Evaluation of Ecosystem Services of Shellfish Culture Operations in North Carolina

SHARES
SHELLFISH AQUACULTURE IN RESERVES: ECOSYSTEM SERVICES

Project Location
North Carolina

Project Duration
November 2016 to June 2020

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Project Type
Collaborative research – Generating science that informs decisions

Products
- Decision-support tool for aquaculture siting
- Project results summary fact sheet and slides
- Five project data sets
- Calibrated models of North Carolina oyster farms
- Several student theses and scientific publications

Project Partners
- Longline Environment Ltd
- North Carolina National Estuarine Research Reserve
- NOAA Centers for Coastal Ocean Science
- Oregon State University
- University of North Carolina Wilmington

Project Webpage
nerrssciencecollaborative.org/project/Darrow16

Overview

North Carolina's shellfish aquaculture industry remained small but stable for many decades, but has experienced significant growth over the past 4 years due to both increased demand and regulatory changes that are creating a climate for growth. With a popular wild oyster fishery and growing interest in creating new oyster farms, natural resource managers need additional science to help them weigh risks and benefits and decide where and when to permit new oyster aquaculture leases. Wild oyster populations provide a range of well documented ecosystem services, including improving water quality and providing habitat for a suite of other aquatic animals. When this project began, there were limited data and no clear consensus about whether shellfish aquaculture, as used in North Carolina coastal waters, had similar benefits.

To help inform oyster farm siting and permitting, this project evaluated the potential ecosystem services and impacts of newly established oyster farms in intertidal and subtidal coastal areas. The project combined intensive field sampling with lab experiments and farm-scale modeling to study water quality and ecological impacts. The project generated information, visualization tools, locally calibrated oyster farm models, and a decision-support framework to help resource managers and oyster growers assess locations and scales of aquaculture operations. Project results have been shared with state agencies and newly formed committees tasked with guiding the expansion of shellfish aquaculture in North Carolina.

Project Approach

Project end-users were decision-makers on shellfish aquaculture siting within the North Carolina National Estuarine Research Reserve, including the North Carolina Division of Marine Fisheries, North Carolina Department of Natural and Cultural Resources, reserve managers, and oyster growers. The end-users and others interested in this issue were incorporated into a stakeholder group to help guide research questions and evaluate results. Together, the group established a decision-support framework, refined a list of parameters to evaluate, and decided on study sites.

The stakeholder group was updated through semi-annual meetings and newsletters, and was asked to provide feedback as data products were developed and refined.

To evaluate the ecosystem services associated with oyster farms, the project team conducted intensive sampling in and adjacent to oyster farms, concentrating on wild shellfish resources and the physical and chemical environment. The team measured a suite of ecological variables for two years after establishment of oyster farms in the Masonboro component of the North Carolina Reserve and in a newly established, larger farm outside of the reserve in the New River. The study parameters focused on water and sediment quality, wild shellfish health, and abundances and diversity of oyster reef-associated estuarine species (epibenthic and nekton).

The project team also collected data on cultured oyster physiology using controlled lab experiments, and combined this with field data on environmental drivers and farm practices from three sites to develop farm-scale models. Locally calibrated Farm Aquaculture Resource Management (FARM) models were used to calculate oyster farm production, nitrogen sequestration, and impacts on phytoplankton using different scenarios typical to North Carolina. The FARM model also enabled the team to quantify the dollar value of ecosystem services, including nitrogen removal from North Carolina oyster farms and estuaries.

Results

The project's combination of lab, field, and modeling approaches allowed for a robust evaluation of potential positive and negative impacts of oyster farms. Several scientific articles discuss the results in detail. A few highlights are explained here.

- *Water quality and food:* Oyster farms did not affect the availability of plankton in the water that serves as food for farmed oysters and many other animals, and oyster feeding and excretion did not increase levels of nutrients in the water or degrade water quality. This is based on repeated measurements of chlorophyll, particulate carbon and nitrogen, total suspended solids, and nitrate and ammonia within and outside of farms.
- *Nitrogen mitigation:* Locally calibrated models of three specific oyster farms revealed that each significantly removed nitrogen from the water as the oysters fed on plankton and incorporated nitrogen into their shells and bodies. The farms removed 50 to 230 kg of nitrogen per acre, per year. This water quality service can be conservatively valued at $1,600 to $7,300 per acre, per year based on costs associated with providing an equivalent level of wastewater treatment.
- *Sediment:* One of the three oyster farms studied show some evidence that nutrients were building up in the sediment below the farm during certain seasons, particularly in September 2018 after Hurricane Florence.
- *Wild oysters:* Wild oyster populations close to shellfish aquaculture operations showed some signs of increased stress compared to control reefs. The team looked at seven genetic biomarkers of stress in wild oysters and found that measurements of gill tissue provided a sensitive indicator of potential stress. However, there was no evidence that oyster farms were negatively affecting oyster growth or recruitment on nearby natural reefs. In fact, the team measured higher numbers and larger wild oysters on reefs closer to the farms.
- *Adjacent reef communities:* Studies of aquatic animals living within and around the reefs showed variability over time, but no signs of impact from adjacent oyster farms.

The project team was able to document the ecological impacts of Hurricane Florence, which dumped 24 inches of rain on the area in September 2018. They found surprisingly high numbers of larval oysters settling on test plates and natural reefs in the weeks following the storm.

Benefits

- Project results have been summarized in a variety of formats to help the project stakeholder group apply and share results. The project's decision-support tool was applied to two North Carolina oyster farm sites and illustrated that there were no significant environmental impacts that should deter the development of appropriately sized oyster farms.
- Project stakeholders reported a new understanding of the impacts and benefits of shellfish aquaculture and new ideas about how oyster farms could be strategically placed to maximize benefits for water quality and local economies. Participating stakeholders reported stronger relationships across sectors and all agreed that the new information would be useful for their work.
- Ten undergraduate and graduate students were deeply involved in this project, leading to eight theses.
- Three project team members served on the North Carolina Policy Collaboratory's Shellfish Mariculture Advisory Committee. Preliminary project findings informed this committee's recommendations on how to balance growth and impacts of shellfish aquaculture in North Carolina. Based on the committee's work, new legislation supporting growth of the shellfish aquaculture industry was passed into North Carolina State Law in 2019 (S.L. 2019-37), including refined guidance on aquaculture siting and avoidance of user conflicts.

What's Next

During the project, state agencies made the decision to not renew leases for the two oyster farms studied in the Masonboro component of North Carolina Reserve based on social and legal considerations separate from this project's focus. Project findings also have relevance for North Carolina coastal areas and have helped inform efforts to promote shellfish aquaculture in the state.

This project helped identify some remaining research questions that are relevant to coastal management, for example: 1) How do ecological services change over time as oyster farms age or increase production; and 2) Social considerations could be included in future studies of a location's carrying capacity for shellfish aquaculture.

In a companion study, project partners found that 11 of the 29 national estuarine research reserves currently host shellfish mariculture. There are few reported environmental impacts noted to date; this study helps to document and explore policies surrounding placement of oyster farms in coastal areas protected by reserves.

About the Science Collaborative

The National Estuarine Research Reserve System's Science Collaborative supports collaborative research that addresses coastal management problems important to the reserves. The Science Collaborative is managed by the University of Michigan's Water Center through a cooperative agreement with the National Oceanic and Atmospheric Administration (NOAA). Funding for the research reserves and this program comes from NOAA. Learn more at nerrssciencecollaborative.org or coast.noaa.gov/nerrs.