Study provides new standards for reliable fisheries

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The many populations of sockeye salmon in Bristol Bay, Alaska act like a diversified portfolio of investments, buffering fisheries and incomes from the ups and downs of particular stocks. Sockeye salmon are one of the most valuable fisheries in the U.S., and since 1950, more than 60% of that value has come from Bristol Bay. A new study in the June 3 issue of *Nature* quantifies, for the first time, just how much depends on this "portfolio effect." Without its current population diversity, the Bristol Bay sockeye fishery would close ten times more frequently - once every two to three years rather than once every 25 years.

The study, by scientists at the University of Washington, draws on five decades of data and provides the first solid evidence that population diversity within a species plays a key role in maintaining stable fisheries.

"We believe this new evidence is a game-changer for managing species and entire ecosystems," says lead author Daniel Schindler, an ecologist at the University of Washington. "Population diversity of species is often overlooked by managers and conservationists. Yet in general, current rates of population loss are probably a thousand times higher than species loss."

The authors argue that, in order to maintain the steady flow of fish and other ecosystem services people depend upon, managers will need to put an explicit priority on preserving population diversity within species. Such strategies require aggressive protection of the habitat networks that ultimately generate and maintain population diversity. Both approaches

will become increasingly important as a first line of defense against climate change.

"Part of it is understanding history and having the discipline not to chase the hottest stock of the day," says co-author Ray Hilborn, also at the University of Washington. "We have to maintain a range of productive elements - a broad range of stocks."

With a landed value of more than $120 million in 2009, the Bristol Bay sockeye fishery has provided a reliable source of income and food year after year. This is because sockeye salmon are finely tuned to the individual streams and lakes in which they were born, and are thus incredibly diverse. Some populations do better in cold, wet years - others thrive when it's hot or dry. Each population experiences its own boom and bust cycles based on environmental conditions and pure chance. But given sufficient diversity, there should be enough winners to make up for the losers every year for the species overall.

"Mother Nature does a pretty good job dealing with uncertainties - climate change, for instance - by producing a diversity of populations," explains Schindler. "In terms of fisheries, we need to have a longer- term vision for the viability of populations; the populations that are strong now are not necessarily going to be strong in coming years, so we need to protect weaker populations too, as insurance for the future."

Protecting weaker populations is a challenge- not only in salmon, but also in other species like tuna and cod. Managers must reduce fishing pressure below the levels that the stronger populations can tolerate, or distribute fishing pressure to protect diversity within stocks. The authors argue that in addition to protecting existing population diversity, we must also preserve and protect the variety of habitats that generate population diversity in the first place.

Many salmon rivers, including the Sacramento River in California and the Columbia in Washington, once enjoyed a high degree of population diversity and productivity. However, decades of heavy fishing, habitat degradation and reliance on hatcheries have dramatically simplified populations in these rivers. This has resulted in intense boom-and-bust cycles and frequent fishery closures. In British Columbia, major salmon rivers like the Skeena and Fraser have some populations that are highly depressed and show symptoms of decreased portfolio performance and increased vulnerability.

Hatcheries are frequently used to bolster wild salmon populations. But over time, hatchery fish can become closely related to one another, and can contribute to declines in unique wild populations. Eventually, hatchery-dominated areas can resemble one giant population. Just as intensive monoculture practices make food crops more vulnerable to disease or bad weather, a dependence on hatcheries can leave a fishery open to huge swings in fortune.

"The first lesson [of this paper] is that a wild multi-stock fishery can function very well on its own - better than we've ever done with any kind of hatcheries," says Jack Stanford, an ecosystem scientist at the University of Montana who was not involved with the research. "Hatcheries are counterproductive if the goal is to sustain very healthy wild fisheries, especially in light of climate change."

Beyond hatcheries, the study results hold other important implications for wildlife management strategies in the US and beyond. In terms of habitat protection, for example, California is currently working on lessening the blow to Chinook salmon, delta smelt, Central Valley steelhead, and green sturgeon in the Sacramento and San Joaquin delta. A March 2010 report by the National Research Council supported recommendations by the Fish and Wildlife Service and the National Marine Fisheries Service to reduce the number of engineered diversions,

such as dams and water diversion channels, in these river systems, on the grounds that they have negative consequences for these endangered species.

"In the Sacramento River, we have a history of exploitation and degradation going back to the gold rush," says Steve Lindley, a research ecologist with the National Marine Fisheries Service in Santa Cruz, CA, who was not involved with the research. "It's radically simplified the habitats that salmon depend on in the valley. In California, people have managed ecosystems with concrete. We build dams, line channels, and build flood control structures. Rivers need room to work, and they make salmon habitat if you let them. This research shows that sustainability depends on a healthy ecosystem, but our technological fixes to ecosystem problems usually have unintended consequences that make matters worse for salmon."

Salmon population loss is not confined to places with lots of people. The same activities that started eroding salmon diversity in the Columbia and Sacramento rivers a hundred years ago are spreading northward quickly.

"Bristol Bay, the most productive salmon ecosystem in the world, is facing decisions about major development proposals such as the giant Pebble Mine copper and gold mining facility, as well as hydroelectric dams," explains Stanford. "This research shows that the choices made in Bristol Bay today will help determine whether the fishery remains reliable for the next hundred years and beyond."

Hilborn adds, "Offshore drilling has also been proposed in Bristol Bay, and a spill similar to what we're seeing in the Gulf of Mexico could devastate this productive fishery. However the diversity in timing of migration to the ocean and age at maturation among different sockeye populations - that is, the portfolio effect - could afford them protection. In essence, protecting diversity is a form of insurance against the

unexpected."

The lessons from Bristol Bay will be important for communities that rely on sustainable ecosystems, as well as the decision makers charged with managing them.

"This is a ground-breaking piece of work," says Jeff Hutchings, a professor of biology at Dalhousie University in Canada and former chair of the Committee on the Status of Endangered Wildlife in Canada, who was not involved with the study. "It's the strongest evidence to date that there's a financial benefit to maintaining population diversity - and a greater chance that species can withstand environmental and human induced change. It's not done in a lab or in a tank. These are real rivers and a strong data set for a major fishery. If managers ignore this, they do so at their own peril."

Provided by University of Washington