2016

Developing a Modified Study to Monitor Predator Response to Dam Removal in Penobscot Bay 2016

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Developing a Modified Before/After, Control/Impact Study to Monitor Predator Response to Dam Removal in Penobscot Bay

A Preliminary Report

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A Before/After, Control/Impact Study Examining Predator-Prey Dynamics in Penobscot Bay Post Dam Removal

Overview:

This year we received funding to pursue an additional research question testing cod recovery and its link to the Penobscot River Restoration. The project uses Sentinel Survey sampling methods and is able to incorporate some stations in both projects. In a modified BACI design (Before-After-Control-Impact) we used the Sentinel Survey jigging protocols to fish on historic cod spawning grounds (Ames 1997) in Penobscot Bay during the months when juvenile alewives have been shown to be present on those grounds by the Maine-New Hampshire Inshore Trawl Survey. At the same time we sampled historic cod grounds further east where there has been less recent river restoration. Our intention is to repeat this annually for the next 3-5 years, to test whether the rebounding alewife populations in the Penobscot are resulting in a groundfish response.

Background:

Atlantic cod (*Gadus morhua*) once dominated the Gulf of Maine's coastal zone as an apex predator (Bigelow and Schroeder, 1953). The sequential depletion and collapse of this iconic and economically important species is well documented. Despite virtually no fishing effort on groundfish in this area for the past 20 years, cod have failed to recover. One hypothesis to explain the failure of this recovery is that loss of forage fish has reduced prey availability. Recent river restoration efforts on the Penobscot River in Maine provide a time-sensitive opportunity to test the forage fish hypothesis.

The Penobscot River has the second largest watershed in New England (8,570 square miles). Since the early 1800s the river has been dammed and spawning habitat for diadromous fish species including river herring (*Alosa pseudoharengus*) was severely constrained. Beginning in 2012 several of the major dams were removed as part of a collaborative effort between state, federal, tribal, and private partners. The removal of these dams has opened approximately 1,000 miles of spawning habitat. This represents one of the largest river restoration projects in US history in terms of restored spawning habitat. Coincident with this habitat restoration the Maine Department of Marine Resources initiated a river herring enhancement program, releasing approximately 140,000 fish from 2010 to 2015. These parallel efforts have facilitated a rapid increase of river herring in the system. In 2016 1.26 million returning fish were counted at the Milford Dam on the Penobscot River and higher returns are expected in subsequent (Note: Historical runs are estimated to have been between 14 and 20 million fish).

The precipitously low levels of Atlantic cod in the Gulf of Maine provide motivation to understand the role diadromous fish can play in facilitating stock recovery. Our hypothesis is that the restoration of river herring in the Penobscot River (and other large Maine rivers) will increase the concentration of local lipid-rich prey species to a level that is necessary for Atlantic cod to eventually rebound in the eastern Gulf of Maine – after being depleted for the past two to four decades. In the short-term we predict an increase in the local abundance of sub-adult and adult cod that are attracted by the lipid rich prey and thus persist and reproduce in this system. Given the scale of the Penobscot River system and its estuary and the magnitude of the restoration effort that has occurred, evidence of this predator-prey relationship would be of

major significance to the entire New England fishing industry, including but not limited to those directly invested in the groundfish sector.

Methods

Program Design

We have begun to use a modified Before-After-Control-Impact (BACI) design that includes three sampling stations within Penobscot Bay (Impact) that were subject to river restoration, and three stations in adjacent areas (Control) that were not subject to river restoration (**Figure 4**). We used historical data to ensure that these stations are independent and aligned the sampling schedule with periods when cod were historically caught in the region.

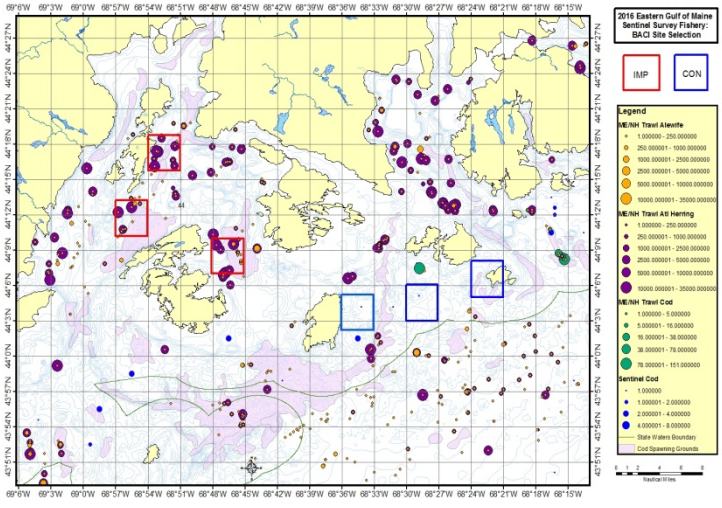

Figure 4: 2016 BACI Stations Map

Stomach and tissue samples were collected at these sites to determine diet along with other biological data necessary to determine size and age of fish. Using stomach and tissue samples as complementary methods to understand the predator-prey relationship will provide information about short- and mid-term diet of cod. Additionally, data collected in the study area from the past seven years of the Sentinel Survey (random stratified jigging stations) and Maine's inshore trawl will serve as a second layer of "Before" data. In taking this approach, we have spatially (control sites vs. impact sites) and temporally (proposed sampling data vs. prior Sentinel data) discrete data. Fishermen captain the vessels used for this sampling effort, and will continue to be crucial toward planning and interpretation of results. Continuing to collect data for this research program will be essential to monitoring a potential recovery of a historically commercially important species. This program can provide an important framework for other river restoration projects around the world, and have significant implications for the dynamics of predatory finfish.

