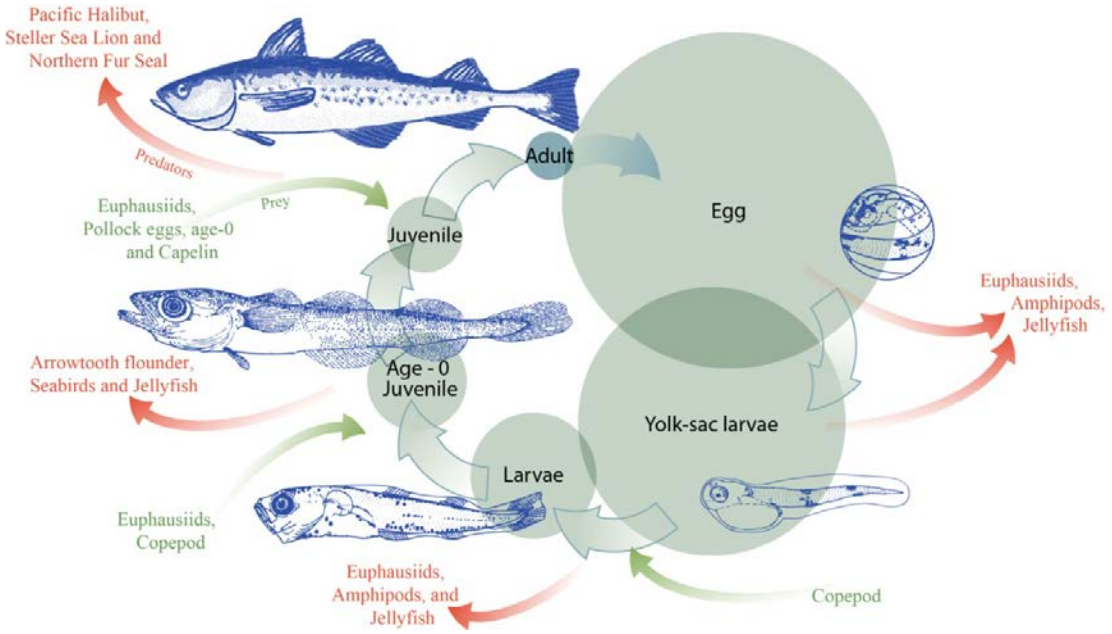
NOAA FISHERIES
Alaska Fisheries Science Center

Science behind Sustainable Seafood Module
Lesson 4: Survival in a Dangerous Environment

Brief Overview

The life cycle of pollock takes it on a wild adventure through dangerous water and dangerous predators. This lesson will help the students explore the stages of a pollock life cycle and the factors that influence their survivability. Students will play the "Pollock Survival Game" to learn why a pollock needs to spawn millions of eggs in order to perpetuate the species. Dangers lurk in the ocean environment from temperature, to currents and even ocean acidification and danger lurks in the mouths of the predators looking to eat pollock for dinner.



Survival in a dangerous environment

Take a spin around the walleye pollock life cycle:

Imagine that you are a walleye pollock egg adrift in the cold waters of Alaska. You are only slightly larger than a pinhead. In order to survive you must overcome big challenges. You are not only fragile, but vulnerable to changing ocean currents and temperature. Ocean temperatures may limit or increase your growth potential. Strong ocean currents can sweep you far out to sea where prey is scarce and you may starve. You don't have to worry about food until you hatch because your yolk sac has been supplying you with precious nutrients. A few days after hatching your yolk sac is empty and you now must swim and search for food. Even as you search for prey, you are also prey for many predators such as jellyfish, euphausiids (krill), and not to mention small fish. As you get older new predators like arrowtooth flounder find you appetizing. If you should find good ocean conditions, find lots to eat, and manage to escape being eaten, then there's a good chance you will grow up to be an adult to contribute by spawning the next generation of fish. If too many young pollock don't survive to adulthood, then there is a possibility the population of pollock will decrease in the future. This would mean lower quotas for fishermen. Scientists consider a lot of factors to ensure pollock populations are kept at a sustainable level.

