzing data from SeaWiFS and MODIS, Pegau and his team discovered two patterns in the Gulf of Alaska: high chlorophyll concentrations show up in April/May, and then again in September/October. But the satellite data also show a third bloom that occurs in late June or early July.

The bloom timing is significant to both fish and birds because it determines when food sources are available. "If you're a fish getting ready for winter, then a fall bloom will provide a food source that will allow you to fatten up enough to get through the winter," Pegau said. "Conversely, if you're a bird, you want the bloom to happen just before your eggs hatch in the spring. If the bloom happens in late July, then it may be too late to be of any value to you."

But exactly what causes the blooms to occur when they do is still a mystery to oceanographers. One theory, Pegau explained, is that the timing may be related to the strength of winter storms. Like all plants, phytoplankton need light, and getting light in the ocean means being able to stay near the surface. If an area is plagued by continual storms, then the phytoplankton keep getting mixed down into deeper water — away from the light. But at the same time, they need the storms to bring nutrients up from the deep and fertilize the ocean surface. "It's a tricky balance," said Pegau. "You need enough storms to bring the nutrients up, but then you also need the storms to cease early enough to allow things to grow."

The team is also using the ocean color data to look at the spatial patterns of blooms, which are believed to have a significant effect on bird populations. "If the area that has a lot of phytoplankton is located far offshore, then the parent birds have to fly farther out to get it and, therefore, have less energy to provide for their offspring when they return," he said. "They eat up more of their food flying than they would if conditions kept the blooms closer to shore."

Having phytoplankton blooms occur far from shore poses risks not only to birds, but to salmon as well. "If food sources are located farther offshore, the juvenile salmon are forced to move away from shore to a place where they're more vulnerable to predators," said Pegau. "The farther out they have to swim to find food, the more likely they are to be taken by predators."

While many fish spend their entire lives in the ocean, other fish — such as salmon — spend a portion of their lives at sea and then return to rivers to spawn. "The ocean provides a much larger food source than the rivers and lakes where these fish are born," said Pegau. "By going out into the ocean to feed, they can grow more rapidly and reach the size and maturity that allows them to spawn. And the faster a fish can grow, the sooner it stops being prey."

Many communities in coastal Alaska are dependent on recreational and commercial fishing for their livelihood. (Image from Photos.com)

Ted Cooney, Professor Emeritus in the Institute of Marine Sciences at the University of Alaska, Fairbanks, believes predators play a significant role in the relationship between salmon and plankton. He and his colleagues have been looking at survival rates of juvenile salmon in Prince William Sound, a large region of protected waters located on the east side of the Kenai Peninsula. "About 800 million juvenile salmon enter Prince William Sound from streams and hatcheries in April and May each year," said Cooney. "These small fish immediately encounter a host of predators, including walleye pollock, Pacific herring, cod, and various seabirds and marine mammals."

The record in the Prince William Sound area suggests that when zooplankton stocks are high in the spring, pollock and herring derive most of their energy from that source, Cooney said. But when zooplankton stocks are low, they're forced to derive more of their energy by feeding on small fishes — like juvenile salmon.

Pegau's team has taken an important first step by identifying the fall and spring bloom patterns, but more work needs to be done before long-term trends can be reported with certainty, he said. "Our hunch is that we're eventually going to find a connection between juvenile salmon and bird survival rates and the phytoplankton bloom patterns," he said.

"The big thing is being able to manage the fisheries more effectively — knowing which years you can expect a big return to come in, and which years aren't going to produce much. You don't want to end up over-harvesting if the ocean isn't supporting the fish that year."

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- Ocean Color Data Support [4]
- SeaWiFS Project [5]
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