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New Science Sheds Light on Rebuilding Fisheries

Business as usual threatens future of fish - Scientists call on managers to incorporate new scientific understanding into fishery plans

Washington D.C. (Press Conference: Saturday Feb. 19th, 1:00 PM Eastern) – In a scientific double whammy, researchers report that fishing pressure is causing fish to evolve to smaller sizes, just as new studies show that larger fish are critical to sustaining populations. In species such as Pacific rockfish, the big, old females not only produce exponentially more eggs than younger, smaller females, but their hearty larvae have a far greater chance of survival. Keeping these big fish in the water increases the chances of strong population numbers in the next generation – which is paramount to the recovery of overfished stocks.

Representing three fisheries science sessions from the American Association for the Advancement of Science (AAAS) meeting, Steve Berkeley of UC Santa Cruz, Larry Crowder of Duke University, Andy Rosenberg of the University of New Hampshire and a member of the U.S. Commission on Ocean Policy, and Jeremy Jackson of Scripps Institution of Oceanography highlight the latest advances in genetics, biology, and evolutionary science that point to new strategies for maintaining fisheries.

As a former leader in the National Marine Fisheries Service, Andy Rosenberg has faced the difficult realities of implementing new fisheries policies. "Over the last ten years the management struggle has been to begin to bring massive overexploitation under control, and that struggle has had *some* success – but rebuilding fish-stocks is another matter," says Rosenberg.

"Many scientists and managers are converging on similar issues – something is just not right with how we are doing things," says Steve Berkeley.

Old Fish Never Retire

Fishing disproportionately removes older fish - which are larger and more highly prized. In fact, management often seeks to shift fishing pressure to these older fish in an effort to let younger, fast growing fish reach spawning age.

Researchers have long known that older fish produce exponentially more larvae. A 50 cm Boccacio rockfish, for example, will produce nearly 200,000 larvae, while an 80 cm fish will produce ten times that - nearly 2 million. These larvae are released into harsh ocean conditions without parental care. For fish, spawning is like entering the lottery, and the older, larger fish have many more lottery tickets. "For northern cod, only one in a million make it to age three," says Jeff Hutchings of Dalhousie University. Similarly, for many species of Pacific rockfish, only a tiny fraction of

mothers – about one in a thousand - succeed in contributing to the next generation of fish, according to Daniel Gomez-Uchida of Oregon State University.

But scientists only recently discovered that the larvae of old fish also have better odds of survival. Berkeley started investigating this advantage after observing Pacific rockfish spawning patterns. He noticed that older females spawned early in the season. And when he looked at the next generation of fish, there were years when most of them had birthdates corresponding with these early spawning events. He wondered whether it was just the timing of release that mattered, or whether the older mothers were somehow giving their offspring a leg-up in life.

"I was astounded when I got the results," says Berkeley. "I suspected some difference, but not the overwhelming difference that we saw – survival rates were nearly three times higher, and growth rates were 3.5 times faster for larvae from older mothers."

Berkeley's team discovered that older mothers produce larvae with a larger oil globule, a sack lunch packed by mom that the baby fish relies on if faced with starvation. Early spawning can also give the larvae a boost when it coincides with peaks in zooplankton. By removing the big, old fish, we lose the benefits of their fecundity and superior larvae, and we also shorten the spawning season – all of which reduce the chances of a robust cohort of recruits the next year.

"Without the oldest females," says Larry Crowder of Duke University, "populations lose their best hope for the success of future generations - the resiliency that can compensate for overfishing."

"Rockfish can live to be 100 years old," says Berkeley. "People understand that you can cut down a 100 year old tree in five minutes, but that it takes 100 years to grow a new one. Old fish are the same way, they accumulate over decades, even centuries, and in a flash they're gone – we can remove them much faster than they can rebuild."

Evolution in Our Lifetimes

Having fewer and smaller fish may not bother the average consumer just yet, but creates a "Darwinian debt" for future generations. Researchers say that the evolutionary effect of fishing has been a blind spot for managers – overlooked, downplayed, ignored because of the complexity, or just not on the radar screen. "The truly worrisome aspect is that repairing evolutionary damage is vastly more difficult than causing it," says Ulf Dieckmann. "The debt we build up is increasing at a sky-high interest rate."

While many think of evolution as a slow, historical process, research by Jeff Hutchings (Dalhousie University), David Conover (Stony Brook University), Mikko Heino (Institute of Marine Research in Norway), Ulf Dieckmann (International Institute for Applied Systems Analysis in Austria) and others shows that by taking out the big fish, we are actually driving selection for smaller fish that mature earlier. Studies show fishing pressures can significantly change the genetic composition of fish populations in as little as 20 to 50 years.

