Surveying Walleye Pollock

Subject: Life Science: Marine Biology, and Mathematics: Statistics

Grade Level: 7-12

Average Learning Time:

Background Information:	One to Two 50-minute class periods.
Dissection Activity:	Two to Four 50-minute class periods
Data Analysis Activity:	Grades 7-8 Four 50-minute class period
Media Letter & Wrap-up:	One 50-minute class period

Lesson Summary:

Part I: Students will measure, weigh, and dissect a sample of Walleye Pollock. They will draw conclusions regarding how they determined body parts, make connections between the functional anatomy of humans and fish, determine the function of body organs, and determine the sexual maturity stage of the fish.

Part II: Students will analyze pollock length data collected from 1994 to 2009 and draw conclusions about how the ages of pollock have varied and why they have changed. Afterward, students will combine their class pollock data, calculate percentages of length data and make comparisons to the BSIERP data. Afterward, students will conclude which year their sample represents. Finally, students, who are the chief scientists behind the survey will create a one-page summary to release to the media on their findings regarding their Walleye Pollock survey.

Overall Concepts: These activities are designed to familiarize students with the techniques involved with sampling surveys, through anatomical exploration of Walleye Pollock and data analysis.

Specific Concepts:

- It is important to understand the delicate ecosystem of the Bering Sea because it supports an incredible variety of sea life, such as whales, seabirds, sea mammals, and fish.
- Walleye Pollock is an important species of fish to study in the Bering Sea because they account for the majority of the fish landed in the fishing industry of the US.
- Scientists studying fish are using a variety of techniques, such as acoustic surveys, fish trawls, and CTD deployments, to learn more about the Bering Sea ecosystem.

- When sampling fish, it is important to select random samples of fish, and collect data from those samples.
- It is important that when compiling data, observations that lead to correlations are necessary but not always exact causes and effects.

Focus Questions:

- What main characteristics classify Walleye Pollock as a vertebrate and more specifically, a bony fish?
- What organs inside a fish are similar to that of a human? Which are unique to fish?
- What organs assist in the digestive process?
- What information does the stomach contents of a Walleye Pollock provide scientists?
- How does the location of certain organs (i.e. the heart) important for animals?
- How can otoliths provide information for scientists?
- How can one determine the differences in the sexual maturity level of both male and female Walleye Pollock?
- What facts can we derive from previous scientific observations and survey data?
- What mathematical concepts can be applied to enable us to analyze the data?
- How can we use our data to make comparisons to other scientific data?
- What hypotheses can we draw based on correlations we observed?

Objectives: Students will be able to...

- Determine characteristics of bony fish.
- Identify critical organs of fish
- Determine the sexual maturity of a Walleye Pollock
- Draw conclusions of the feeding habits of Walleye Pollock based on stomach contents.
- Compare class data with scientific data to derive correlations.
- Analyze scientific data and draw hypothetical conclusions.

Background Information:

Since 1979, NOAA's Alaska Fishery Science Center has conducted acoustic trawl and bottom trawl surveys to assess Bering Sea Pollock populations. Recently in 2007, two organizations, The North Pacific Research Board and the National Science Foundation, has partnered with NOAA to initiate a $52 million study to understand the ecosystem of the Bering Sea as the Earth's climate continues to change and ice cover continues to decrease. The partnership, called the Bering Sea Integrated Ecosystem Research Project (BSIERP) provided additional funding and support to increase the scope of ecosystem research in the Bering Sea. Some examples increase physical oceanographic sampling, fish diet studies, and increases in funding for seabird and marine mammal surveys. The Bering Sea region is highly productive as it "provides nearly half of the seafood consumed in the US," (BSIERP, 2010). According to the Bering Sea Project, "The largest concentrations of pollock occur in the eastern Bering Sea," and more specifically, "Walleye pollock support the largest single commercial fishery in the U.S., producing the largest catch of any one species inhabiting the 200-mile US Exclusive Economic Zone." The pollock industry is incredibly important to the people living in Dutch Harbor and Unalaska because pollock is one of the main fishes processed there and has helped classify Dutch Harbor as America's #1 fishing port in the USA for fish landed (NOAA, 2009). Additionally, whales, seals, and seabirds breed in this location and feed on the abundance and variety of food. The Bering Sea Project is also working with local indigenous communities to learn about how these groups have used and survived in this ecosystem along with how changes in the ecosystem will affect those communities.

