A matter of scale. Selective catches of Atlantic silversides (above) left genetic legacies.

some stocks from swimming down dangerous evolutionary paths. "Managers haven't focused enough on the long-term, Darwinian consequences of selective harvest," says one author, ecologist David Conover of the State University of New York, Stony Brook. Some biologists, however, say the lab-based results lend little to the current debate over how best to protect teetering populations.

Scientists have already suggested that some fish populations are evolving rapidly in response to heavy fishing. Several cod and salmon stocks, for instance, appear to have shifted to smaller, earlier maturing fish as fishers systematically removed larger and older specimens. But wild populations can be difficult to study, so fishing's genetic impacts have remained in dispute.

To get a clearer view, Conover and graduate student Stephan Munch moved to the more manageable confines of the lab. Four years ago, using eggs collected from wild stocks, they hatched six captive populations of Atlantic silversides. Then they went fishing. From each school of 1000, they removed 90%. In two of the tanks, they took the largest fish; in two others, the smallest; and in the remaining control tanks, the harvest was random. After allowing each school to rebound to its original size, they repeated the process for four generations, charting how the size, weight, and growth rates of the populations changed over time.

The results were dramatic. Population characteristics in the random-catch tanks, as expected, stayed relatively even. But the balance disappeared with other methods. Taking the bigger fish produced a catch that was initially heavier than in controls. The average weight of individual fish soon shrank, however, and by the fourth generation, the catch was substantially smaller than in controls. In contrast, taking the smaller fish produced a catch that was lighter at first, but the hauls and the individuals grew heavier over time.

The rapid shifts in the selectively culled populations were due to inherited genetic changes, the authors say. The same thing is happening in the wild, they speculate, although on a much slower timetable, due to the greater size and age diversity of natural stocks. As a result, "management practices meant to maintain [robust catches] may be having the opposite effect over the long run," says Conover. The pair recommend establishing more reserves that are off-limits to anglers and regulations that protect larger fish as well as smaller ones.

Several fisheries scientists, including Felicia Coleman of Florida State University in Tallahassee, say the findings suggest that those ideas are on target. But others, including Carl Walters of the University of British Columbia in Vancouver and Ray Hilborn of the University of Washington, Seattle, say the experiment is far too limited to support major management changes. "All they have done is show that growth rates are heritable; what they haven't done is see what the impact of this would be on a realistic fishery," says Hilborn. **–DAVID MALAKOFF**

CREDITS: (TOP TO BOTTOM) D. CONOVER; PHOTODISC

COMPUTER SCIENCE

Collective Effort Makes The Good Times Roll

Two wrongs don't make a right, but two dozen of them might. A pair of physicists has found that groups of imprecise clocks can collaborate to tell time with remarkable accuracy. Their findings might one day help computers tackle tough problems as a team.

Scientists and engineers know the difficulty of extracting accurate information from a collection of imperfect devices, such as a clutch of clocks. Every clock gives a slightly different reading, and the problem is how to combine those readings to get the best estimate of the time. The most obvious solution is to average readings from all the clocks—a strategy once employed by sailors at sea—but the inaccuracy decreases only slowly as the number of clocks increases. For example, to get an estimate 10 times more accurate than that of a single clock, a timekeeper would need about 100 clocks.

On time. Working together, imprecise clocks can keep good time.

A far better way is to read only some of the clocks, report physicists Damien Challet and Neil Johnson of Oxford University. In a computer study, the researchers simulated collections of clocks with readings distributed around the correct value according to a bell curve. They then took the reading of each clock individually, the average reading for each possible pair of clocks, the average reading for each group of three, and so on. By trying every subset, Challet and Johnson found that they could usually identify a combination containing roughly half the clocks whose average reading was far closer to the correct time than the simple average of all the clocks, as they report in the 8 July issue of *Physical Review Letters*. For example, starting with 20 clocks, they typically found a subset of about 10 whose inaccuracies compensated for one another almost perfectly, so that their average was 100,000 times more accurate than was the average of all the clocks.

Moreover, Challet and Johnson proved mathematically that in certain cases, it is relatively easy to compute the best combination, given the amount by which each clock is fast or slow. That implies that a technologist should be able to figure out how to cobble together a nearly perfect machine from a basket of faulty parts after simply checking the inaccuracy of each part.

The work is an important step in the study of "collectives," groups of autonomous agents that conspire to achieve a common goal, says David Wolpert, an expert in complex systems at NASA's Ames Research Center in Moffett Field, California: "Things become really interesting when the agents aren't little clocks but computer chips." Such studies will be crucial, Wolpert adds, as computers evolve from machines that perform specific tasks, by following strict rules, to more adaptable entities that can work together and find their own ways to solve larger problems.

–ADRIAN CHO

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