Science behind Sustainable Seafood: Solving the Ecosystem Puzzle!

Brief Overview

Pollock are a key species in the Bering Sea food web. How do we know? Scientists at the Alaska Fisheries Science Center have studied the contents of thousands of fish stomachs to determine what those fish ate. Now with the help of computers models we are beginning to understand what influences an ecosystem. These activities will give students the chance to better understand what it means to have a diverse diet and how all living things are interconnected through something called a food web.

Solving the ecosystem puzzle

In the Bering Sea, survival is about eating or being eaten. Your survival depends on your ability to prey upon food resources while avoiding becoming a predator's next meal. To better understand the relationships between predators and prey in the Bering Sea, scientists at the Alaska Fisheries Science Center annually collect and examine the stomachs of thousands of fish. What they see tells them a lot about how important all species in the Bering Sea are to maintaining balance within the entire ecosystem.

Big Ideas: Organisms are interconnected by what they consume.
Essential Question: What is the effect of the removal of a primary food source in Alaska waters?
Objectives: The student will be able to differentiate between a food web and a food chain and construct a food web using real data.

Key Subjects/Standards

Science, Math,

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 based on suggestions made by authors.
4. The activity may take up to two 50 minute periods, if a review of basic fish biology is needed. First 50 minute period will be to review basic fish biology, second 50 minute period will go into why knowing age

distribution of a harvested fish population is important and include an age and growth data manipulation activity.

Materials List

- Stomach data from file
- Alternative Stomach data from AFSC website
- Pollock Flexa-hexagon –
- Yarn

Background

Alaska's Bering Sea fisheries provide nearly half of the seafood consumed in the U.S., forming a powerful economic engine for fishing communities and the core of an ocean-based subsistence lifestyle. Whales, seals, and seabirds travel from afar to feed and mate here. Fur seals breed on island rookeries, while walrus haul out on sea ice to bear young. Whales and porpoises feast on huge schools of smaller fishes and tiny planktonic crustaceans. Orcas hunt other whales, seals, or salmon. Sea otters forage in kelp forests, plucking invertebrates from the seafloor. Nearly half of Alaska's seabirds live in ten colonies in the Bering Sea. Some 36 million seabirds breed here, including shearwaters, fulmars, kittiwakes, albatrosses, storm-petrels, puffins, and murres.
Climate change and reduced ice cover could significantly impact the Bering Sea ecosystem.

Instructional Strategies/Procedures

Exploration

- Ask students to free write what comes to mind when they hear the term "food web" (5 minutes)
- Have students underline three things that they wrote which are important to a food web
- Introduce the concept of a food web - watch video about Krill by National Geographic (2 minutes)
    - Get students wondering how/why such a small animal can be the basis of the food chain.
    - What animals ate krill in the video?
      Ask students to describe a food chain they saw in the video or elsewhere.
    - Have the students discuss how a food web differs from a food chain. Go to science bob website http://www.sciencebob.com/questions/q-food_chain_web2.php

Making connections in the Bering Sea:

Just like how our highway system connects our cities and towns, an ecosystem connects organisms. A simple way to draw an ecosystem is to first draw a food chain and then a food web.

Parts of the Bering Sea ecosystem

Sun

The sun's energy is converted into nutrients for plants through a process called photosynthesis. On land and in the ocean plants or algae are the foundation of most food chains.

Phytoplankton

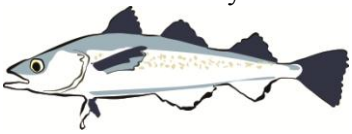
Phytoplankton are microscopic plants that drift in the ocean. They are at the base of all food chains in the Bering Sea. What organisms do you think eat phytoplankton? Zooplankton are planktivores -- grazers of the sea!

Zooplankton

Zooplankton are microscopic animals and are found near the bottom of the Bering Sea food chain. Zooplankton like amphipods and copepods are prey to many small fish. Even big baleen whales eat zooplankton. Can you name one? The humpback whale!

Herring

Small fish like herring and juvenile walleye pollock can be both predator and prey since they sit in the middle of the food chain. They feed on zooplankton below them and in turn are prey to larger fish from above.



Adult Walleye Pollock

Adult walleye pollock can also be both predator and prey. Even though they are high up in the food chain, they are not the top predator. Their diet includes krill and juvenile pollock (Yes, they are cannibals!).

