Statistical modeling helps fisheries managers remove invasive species

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South Dakota Game Fish and Parks biologists Dave Lucchesi and Todd St. Sauver, front; South Dakota State University graduate student Matt Hennen, in orange cap, and crew members from the Dave Raw Fish Company in Minnesota, remove carp from Lake Norden in Hamlin County, South Dakota. Credit: South Dakota State University

Reeling in a big fish and discovering it's a common carp is often a disappointing experience for anglers. "They're an invasive species," explained South Dakota State University fisheries scientist Michael Brown. One of the primary methods of reducing the abundance of such invasive species is to physically remove them from the lake, but timing is crucial.

However, collaboration among South Dakota State statisticians and natural resource management researchers may help fisheries managers determine the best time and location to capture and remove a maximum number of this invasive species from lake systems.

Damaging lake ecosystem

Carp feed on bottom-dwelling macroinvertebrates, such as bloodworms, by sucking up the mud, then selecting their food and ejecting most of the non-food portion. This feeding technique dislodges vegetation and stirs up sediment, which makes the water cloudy and causes nutrient release and algal blooms, Brown explained. These actions degrade the quality of the lake water and impact native fish populations.

"Carp are not a preferred species, so they go untapped in terms of angler harvest," Brown explained. Consequently, commercial harvest is one of the methods used to decrease carp populations. But figuring out where and when to "cast their nets" to harvest a maximum number of carp involves complex modeling—that's where the statisticians can help.

Wildlife and fisheries graduate student Matt Hennen, left and South Dakota Game Fish and Parks biologist Brian Blackwell, who earned his doctoral degree at SDSU, insert an ultrasonic transmitter into an adult carp. Credit: South Dakota State University

"Fisheries scientists can answer basic questions, but when it comes to

extensive modeling approaches that add certainty to your conclusions, it's wise to consult with the people who do this on a daily basis," Brown said.

To track fish movement, wildlife and fisheries graduate student Matthew Hennen implanted ultrasonic transmitters in 19 carp in Round and Brant lakes, which flow into the Big Sioux River and eventually into the Missouri River in eastern South Dakota. Using fixed station, under-ice receivers, Hennen collected data on carp movement for 168 days beginning November 2007 and for 128 days beginning in November 2008.

The research was funded by the South Dakota Game, Fish and Parks Department through a Federal Aid to Sportfish Restoration grant.

Evaluating modeling approaches

After doing his initial analyses, Hennen took the data to the Department of Mathematics and Statistics. Associate professor Chris Saunders, whose research focuses on developing computationally efficient algorithms for statistical learning and pattern recognition, and graduate student Doug Armstrong evaluated two modeling approaches— the multinomial model and Bayesian hierarchical Markov model.

Ten stationary submersible receivers were placed in Brant Lake to track the movement of adult carp equipped with ultrasonic transmitters. Credit: South Dakota State University

To reduce the complexity of the modeling, the statisticians transformed the raw data to a function of discrete time measured in days and combined detection zones to reduce the number from 10 to five.

The Markov model assumes that where a carp is on a given day is a function of its location(s) the previous day, while the multinomial model predicts movement independent of current location, which makes it less sensitive to changes in the system. Consequently, the more complicated

Markov model detected a sudden increase in carp dispersal activity in mid-February 2007 that the other model did not. Therefore, the Markov model was better at predicting carp movement.

The Markov simulation showed that carp segregated in a small, deep area in the northwest portion of Brant Lake during the latter two weeks in January, which is when efforts to remove carp would be most productive.

"As with any modeling approach, vetting it through multiple studies increases the level of inference and degree of certainty so that when the model is applied in subsequent cases, it will have the same result," Brown said. "This collaboration gave us more confidence in our findings."

The Minnesota Department of Natural Resources has since applied this approach by implanting telemetry tags in a few carp, referred to as "Judas" fish, to locate them during the under-ice segregation period, according to Brown. Once located, commercial fishermen can deploy large seine nets that encircle the area and effectively remove a large portion of the carp population.

More information: Douglas E. Armstrong et al. Modeling common carp under-ice movement using hierarchical Markov simulation, *Ecological Modelling* (2016). DOI: 10.1016/j.ecolmodel.2016.04.014

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