Lessons in Mariculture

Lesson 7: Open Water Marine Finfish Aquaculture and Its Environmental Impacts

Objectives:

By the end of this lesson, students will be able to:

1. Explain some of the environmental impacts of open water marine finfish aquaculture.

2. Identify environmental sustainability best practices for open water marine finfish aquaculture operations.

Overview:

All types of farming can affect the environment — positively or negatively. What are the impacts of marine aquaculture, and specifically the practice of growing finfish in open marine water environments? This type of aquaculture can result in nutrient pollution if excessive fish feed and fish waste are released into the environment. In this lesson, students will learn about a variety of environmental concerns related to open water marine finfish aquaculture and explore potential solutions.

Science Standards:

EEn.2.2.1
• Explain the consequences of human activities on the lithosphere (such as mining, deforestation, agriculture, overgrazing, urbanization and land use) past and present.

EEn.2.4.1
• Explain various water uses by humans and evaluate for benefits and consequences of use (e.g., wells, aquifer depletion, dams and dam removal, agriculture, recreation).

EEn.2.7.3
• Explain effects of human population growth, habitat alteration, introduction of invasive species, pollution and overharvesting on various plant and animal species in North Carolina.

EEn.2.8.2
• Critique conventional and sustainable agriculture and aquaculture practices in terms of their environmental impacts.

Grade Level: 11-12

Duration: 1 class period

Sea Grant North Carolina
UNC-SG-19-08.7

Vocabulary:

benthos: flora and fauna found on the bottom, or in the bottom sediments, of a sea, lake or other water body; these organisms are usually scavengers or feed on dead organic material

biosecurity: protection against the incursion or escape of potentially harmful or undesirable organisms

ecological carrying capacity: the maximum population of a species or biomass that an area or specific ecosystem can support indefinitely without deterioration of the character and quality of the resource

effluent: discharge of pollutants or waste; aquaculture operations must manage effluents, such as feces and food particles, into the environment

NGO: non-governmental organization, and typically a not-for-profit group independent of government that is dedicated to a particular social cause or advocating for a certain point of view

nutrient assimilation: absorption of nutrients into a biological system

nutrient loading: process in which nutrients, mainly nitrogen and phosphorus, travel to water bodies and can act like fertilizer, potentially causing excessive growth of algae and nutrient pollution

pelagic: relating to the open sea; pelagic fish inhabit deeper waters far from the coastline

Background:

Increased aquaculture production can have adverse impacts on the environment if sustainable and responsible methods are not used. It is important to determine which technologies and practices can mitigate problems. This activity addresses environmental concerns related to open water marine finfish aquaculture, including water pollution, disease transmission to wild stocks, fish escapes and the sustainability of fish feed sources.

Open water marine finfish aquaculture generally relies on net pens, depicted in the following illustration. This culture method confines fish in a mesh enclosure in a marine environment like the ocean. Water moves freely between the net pen and marine environment. Salmon are commonly grown with this aquaculture method. North Carolina regulations currently prohibit open water marine finfish aquaculture.

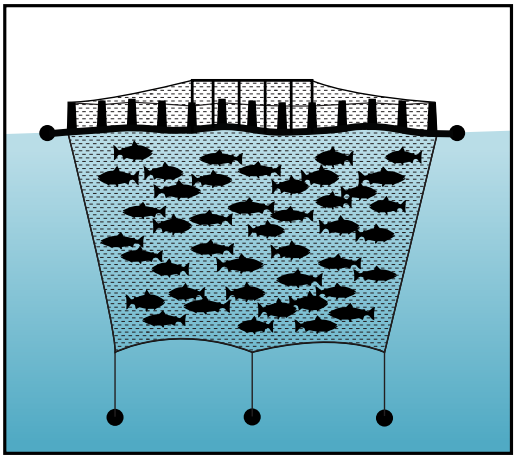
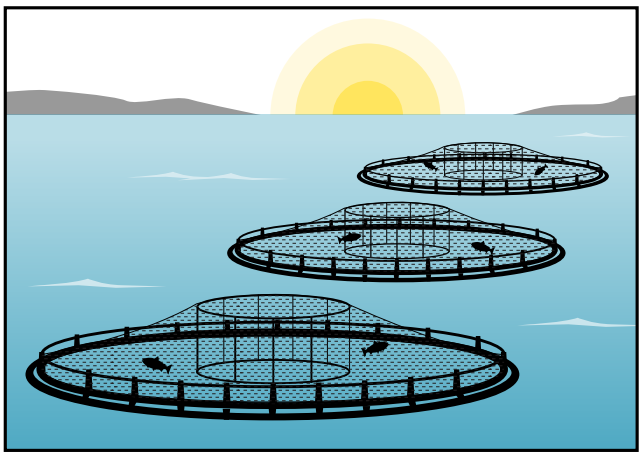