Key Subjects/Standards

National	**Science**: NS.9-12.1 Science as Inquiry. NS 9-12.3 Life Science: Interdependence of organisms, Behavior of organisms. NS 9-12.6 Personal and Social Perspective: Population growth, Natural resources, environmental quality. **Math:** NM-NUM. 9-12.3 Number and Operations: compute fluently and make reasonable estimates. NM-PROB.CONN.PK -12.3 Connections: recognize and apply mathematics in contexts outside of mathematics. **Economics:** NSS-EC.9-12.1 Scarcity. NSS-EC.9-12.4 Role of incentives. **Social Sciences:** NSS-G.K-12.2 Places and Regions. NSS-G.K-12.3 Physical Systems.
Ocean Literacy	5. The ocean is filled with diversity. 6. The ocean and humans are inextricably interconnected (b, c, e, g).

Teacher Preparation

1. Read the entire activity and review all background material and resources.
2. Determine the amount of time you would like to dedicate to this activity. If classroom time is readily available, a minimum of two 50-minute classroom periods is advised. If classroom time is limited, students may complete some of their tasks as homework.
3. Determine the best assessment strategy for your class.

Materials List

- Pollock life cycle game board
- Die
- Game pieces
- Life stage cards
- Powerpoint presentation
- Hexa-flexagon of pollock life-history
- PDF with distribution maps of various pollock life stages
- Contact afsc.outreach@noaa.gov for materials or go to website.

Big Ideas: Pollock survival, throughout its life cycle, is influenced by many ecosystem factors.
Essential Question: How does the ecosystem influence survivability of pollock through its life cycle?
Objectives: The student will be able to explain pollock life cycle and how ecosystem factors relate to recruitment to the fishery (adult population).

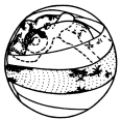
Background

Walleye pollock make up the largest by volume fishery in the U.S. The fishery as well as the center of their abundance is located in the Bering Sea, a smaller fishery happens in the Gulf of Alaska. They are in the gadid family with other cod and cod-like species and live in large schools about 300 to 1000 feet below the surface of the ocean. They are an important part of the Bering Sea ecosystem as predators and for providing a source of food as prey for many species of animals.

Throughout their life history pollock populations are also influenced by many environmental factors. These include oceanographic factors such as currents, temperature and nutrients. One of the more influential environmental factors affecting pollock survival is at their larva stage. The success of pollock at the larval stage is dependent on the spring plankton bloom where microscopic plants called phytoplankton begin growing in the ocean. When the bloom begins depends on factors such as the amount of sunlight, nutrients and temperature of the water. The spring phytoplankton bloom is important because it supports reproduction of copepods that are a source of food for walleye pollock. Copepods are small animals, the size of a grain of rice, called zooplankton. Zooplankton feed on phytoplankton, as do their eggs, called copepod nauplii, which are the food source of the larval pollock. If the spring plankton bloom does not occur near or during the time when the larvae are ready to eat, then their survival will decrease.

Recruitment for commercially fished species occurs when they grow to the size captured or retained by the nets or gear used in the fishery. For each species or ecosystem component that we study, we attempt to learn what biotic and abiotic factors cause or contribute to the observed population fluctuations. These population fluctuations occur on many different time scales (for example, between years, between decades).

What are a pollock's life stages?



Egg: Beginning in late winter, trillions of tiny walleye pollock eggs are spawned near the bottom in specific areas in Alaska waters. In the Gulf of Alaska, pollock spawn in Shelikof Strait and in the Bering Sea they spawn around the Pribilof Islands and along the Alaska Peninsula. These eggs will drift for two weeks impacted by currents and predators.

Larva When larvae (plural of larva) first hatch they rely on food stored in a membranous pouch under their bodies called a yolk sac. While their eyes, stomachs and mouths develop the yolk sac is their only food source for about a week after hatching.

Once the yolk sac is consumed the larvae, still tiny at about 5 mm in length, catch their own food as they drift with the ocean currents. For about three months the larvae will continue to grow.

Age-0 Juvenile After their larval stage and before their first birthday, walleye pollock are called "Age-0 (zero)" and measure about 5 inches in length (about 13 cm). These juveniles are an important food source for sea birds, jellyfish and even adult pollock.

Juvenile Walleye pollock are considered juveniles until they have developed enough to spawn (**3-4 years**). Juvenile fish in the Gulf of Alaska spend their time near shore in coastal bays and estuaries known as nursery areas and in the Bering Sea they have no place to hide.

Adult Walleye pollock mature into adults at 3 to 4 years of age and are about 14 inches (35 cm) long. Adults can live up to **17 years**, and can grow as large as 3 ft in length (1 m).