Because of the changing climate in the ocean, it is thought that the fisheries and local indigenous populations will be impacted. Therefore, it is important to understand how the abundance of fish and their distribution will change. Some of the vessels involved in this research operation are The USCGC *Healy*, R/Vs *Oscar Dyson* and *Miller Freeman*, the USFWS *Tiĝlaˆx,* and chartered boats such as the *Frosti* , the *Alaska Knight* and the *Aldebaran*.

There are two summer surveys being conducted to estimate the Bering Sea pollock population: Acoustic-Trawl Survey and the Bottom-Trawl Survey. During June and July 2010, the Oscar Dyson conducted an Acoustic -Trawl Survey. A combination of information from acoustics data, fish samples (weight, length, sex, sexual maturity, otoliths, stomach extractions), and CTD deployment data (water temperature, salinity, nutrients, oxygen, and chlorophyll), were used to draw conclusions that help estimate population size and ecological factors affecting pollock. The compilation of data will also help scientists understand how the distribution of pollock has changed in past years and may also provide information about how it could change in the future.

Walleye Pollock are considered vertebrates and **bony fishes** because they have a skeleton composed of calcified bone as well as a backbone. Their bones are like those of a human because the bones have been calcified. A special apparatus found in fish is called the **swim bladder** which allows the fish to adjust it's buoyancy. The internal anatomy of fish is differs from that of a human's but there are some similarities. For example, fish and humans both have eyes, a heart, stomach, liver, spleen, and ovaries or testes. However, fish have body parts that are very different from humans. Because fish need to be aware of vibrations in the water, they have an adaptation called a **lateral line** to help them know when other animals and varying objects are in the water, especially when visibility is low. Another specialized characteristic that is unique to fish are inner ear bones, **otoliths**, which are used to identify when the body changes position. Otoliths are important for research because they can be used to classify fish, determine age, and reveal growth patterns (much like the growth rings on the trees). For these reasons, when identifying fish fossils, otoliths are incredibly valuable.

Common Misconceptions/Preconceptions:

- Walleye Pollock only spawn once
- Walleye Pollock like really cold water
- Correlations provide cause and effect relationships

Dissection Activity:

Materials:

- Student Dissection Guide (one copy per group)
- Random Sample of Walleye Pollock (one per group of two students or for each student)
- Canvas tarp (to keep floor or tables clean) or newspapers
- Neoprene disposable gloves
- Collection of whole randomly selected Walleye Pollock rinsed (enough for groups of two or for individual dissections)
- Small board and meter stick
- Scale
- Dissection utensils
    - scissors
    - serrated steak knife
    - scalpel
    - tweezers
    - Dissection pad (if this resource isn't available, use cardboard wrapped in aluminum foil)
    - safety goggles
- Dissection Guide
- Apron or an extra-large t-shirt that can be spoiled
- Soap and water
- Paper towels

Vocabulary

Fork Measurement: Measure from the tip of the head to the fork in the fin
Gills: for breathing and exchanging oxygen
2-Chambered heart: Circulates the blood through the body.
Liver: filters and cleans the blood
Pyloric caeca: makes the digestive fluids
Gonads (reproductive organs): Ovaries produce eggs and testes produce sperm
Intestine: digesting and carrying the digested food from the stomach to the anus
Kidneys: Produce urine
Urogenital opening: exit for urine, eggs and sperm
Swim Bladder: controls whether the fish will sink or float
Gall Bladder: small sac containing bile that is secreted by the liver
Otoliths: ear bones
Spleen: removes old blood cells and aids in immune health
Operculum: protects the gills
Nare: nose

Technical Requirements:

- Internet Access to view videos regarding the processes involved in a Pollock Survey aboard the Oscar Dyson, Summer 2010 3rd Leg of the Pollock Survey by Story Miller

