Northeast Fisheries Science Center

Science Spotlight

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Fish Follow the Leader: Acoustic Research on Atlantic Herring Aids Understanding of Group Behavior

Technique Could Help Estimate Fish Stocks Over Wide Areas of Ocean

Like other species, Atlantic herring play "follow the leader," quickly forming large social groups called shoals containing hundreds of millions of fish that migrate as a group. Little has been known until recently about how these fish shoals form and behave, but thanks to a new acoustic tool, scientists can now monitor fish populations over huge areas, hundreds to thousands of square miles, in a matter of minutes.

The research findings, reported in the March 27 issue of *Science,* document the group behavior of Atlantic herring (*Clupea harengus*), which are known to regularly and abruptly form into large shoals. NOAA scientists and colleagues from the U.S. and Norway used Ocean Acoustic Waveguide Remote Sensing (OAWRS), a technique that uses sound to detect, locate and record images of fish. They also used conventional fish-finding sonars and capture by nets for the 2006 experiment during the herring spawning season on Georges Bank.

Mike Jech, a research fishery biologist at the Northeast Fisheries Science Center (NEFSC) laboratory of NOAA's Fisheries Service in Woods Hole, Mass. and a study co-author, says the researchers used historic data from the center's annual surveys to find locations where herring shoals were most likely to form. Georges Bank is one of the primary spawning grounds for herring, an important ecological and commercial species, making the herring population there an ideal group to study.

"The herring seemed to come out of nowhere along the ocean floor to what appears to be a very specific location in the water column within a matter of minutes just before sunset, and then queue up and spread horizontally as a very dense cluster of fish," said Jech. "The speed at which these clusters of millions of fish formed and moved in a synchronized fashion suggests they are using coordinated communication that travels through the shoals much faster than an individual fish can swim. The shoals sometimes covered 25 miles until the herring dispersed as the sun came up."

During the field experiment, researchers using the OAWRS system directed the NOAA ship *Delaware II*, based at the center's lab in Woods Hole, and the University of Delaware's *Hugh Sharp* to monitor suspected fish shoals. The two ships, operating conventional fish-finding sonars and towing pelagic nets, surveyed these shoals to confirm that these were composed of

Atlantic herring. The OAWRS system used a moored acoustic source, deployed from the University of Rhode Island vessel *Endeavor,* which takes advantage of oceanographic features to transmit sound long distances using much lower levels than conventional fish sonars, and a towed receiver on the Woods Hole Oceanographic Institution vessel *Oceanus* to locate and monitor the vast shoals.

Atlantic herring migrate from summer feeding grounds in the Gulf of Maine to Georges Bank for spawning in September and October. The study found that once the fish banded together in vast shoals, they migrated toward spawning grounds on the northern flank of Georges Bank, crossing bathymetric contours onto the bank to spawn.

Using traditional optical, acoustic and tagging methods, researchers can only sample a small fraction of a shoal during an entire survey and can not distinguish changes over time and space simultaneously. However, recent developments in OAWRS have enabled scientists to study shoaling fish using sound on continental-shelf scales by instant imaging and continuous monitoring over tens of thousands of square miles.

The authors believe the biological reason the Atlantic herring shoal at night and in deeper water may be that it is better for group spawning, when each female must produce many eggs within an hour or so. The behavior may also help the herring avoid predators like pilot whales, porpoises, tunas and other marine life that seek prey in shallower spawning grounds at night.

The researchers found that certain environmental and biological conditions have to be in place for shoal formation to occur. A few leaders must emerge from their hiding places on the bottom, perhaps triggered by declining light levels. Then there must be enough individuals that join the leaders to reach a critical mass, which then forms into a highly organized structure about hour before sunset. These dense layers form at a few locations in a matter a minutes.

The authors note that “the rapidity, synchronicity and regularity with which these vast oceanic fish shoals form provide ecosystem-scale evidence for the extreme biological pressures on individuals of some species to conform to large social groups.”

“In this case the group has an advantage over an individual in terms of spawning, avoiding predators and feeding, yet just a few leaders can have a significant influence on a very large group,” Jech said. “This study provided evidence that what has been theorized and studied in the lab in terms of group behavior actually happens in the wild. That knowledge may help us in conservation and management of the herring fishery.”

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