Instructional Strategies/Procedures

Activity 1A - Engagement Pollock Life Cycle (50 minutes)

1. Before starting the discussion about pollock life cycle, have a discussion with the students on what the different stages in the life history of a human being are.
    1. Discuss how those stages are defined. Are you using age? Height? Grade level in school?
2. Using the pollock life cycle graphic on the back of the game board, go through the life history of pollock. At each life stage discuss with the students what environmental factors may be detrimental to the success of the pollock to survive to the next life stage. Explain that population health is influenced
3. Spend about 15-20 minutes and have students create their own pollock flexa-hexagon that illustrates the pollock life cycle, their prey and their predators.
    1. Have students come up to the front of the class and give an example of pollock prey and predators using the flexa-hexagon.

Engagement

Activity 1B - Pollock survival game (50 minutes)

1. Each student begins in Shelikof Strait with 5 Egg Cards or half a million eggs.
    a. Record how many egg begin the game (# of players x 500,000).
2. Students can begin in reverse-alphabetical order by last name.
3. Begin the game with a roll of the die.
4. Move the number of spaces.
5. Follow directions on the space you landed.
6. Predator – the player who lands on this space has two options:
    a. Keep moving forward: Discard a life stage card into the discard pile
    b. Keep all of your cards: Go back to start and pick up one more egg card.
7. Ocean Condition – Roll the die and follow the directions under ocean condition list on the board for that life stage.
8. Ocean Eddy – If you land on this space you get stuck in an Eddy.
    a. Place your game piece in the Eddy off of the board
    b. At your next turn you must roll the number in the Eddy to get out or lose a turn.
    c. When you are released from the Eddy you start counting from the Eddy space.
9. Short Cut – If you land on this space, determine if you will take the short cut or not BEFORE your next turn.
10. Level Up - At each new life stage trade in your younger life stage cards to the next older level.

The End

1. Any surviving adult cards are placed at the end.
2. Record discard pile cards by life stage and the numbers they represent – on white board, flip chart or piece of paper.
3. Students can graph all of these numbers to come up with the story of the pollock life cycle.

After the Game

Have students discuss or reflect on what they learned or answer the following questions:

- Why does the number of pollock decrease as they get older (go up a level)?
- What would happen to the pollock population if fishing stopped?
- What would changing ocean temperatures do to pollock?
- How could ocean acidification impact pollock survival? (Hint: What are Euphausiids and Amphipods made of?)
- How can the game be modified to include life history challenges (for instance, if you land on a spot with another player, can you develop a way to incorporate cannibalism?)

Extensions & Connections

- Read pollock larvae mortality paper by Bailey and Macklin – elaborate on what influences larvae mortality that may be different than what was in the game.
- Read Influence of environment on pollock by Smart et.al. – Discuss how more environmental factors can be incorporated into the survival game.

Assessment

Lab write up
Complete game
Recording data
Data analysis

Vocabulary**:** Life history, life stage, mortality, predation, recruitment, amphipod, euphausiids, predator, current, plankton, zooplankton, phytoplankton, climate, marine mammals, proportion, jellyfish, static, dynamic.

Possible Misconceptions

Food resources for fish are unlimited.
Ocean is static environment – not dynamic.
All eggs hatched survive to adulthood.

Reflection on Roles

Have students break up into their groups – Industry, scientists, concerned citizens and council members. Have them reflect on what today's lesson may be relevant to their supporting statements they will be giving to the council members. Council members can reflect on what they would expect to see from each group.

Project Evaluation

At the end of the project the teacher should fill out the SBSS Evaluation sheet.

Resources for Teachers

Climate and Fish Sticks article
Bloom or Bust: The bond between Fish and Phytoplankton - http://earthdata.nasa.gov/featured-stories/featured-research/bloom-or-bust-bond-between-fish-and-phytoplankton
SeaWiFS (Sea-viewing Wide Field-of-view Sensor) - Teacher resources - http://oceancolor.gsfc.nasa.gov/SeaWiFS/TEACHERS/
Instructional video about ocean surface currents
http://www.watchknowlearn.org/Video.aspx?VideoID=13205

For more information and questions:

Contact the Alaska Fisheries Science Center Education Team
Website: http://www.afsc.noaa.gov/education/
Email: afsc.outreach@noaa.gov