Figure 1. Underwater view of net pen aquaculture

When nutrient inputs from net pen operations exceed the physical, chemical and biological capacity of the ecosystem to assimilate them, negative effects on water quality and surrounding

benthos can occur. Uneaten feed and fish wastes are the main sources of excess organic nutrients. Because nutrients disperse directly into the marine environment, effluent treatment is not feasible. To optimize fish growth and nutrient assimilation, fish farmers seek to manage nutrient waste through sustainable aquaculture practices. Those can include efficient feeding practices, as well as favorable farm orientation and pen configurations.



Melissa D. Smith

Figure 2. Aerial view of net pen aquaculture

Other concerns related to open water marine finfish farming include escaped fish, as well as transmission of diseases and antibiotic resistance from farmed to wild fish. The free movement of water between net pens and the open marine environment allows for pathogen transfer, and sometimes facilitates fish escape. A fish farm's success hinges on its ability to market fish that are healthy, with high survival rates.

Fish farmers employ various methods to control fish movement and disease events. Those methods can involve optimizing the physical infrastructure of the farm, biosecurity measures like reducing disease pathways, fish vaccines, appropriate nutrition, appropriate rearing densities and other fish health practices.

In general, farmed fish are fed diets containing fish meal and fish oil that are sourced from wild fisheries. Indeed, about 70% of fish meal and oil comes from small pelagic fish such as sardines, anchovies, menhaden and capelin. The rest uses processed fish remains generated by wild and farmed fish alike. The heavy reliance on wild fisheries for aquaculture feed is a major challenge to the sustainability of those stocks, and is a limiting factor in the growth of marine finfish aquaculture.

Modern fish feeds are formulated from a variety of ingredients to provide a balanced mix of essential nutrients and energy at the lowest practical cost. However, the cost of fish meal and oil has risen dramatically since the early 2000s, spurring interest in the development of new formulations for fish feed. Soybean oil is a leading substitute protein.

Activity:

Students will watch two videos on open water marine finfish aquaculture. Both videos feature farms using innovative and environmentally responsible practices. While watching the videos, students should answer the questions on the Student Worksheet at the end of this lesson.

Question and Answer Key:

VIDEO A. Island Farmer Spotlight: Kampachi Farms. (5:00). *RACPacific* http://www.kampachifarm.com/projects

1. What is the tremendous breakthrough in marine open water aquaculture, according to Neil Sims, co-founder and co-CEO of Kampachi Farms? **Kampachi, which is also known as Hawaiian yellowtail or almaco jack, can now be grown in a hatchery. [A hatchery is a mix of a laboratory and a farm; it is where fish and shellfish are spawned, then hatched and cared for.] Aquaculture farms require a steady, predictable source of juveniles from hatcheries in order to stay in operation and provide a consistent product.**

2. What are two sources of alternative fish feeds that Kampachi Farms is experimenting with? **Soy-based diets and proteins sourced from fish waste discarded by the fishing and food processing industry are alternative fish feeds used. These alternatives reduce the need for wild-caught fish meal and fish oil.**

3. Which ecologically threatened fish species is Kampachi Farms growing? **A local species of grouper (*Epenephelus lanceolatus*) and an herbivorous local fish called the nenue (*Kyphosus spp.*) are being grown. The Pacific giant grouper, for example, has been so overfished that it is one of the rarest coral reef fishes in the world. Nenue eat seaweed, which means they could be grown on a highly sustainable and economical diet of macroalgae, agricultural byproducts and other plant-based materials.**

4. Kampachi Farms conducted the Velella project, which was the first trial of open-ocean aquaculture to be sited in what type of U.S. waters? **The Velella project took place in U.S. federal waters. Most state waters extend from the shoreline to three nautical miles. Federal waters consist of the waters extending from the state water boundary to 200 nautical miles. The Velella project used an unmoored net pen called the Aquapod, stocked with around 2,000 kampachi, between 3 and 75 miles offshore of the Big Island of Hawaii. Technicians operated the farm remotely.**

VIDEO B. Can a Fish Farm Be Green? (6:00). *Frontline*. https://www.youtube.com/watch?v=OOy8kjohevc

The teachers should use closed captioning, and play the video until 2:05. Then hit stop.