- Internet Access to view NOAA Ship Tracker to see paths of Pollock Survey Trawls

Teacher Preparation:

- View videos about the pollock surveys
- Locate a fish processing company that processes Walleye Pollock to obtain samples.
- Dissect a Walleye Pollock and go through the lab before introducing to your students.
- Read about the Bering Sea Project online to learn more about the motives behind the study.
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Pre-assessment/Introduction:

Start by asking students if they know where Dutch Harbor and Unalaska Island are. It may be necessary to refer to the popular TV series, *The Deadliest Catch.* Clarify that while crab fishing is an important part of the fishing industry, the largest percentage of fish processed is the Walleye Pollock. Ask students if they have eaten fish sticks or imitation crab meat. If they have, they have eaten Walleye Pollock.

Review the components animals need to survive in a habitat for many years (food, water, shelter, etc).

Review or have students brainstorm possible factors that could negatively affect the ecosystem of the Bering Sea. Also have students brainstorm why fishermen, who's income rely on successful fish seasons, want to understand the habitats of the Walleye Pollock. At this point, it is critical that students become aware that fishermen want to know about the information scientists collect so that they can fish responsibly in the waters and protect a habitat where Walleye Pollock can reproduce successfully to ensure successful fishing in the future.

Have students read the blog and watch the videos produced by TAS Story Miller at: http://storymillernoaa2010tas.blogspot.com/

Tell students that they are official scientists, hired by the National Science Foundation to analyze and make sense of the data they collect from their sample of Walleye Pollock.

Dissection Lesson Procedure:

1. Introduce safety procedures when handling the sharp dissection equipment. Depending on previous dissection exposure will determine whether you walk the kids through each step in the dissection manual, or allow them to work at their own pace.
2. Constantly ask students how they were able to conclude what names belonged to certain body parts and what the function of those parts are.

Data Analysis Activity

1. Emphasize to students the importance of using the data to analyze and try to draw conclusions. Encourage them to ask themselves, "What is all this data telling me?"
2. Emphasize that oftentimes, correct answers are difficult to obtain when analyzing information and that it is important to keep their minds open to other possibilities at all times.
3. Emphasize that while students may see relationships in data (correlations) that it doesn't necessarily mean the relationships *cause* one or the other.
4. When writing the one-page summary, it is important that students keep a neutral, professional voice that does not make assumptions without being backed-up by the data they have.

Assessment:

The final one-page summary is one form of assessment that will evaluate how well the students can think like a scientists. Their answers from the lab manual also serve as a form of assessment.

It would be incredibly valuable to spend a period wrapping up all the information the students uncovered in the activities. Some ideas that come to mind are:

- Creating KWL charts
- Writing a letter to a scientist working on the Bering Sea Project
- Creating another experiment they think would help with the research involved with the Pollock Survey.
- Students could extend their data analysis skills by a class box and whisker plot of the length data.

Standards:

National Science Education Standards:

- Unifying Concepts and Processes
  - Systems, order, and organization
  - Evidence, models, and explanation
  - Change, constancy, and measurement
  - Evolution and Equilibrium
  - Form and Function

- Science as Inquiry
  - Abilities necessary to do scientific inquiry.
  - Understandings about scientific inquiry

- Life Science
  - Structure and function in living systems
  - Reproduction and Heredity
  - Regulation and Behavior
  - Populations and ecosystems
  - Diversity and adaptations of organisms

- Science and Technology
  - Abilities of technological design
  - Understandings about science and technology

- Science in Personal and Social Perspectives
  - Populations, resources, and environments
  - Natural Hazards
  - Risks and benefits
  - Science and technology in society

- History and nature of Science Standards
  - Science as a human endeavor
  - Nature of science

Alaska State Science Standards:
Inquiry
- The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating [SA1.1]
  - ...by collaborating to design and conduct repeatable investigations, in order to record, analyze, interpret data, and present findings [SA1.2]
- The student demonstrates an understanding of the attitueds and approaches to scientific inquiry by recognizing and analyzing differing scientific explanations and models as well as identifying and evaluating the sources used to support scientific statements [SA2.1]
- The student demonstrates an understanding that interactions with the environment provide an opportunity for understanding scientific concepts by conducting research to learn how the local environment is used by a variety of competing interests [SA3.1]