Humans

Humans are at the top of the food chain. This means that we are a top-level predator. We benefit from all the energy that has been put into a food chain.

Northern Fur Seal

In the Bering Sea, northern fur seals are also a top-predator. Their diet includes fish like walleye pollock, Atka mackerel and Pacific cod.

Engagement

Activity 1A- Predator diets in the Bering Sea (50 minutes)

This excel lab uses the spreadsheet Lesson_3_Fish_diets.xls. The spreadsheets in this file require different skill levels.

What you will learn: what fish eat, how to build a food chain, how to build a food web

Excell skills: make graphs with one series, multiple series, change graph attributes. Copy and paste, sum

Analytical skills: Compare order and prioritize and summarize information

1. Open excel file Fish_diets.xls.
2. Go to spreadsheet Bering Sea (light blue tab) This spreadsheet contains the diet of several fish: forage fish, walleye pollock, Pacific cod, arrowtooth flounder, and a marine mammal –northern fur seal.
    1. The first 3 rows give you general information of how this data was collected: the year, the number of full stomachs and the number of hauls (sites) where we collected the stomachs). For example, Forage fish were collected in 1999, there were 15 stomachs collected in total in 2 hauls.
    2. Starting in row 8, for each animal (predator) the column on the left show the prey name or categories and the column on the right shows the percent prey weight. This means we took a stomach and weighed it, then opened the stomach, separated the contents by prey type and weighed each prey type separately.
3. Check data
    1. Since the data are in percentages, the column "percent weight" should add to 100.
        1. How to sum: Click on the cell after the last box in the table: for example B22 is the box to click for "Forage Fish" - in cell B22 type: "=SUM(B9:B11)"
        2. Do they add to 100?

Alternative activity with online data source

1. Go to the website for real time data on predator diets in Alaska. http://access.afsc.noaa.gov/REEM/WebDietData/DietTableIntro.php
2. As a class select an ocean basin - Bering Sea, Aleutian Islands or Gulf of Alaska
3. Pairs of students can determine which species they want to study
    1. Pollock
    2. Pacific Halibut
    3. Arrowtooth Flounder
    4. Grenadier
    5. Pacific Cod
    6. Greenland Turbot
4. Students then navigate to the web page by selecting their species in the drop down box. This web page has a list of ocean basins and years where diet data are available. For example here is the page for Pacific halibut http://access.afsc.noaa.gov/REEM/WebDietData/DietTableSpeciesList.php?NODC=8857041901
5. Have students select one year, ideally same year, and same ocean basin as the rest of the class. Copy and paste data into an excel spreadsheet or print out for each student pair.
6. Everyone should now have a table with a list of prey and their percent weight. You can now continue with original activity.

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4. Let's look at what each predator eats.
    1. Scan each table and find the top three prey items for each predator.
5. For each predator think about the best way you can visually represent the data. What kind of chart would you use?

6. Let's make a chart!
    1. Highlight the cells with the information you are interested on (this means clicking and holding the top cell of the predator names while dragging the cursor over both the prey name and percent weight column, ending at the last cell in the percent weight column.)
    2. Click on the icon from graphs or go to "Insert" tab - Click on one of the Charts in the chart box.
    3. Which one represents the data best? Hint: Since the prey items add up to 100, you know the whole story of what they eat. It's as easy as pie.
7. Make the same type of chart for the rest of the predators.
8. Explanation:
    1. Why do you think a predator has multiple types of prey?
    2. What kind of advantages would having more prey types in your diet give an animal?

Activity 1B - Predator diets in Alaska (50 minutes)

Predator diets in the Bering Sea compared (25 minutes)

Exploration

1. Use worksheet “Bering-Sea_table” in the fish_diets.xls file.
2. These are the same data as in the worksheet Bering_Sea, but arranged as a table. Note: Using a table is one way of summarizing similar data from multiple species because you don’t have to write the prey categories every single time, just once.
3. The first column in this table show “prey categories" and the first row shows “predators”

Alternative data instructions

1. As a class make a single table with the different species/predator data.
2. Distribute this table to all students in excel format or printed.