Sampling Methods

Each station was sampled using the Sentinel Survey jigging sampling methodology, modeled after a after a hook and line survey used in a west coast stock assessment of Bocaccio rockfish (Harms et al., 2010). There were two anglers per station sampled. Each angler had jig gear consisting of a five-pound diamond jig, with three un-baited hooks attached approximately a foot apart vertically. Each hook had a different lure attached. Anglers dropped each jig simultaneously, and fished for 5 minutes at each station. If the angler caught a fish before the five minutes expired, they were not allowed to re-drop. A total of five drops were completed per station type. All control stations were sampled one day

per week, and all impact stations were sampled on a different day that same week. Therefore, a total of fifteen drops per week, per station type were conducted. The survey spanned for five weeks in the fall (September-October).

For each fish captured, length and weight were recorded. Depth, bottom sediment type, sea-surface temperature, bottom temperature, wind speed and direction, and sea condition were recorded for each drop. Stomach samples and otoliths were taken from Atlantic cod for diet and age structure analysis. Tissue samples were collected for pollock and cod for stable isotope analysis. Photographs of cod were taken for collaborative morphometric studies.

Results (Preliminary)

We evaluated the average catch of cod per week, per station type for the five-week sampling period. We found that, for almost every week, there was a higher average catch of cod at control stations than at impact stations (**Figure 5)**. Additionally, we looked at catch composition for all weeks at control and impact sites. We found that at control sites, pollock made up 57% of catch for all weeks, mackerel made up 26% of catch, and cod made up 16% of total catch (**Figure 6**). At impact stations, mackerel made up 85% of the total catch, cod made up 10%, and black sea bass and herring made up 2%, respectively (**Figure 7).**

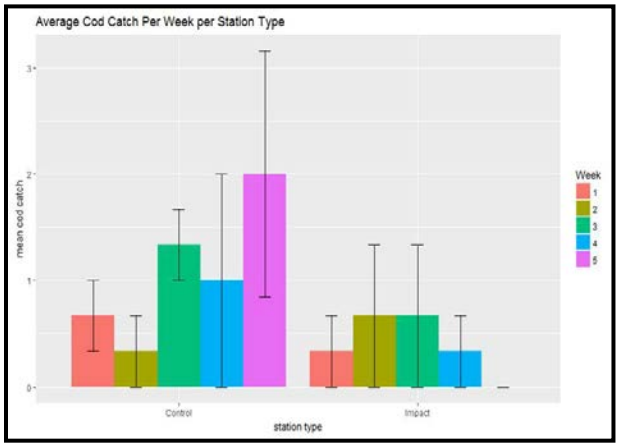

Figure 5: Average Cod Catch per week, per station type

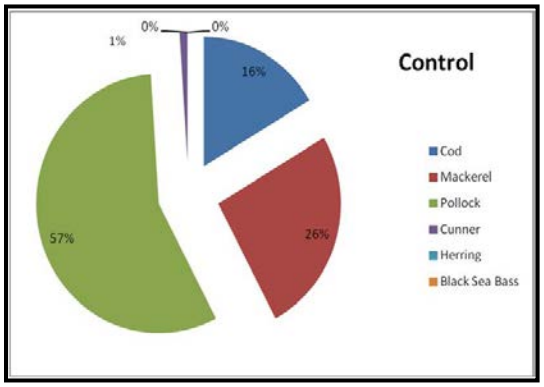

Figure 6: Total catch at all control stations in 2016

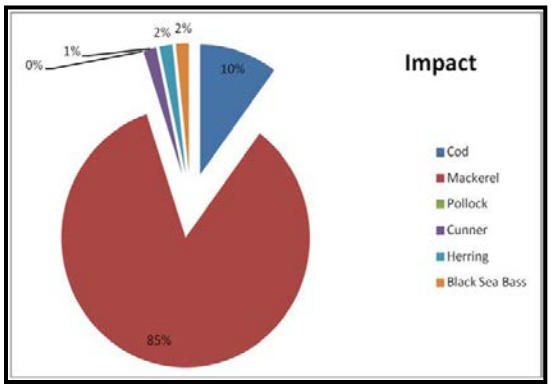

Figure 7: Total catch at all impact stations in 2016

Future Steps

We have collected stomach samples, tissue samples, and otoliths as well as length/weight information for those species caught as part of the BACI sampling program. The data collected from the program will be compared with data from the Sentinel Survey, which has important pre-dam removal information.

At impact stations we had catch of Atlantic cod at stations where there is no recorded catch by the Maine/New Hampshire Inshore Bottom Trawl Survey, or the Eastern Gulf of Maine Sentinel survey, for the last 10 years . It is our hope that, with continued sampling, we can establish a robust time series in this region. It is crucial that post-recovery events be adequately captured by efficient monitoring programs. Additionally, it is important that coastal community members who will be impacted by a recovery event are directly involved in the scientific monitoring process, and who can help strategize potential management outcomes from the scientific advice developed for the region.

Works Cited

Bigelow, H.B., Schroeder, W.C., 1953. Fishes of the Gulf of Maine. Fishery Bulletin of the Fish and Wildlife Service.

Harms, J.H., Wallace, J.R., Stewart, I.J., 2010. Analysis of fishery-independent hook and line-based data for use in the stock assessment of bocaccio rockfish (*Sebastes paucispinis*). Fisheries Research 106, 298–309.