Life Science
- The student demonstrates an understanding of how science explains changes in life forms over time, including genetics, heredity, the process of natural selection, and biological evolution. [SC1]
- Students develop an understanding of the structure, function, behavior, development, life cycles, and diversity of living organisms. [SC2]
- Students develop an understanding that all organisms are linked to each other and their physical environments through the transfer and transformation of matter and energy [SC3]

Science and Technology
- Students develop an understanding of how scientific knowledge and technology are used in making decisions about issues, innovations, and responses to problems and everyday events. [SE1]
- Students develop an understanding that solving problems involves different ways of thinking, perspectives, and curiosity that lead to the exploration of multiple paths that are analyzed using scientific, technological, and social merits. [SE2]
- Students develop an understanding of how scientific discoveries and technological innovations affect and are affected by our lives and cultures [SE3]

Cultural, Social, Personal Perspectives, and Science

- Students develop an understanding of the interrelationships among individuals, cultures, societies, science, and technology. [SF1]
- Students develop an understanding that some individuals, cultures, and societies use other beliefs and methods in addition to scientific methods to describe and understand the world. [SF2]
- Students develop an understanding of the importance of recording and validating cultural knowledge. [SF3]

History and Nature of Science

- Students develop and understanding that scientific knowledge is ongoing and subject to change as new evidence becomes available through experimental and/or observational confirmations [SG3]

Other AK State Standards:

Mathematics

- The student accurately solves problems (including real-world situations by using percents and percentages [M3.3.3 & M3.3.4]
- The student demonstrates conceptual understanding of mathematical operations by using models, explanations, number lines, real-life situations. [M1.2.3]
- The student demonstrates understanding of measurable attributes by estimating length to the nearest millimeter [M2.3.1]
- The student solves problems (including real-world situations) using estimation by applying and assessing the appropriateness of a variety of estimation strategies and to check for reasonableness of solutions [M3.3.1]
- The student demonstrates an ability to classify and organize data by displaying and explaining the classsification of data in real-world problems using frequency distributions, bar graphs, and (optional) box and whisker plots with an appropriate scale [M6.3.1]
- The student demonstrates an ability to analyze data by using information from a variety of displays [M6.3.2]
- The student will make projections based on available data and evaluate whether or not inferences can be made given the parameters of the data [M6.3.4]
- The student will use sample spaces to make predictions about independent events [M6.3.5]
- The student demonstrates the ability to apply mathematical skills and processes across the content strands by using real-world contexts such as science, humanities, peers, community, and careers [M10.3.1 & M10.3.2]

Additional Resources:

Websites:

- http://bsierp.nprb.org/
- www.afsc.noaa.gov/species/pollock.php
- www.nmfs.noaa.gov/fishwatch/species/walleye_pollock.htm
- www.nefsc.noaa.gov/sos/spsyn/pg/pollock/
- http://storymillernoaa2010tas.blogspot.com/
- http://bsierp.nprb.org/