"We see it in the models, in the lab, and in the real world – smaller fish and fewer of them," says Heino, a co-organizer of one of the AAAS fisheries sessions.

"Since these changes are genetic," adds Hutchings, "they are not readily reversible – we'll be stuck with them for a long time. No one wants that – fishermen or conservationists."

Scientists now have evidence that the age of sexual maturation in several populations of cod has been reduced by a quarter, and for plaice (a type of flatfish) nearly a third. "These examples are probably just the tip of the iceberg," says Heino. "We've detected fisheries-induced evolution in almost every species we've studied."

Researchers are also documenting the links between size and other traits that are key to long-term survival. In experiments with Atlantic silversides, size-selective fishing altered production by a factor of two in just four generations of fish. "And by selectively harvesting the largest fish, we end up changing the whole biology – not only growth rates, but egg size, fecundity, feeding behavior... even the number of vertebrae – we're changing an entire suite of traits," says Conover. "The scary part is that when we stopped size-selective harvest, the biology didn't change back…it was permanent."

"Resource managers and decision-makers need to be aware that fishing can cause genetic changes - changes to characteristics that are vitally important to the continuity of the population," says Hutchings.

Overfishing Can Reach A Point of No Return

Cod off the coast of Newfoundland - once one of the largest populations in the world – has suffered a 99% decline since the 1960s. Hutchings latest work shows that the changes in size and age at maturity caused by just 30-50 years of fishing have reduced the chance of cod's recovery by 25-30%. Hutching's findings confirm the importance of keeping old fish in the sea and may explain the failure of closures to bring about a rebound in the cod population.

Researchers suspect that this evolutionary change is happening with other stocks too. "We have this belief, that we can knock down fish populations to exceedingly low levels and they can bounce back rapidly," says Hutchings. "Not to say that it can't happen. But little or no recovery appears to be the general pattern. Unfortunately, it appears to be the exception that drives policy."

Genetic and ecological studies led by Ralph Larson of San Francisco State University point to an additional problem with current management. Larson's work shows that simply keeping enough spawners in the sea isn't enough to prevent populations from crashing – first you need the big fish, but you also need big fish throughout their geographic range. Each year only a subset of rockfish spawn successfully, and it's impossible to predict where these "winners" will be from year to year. "If we want to have more consistent levels of replenishment from year to year– rather than a boom and bust cycle – we have to protect spawners throughout their range," he says.

Solutions

While the scientists acknowledge that there is no quick and easy way to integrate the true complexity of fish population dynamics into management, they all point to the need to preserve large, old fish and maintain the balance of age classes in the population.

"If the new studies are widely applicable to other species, then it isn't a question of doing a *better* job, it is a question of doing a *different* job. The old management tools will not work to protect age

structure or genetic diversity, or prevent local depletions – we'll have to use new tools to achieve new objectives," says Berkeley.

Crowder calls for new strategies that address cumulative impacts on fish populations and protect entire segments of struggling populations. "We have to move toward true ecosystem based management," he explains. "Commercial and recreational fishing have reduced top predators to a remnant of their former abundances, but pollution and nutrients from the land also drive fish, crabs, and shrimp to suboptimal habitat, making it even harder for these populations to recover – it's in fact a triple whammy."

One approach consistent with ecosystem-based management is ocean zoning. "Some areas might be totally protected, some closed seasonally, some open to commercial fishing, some only open for recreational fishing and so on," says Berkeley. "As far as protecting age structure and maintaining big old fish, I can't come up with anything better than a marine reserve-type approach where you protect a segment of the population from fishing. There may be other approaches that would work, but I think we know enough to get a good start on a network of marine reserves."

"We need to protect some fish of all ages, genetic diversity and a functioning marine ecosystem if we expect to recover the huge losses have incurred by overexploitation in the past," says Rosenberg. "We have been ingenious enough to figure out how to overexploit a very big ocean. We must now be ingenious enough to figure out how to deal with the complexity and regain our lost resources."

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MEDIA NOTE: The scientists will discuss their findings in three sessions at AAAS: *Evolutionary Fisheries Science* (Friday, 8:30 AM); *New Findings Challenge Foundations of Fisheries Management* (Saturday, 8:00 AM); and *Recovering our Lost Legacy: Science and Policy to Restore Overfished Seas* (Sunday, 1:45 PM). For assistance contacting the speakers during AAAS please call Jessica Brown at #202-497-8375.

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