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4. To make a chart that shows the diet of multiple predators follow the steps you learned in the previous activity with the only difference being that you are selecting the entire block. Note: you can’t use all types of charts, for example –you can’t make pie charts.
5. Alternatively, if students don't have access to a computer they can round up the prey data and then make a graph summarizing the data from each species.

6. Explanation - have students discuss some of these questions:
    1. Which animals have similar diets?
    2. Which prey species occurs in all of the diets?
    3. Which prey species occurs in most of the diets?
    4. Which predator has the most different or specialized diet?

Predator diets in Alaska compared (25 minutes)

1. Compare diets for the same predator in different places – Use worksheet "Alaska_table" or alternatively follow above directions to get data from different ocean basin.
2. Data shows the diet of Pacific cod in the Bering Sea, the Gulf of Alaska and the Aleutian Islands. These are very different regions and far apart.
3. Do Pacific cod eat the same prey in all 3 places?
4. Do cod eat the most of the same prey in all 3 places?
5. We say Pacific cod has a different predator role in each system, because it feeds on different prey and in different quantities.

Activity 1C - Make a Bering Sea food chain and food web (50 minutes)

To make a food chain you need only one prey of one predator at a time. (25 minutes)

1. Begin with phytoplankton
2. Find on the prey categories of all the predators who eats phytoplankton and write it below it
3. Repeat for whatever you wrote and continue until you can lo longer find someone that eats that prey.

Example: phytoplankton-zooplankton-pollock-cod

HINT:

- all zooplankton feed on phytoplankton.
- all benthic invertebrates, shrimp and crab feed on detritus
- and squid feed on forage fish

To make a foodweb choose a few predators and few prey categories (25 minutes)

1. Make a table: predators name on the first row; prey on the first column.
2. Mark on the table if you can find the predator-prey combination on your data.
3. To draw the foodweb, write the names of the predators and prey you chose –leave lots of space between them.
4. Now draw a line to join each predator with every prey it eats. You have just created a food web.

Alternative food web activity- Get moving!

1. Each student represents a prey item (there would be more students as a phytoplankton and zooplankton than a pollock or cod).
2. Each prey item gets long pieces of yarn low trophic level gets 6, middle tropic level gets 3 and high trophic level gets one.
3. Each predator goes to a prey item and takes a piece of yarn. Do this until there is no more yarn.
4. The students should have created a large web.

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5. Did you include all the predators and all the prey? Do you think this is a model of a food web or the "real" food web.

Extensions & Connections

- Research animals in the food web and to find out more about what they eat during different parts of their life cycle. Is their information on how much they eat?
- Students can test hypotheses by looking at environmental factors that may be influencing population size on this website:
- Bering Sea Climate page
- Have students read Aydin and Mueter paper and discuss

Assessment

Lab write up
Complete game
Recording data (need to create worksheet)

Vocabulary: Competition, predator, prey, food web, food chain, interconnection, trophic level, carrying capacity

Possible Misconceptions

Humans do not impact the marine food web.
Ocean resources are unlimited.

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 form.

Resources for Teachers

Scientific Paper by Gudmanson,
Comparison of Alaska Large Marine Ecosystems: http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-178.pdf
NOAA Education website - Aquatic Food Webs - http://www.education.noaa.gov/Marine_Life/Aquatic_Food_Webs.html
Similar activity from USC sea grant
http://www.usc.edu/org/seagrant/Education/IELessons/Unit3/Lesson5/U3L5A.html
Bering Sea Buffet Activity from PolarTrec - http://www.polartrec.com/resources/lesson/bering-sea-buffet-a-foodweb-activity
The role of juvenile walleye pollock on Northern Fur Seal Diet by Elizabeth Sinclair
Bioenergetics project from Canisius College
Book from Alaska Sea Grant - The Bering Sea and Aleutian Islands: Regions of Wonder
http://seagrant.uaf.edu/bookstore/pubs/SG-ED-42.html
Make your straw krill (Art project)
http://www.youtube.com/watch?v=qPNONrWWi5Q
http://www.wikihow.com/Make-a-Shrimp-out-of-a-Plastic-Straw
NASA Arctic Sea Ice 101
http://youtu.be/_m-M37vc-m0
High Rez video showing 2007 Arctic sea ice from Jan 07-Sept 07.
http://youtu.be/EA2C0N39czs
Google Earth Arctic Sea Ice visualizations
http://nsidc.org/data/google_earth/