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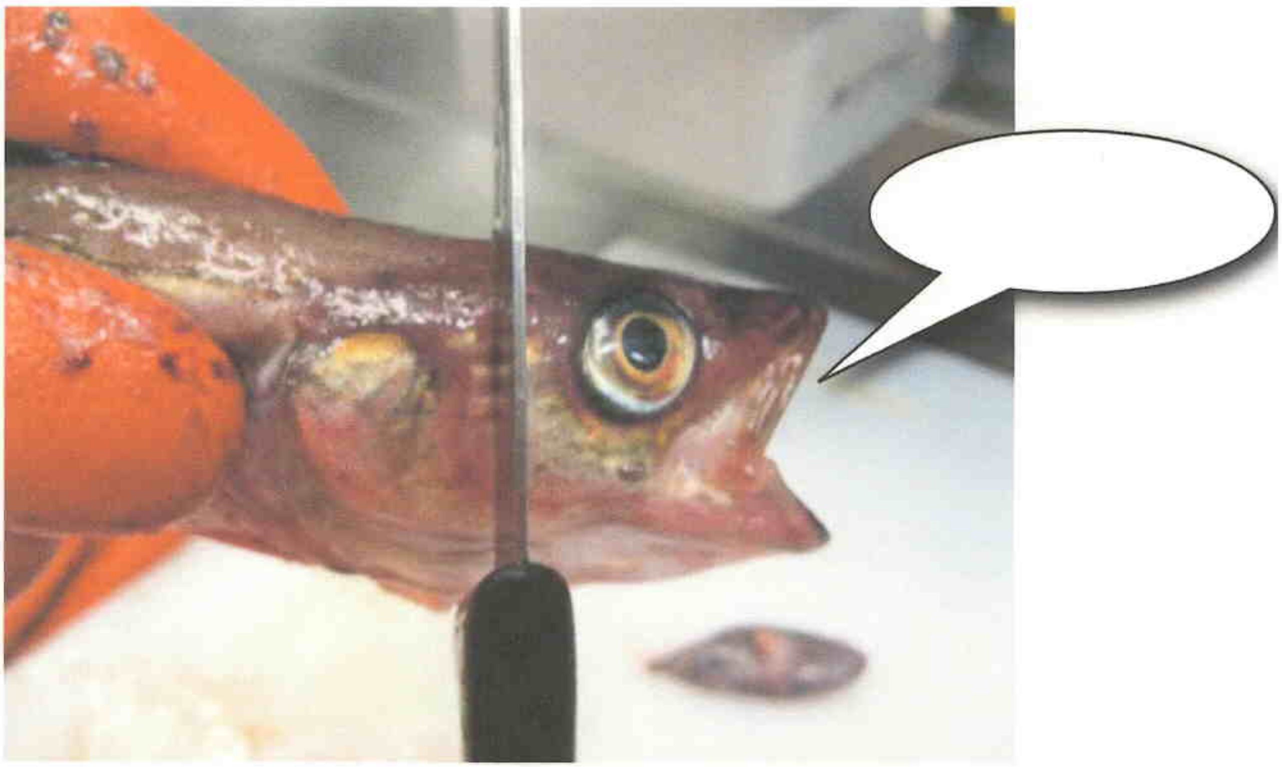
Creation Date: August 2010

Dissection Guide for Walleye Pollock

(*Theragra chalcogramma*)



Created by NOAA Teacher At Sea
Story Miller
Unalaska City School District

Pre-dissection:

1. Place the small board perpendicular to the table. Press the **nare** of the fish against the board. The fish will be stiff but do your best to have the mouth closed and body pressed flat so that the tail fin is also flat. Measure the length from the nose to the fork in the middle of the tail in centimeters (include the decimal).

Length: ______________________

2. Next, weigh the fish in kilograms. Round to the nearest gram!

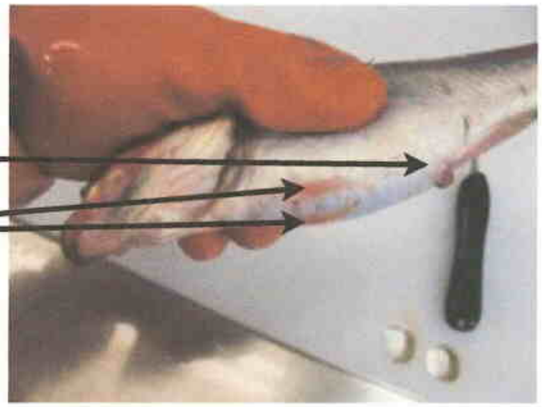
Weight: ________________________

3. Make a quick sketch of your pollock. Label all parts of the fish you already know.

Dissection!

1. If you are right-handed, it will be beneficial to position the fish as seen in Figure 1 where you are holding the fish with your left hand and the scalpel with your right. If you are left-handed, position the fish in your right hand.