1. What are the four problems that early salmon fish farms needed to address, according to the speaker, Steve Damato? **The four problems are: (1) farm site locations were based on convenience, not environmental impacts, (2) escapes were "not looked at as a big deal," (3) farmers thought it unnecessary to address sea lice and (4) no one cared about how much protein was needed to make protein.**

Students should then be divided into four groups that will each research one of the four problems (do not restart the video). The research could be done in class or at home.

2. The groups should investigate:

- cause of the problem
- results of the problem
- ways to solve the problem

During class time, each group should summarize their research on whiteboards or posters to be shared with the class. After they have shared their findings, return to the video and watch until the end to see how the salmon farm addressed these problems.

Students will then individually answer the following questions, writing their answers on the Student Worksheet. Responses could be shared with the class.

3. Would you eat salmon from the farm featured in the video? What about from a conventional open water salmon farm? Why or why not?

4. Which practices used at this farm are realistic for other fish farms? Why? Which practices might be more challenging to adopt?

Extension:

Students will conduct research on the inputs and outputs of marine finfish farming. They should choose a commonly farmed marine finfish (e.g., Atlantic salmon, steelhead). They will create a flowchart that shows inputs — such as fish feed, or the production technology or gear used — and the impacts of outputs, like excess fish feed and fish waste. Students should indicate possible measures that can be implemented to reduce negative environmental impacts.

References:

1. Nutrient impacts of finfish aquaculture. 2018. NOAA. https://www.fisheries.noaa.gov/aquaculture/nutrient-impacts-finfish-aquaculture

2. VIDEO - Lobster and aquaculture: Studying interactions on Canada's East Coast. (5:09) *Fisheries and Oceans Canada.* https://www.youtube.com/watch?v=li_61ldtL4o

3. Price, C.S. and J.A. Morris, Jr. 2013. Marine cage culture and the environment: Twenty-first century science informing a sustainable industry. NOAA Technical Memorandum NOS NCCOS 164. 158 pp. https://www.noaa.gov/stories2013/pdfs/2013_PriceandMorris_MarineCageCultureandTheEnvironment(5).pdf

4. Rust, M.B., Amos, K.H., Bagwill, A.L., Dickhoff, W.W., Juarez, L.M., Price, C.S., Morris, J.A., and M.C. Rubino. 2014. Environmental performance of marine net-pen aquaculture in the United States. *Fisheries* 39 (11): 508-524.

Open Water Marine Finfish Aquaculture and Its Environmental Impacts

Student Worksheet Name _____

Watch the following videos to answer questions about open water marine finfish aquaculture. Both videos feature farms using innovative and environmentally responsible practices.

VIDEO A. Island Farmer Spotlight: Kampachi Farms (5:00) *RACPacific* https://www.youtube.com/watch?time_continue=78&v=INNfQmR503o

More information on Kampachi Farms' practices can be found here: http://www.kampachifarm.com/projects

Questions:

1. What is the tremendous breakthrough in marine open water aquaculture, according to Neil Sims, co-founder and co-CEO of Kampachi Farms?

2. What are two sources of alternative fish feeds that Kampachi Farms is experimenting with?

3. Which ecologically threatened fish species is Kampachi Farms growing?

4. Kampachi Farms conducted the Velella project, which was the first trial of open-ocean aquaculture to be sited in what type of U.S. waters?

VIDEO B. Can a Fish Farm Be Green? (6:00) *Frontline*. Stop the video at 2:05. https://www.youtube.com/watch?v=OOy8kjohevc

1. What are the four problems that early salmon fish farms needed to address, according to the speaker, Steve Damato?

2. Choose one of the four problems to research. Investigate the cause of the problem, results of the problem, and ways to solve the problem.

Problem Chosen:

Cause of Problem:

Results of Problem:

Ways to Solve Problem:

3. Would you eat salmon from the farm featured in the video? What about from a conventional open water salmon farm? Why or why not?

4. Which practices used at this farm are realistic for other fish farms? Why? Which practices might be more challenging to adopt?