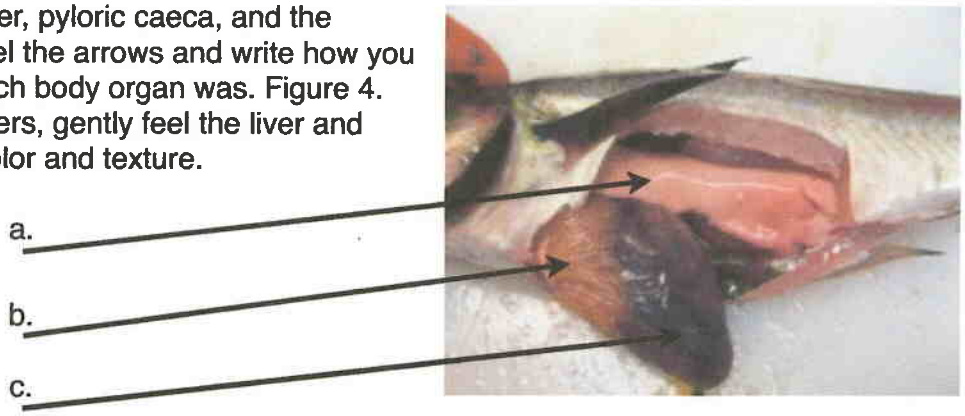
2. Turn the fish over and locate the **Anus** and **Pelvic Fins**. **Label the arrows.**



Locate a second opening behind the anus. This is the urogenital opening where eggs and sperm are released.

3. Using the scalpel make a shallow (not very deep) cut from the anus to the pelvic fins. Be careful with your cut so that you do not accidently slice the stomach open!

4. Locate the liver, pyloric caeca, and the stomach. Label the arrows and write how you knew what each body organ was. Figure 4. With your fingers, gently feel the liver and describe its color and texture.



How did you figure out what each body part was? Explain using evidence and previous knowledge:

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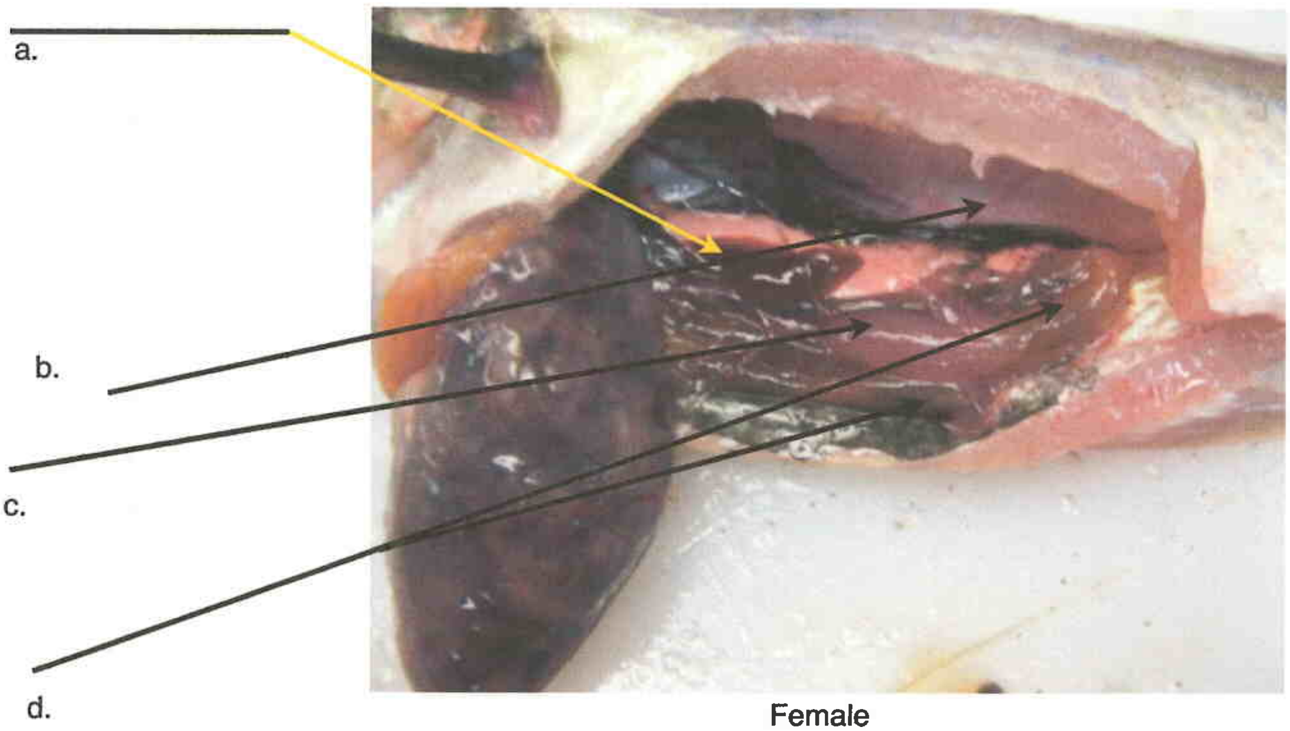
5. When finished, using your fingers and scissors, detach the liver from the body. Careful not to cut the stomach! Find the pancreas, ovaries or testes, swim bladder and the intestines. Whether you have a male fish or a female, make sure to label all the parts on this sheet!



Female

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Male

Explain how you knew what each body part was. Make sure to include any evidence you thought of to make your decision!

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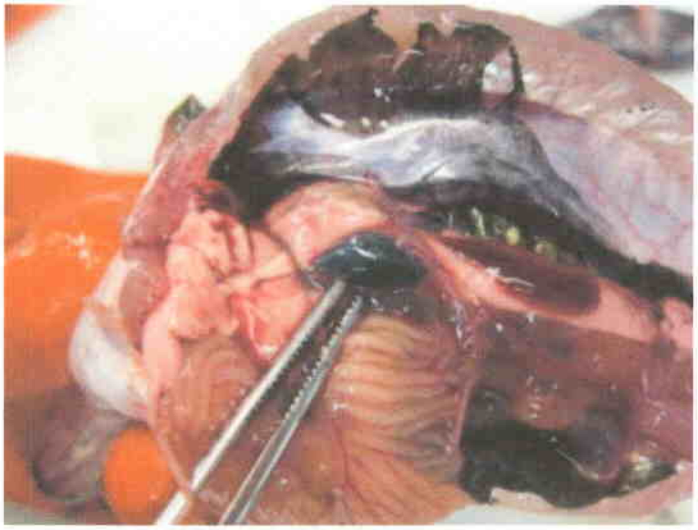
6. Carefully extract the stomach by grabbing the connection near the head with the tweezers and snipping it off using the scissors. Note that you will need to cut twice! Make an incision in the stomach and take out its contents. What did your Walleye Pollock have for its last meal? Usually pollock feed on amphipods, copepods, euphausiids, and small fish.

Describe what you see. Give details!

My pollock had the following for dinner:

7. Inspect a tiny greenish, blue sac near the pyloric caeca. Make a hypothesis about what this body organ is. As you go through the dissection lab, you may decide to change your answer. If you must change your answer, write it on the line below your hypothesis and explain the function of the correct part.



Hypothesis:

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Correct ID:

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Function:

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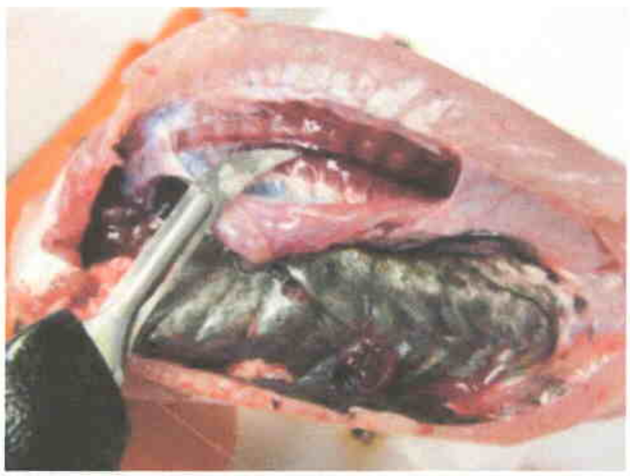
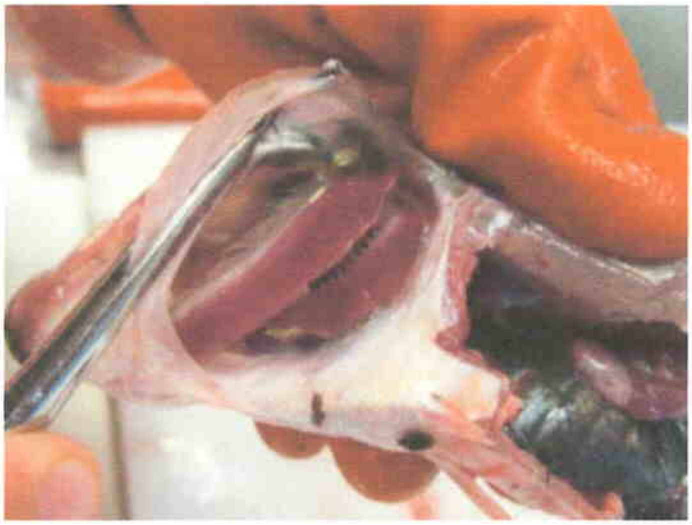
8. Very carefully, using your tweezers and scissors, cut away the swim bladder to reveal the kidneys.



9. Inspect the gills. Lift the operculum and look at the gills. Now cut the operculum away at its base, exposing the gills. With your scissors, you may cut out the gills but do not poke too far inside! Only do this on ONE side!



Sketch the gills you see in the space next to the picture.

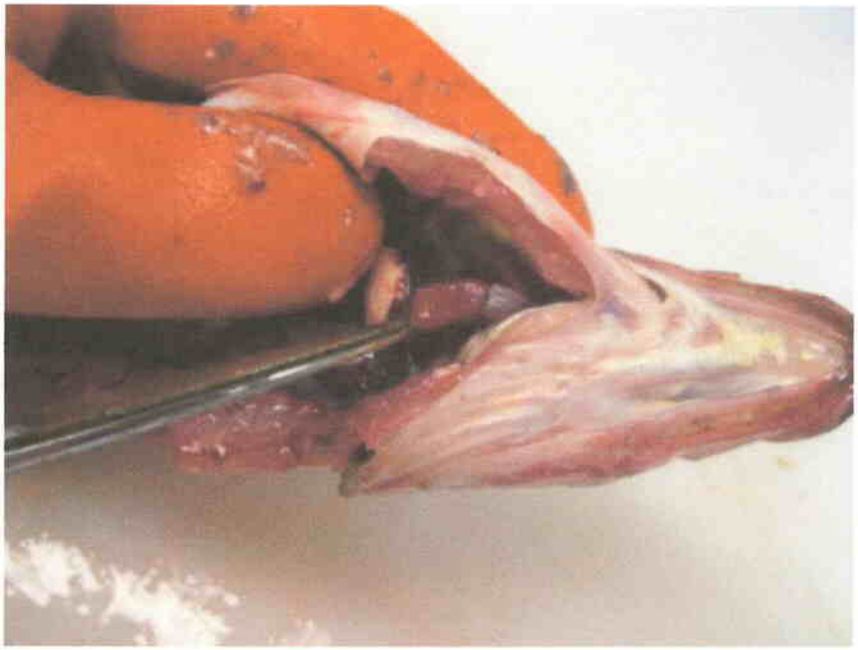
Describe the shape and texture of the gills. What are gills used for?

How does the shape and texture form help with their function (what the gills are supposed to do)?

10. To see the heart, you must be extremely careful with your cuts or you will accidently cut the heart!

Starting between the pelvic fins, use your scissors and make a shallow cut up to the middle of the jaw.

Using your fingers, pull back the body to see the heart.



A human heart is found in the chest cavity. Why do you think that it is advantageous for the heart of a fish to be close to the front of the head? To guide your explanation, think about what the heart does when it pumps blood! Also consider what body organs the heart is next to!

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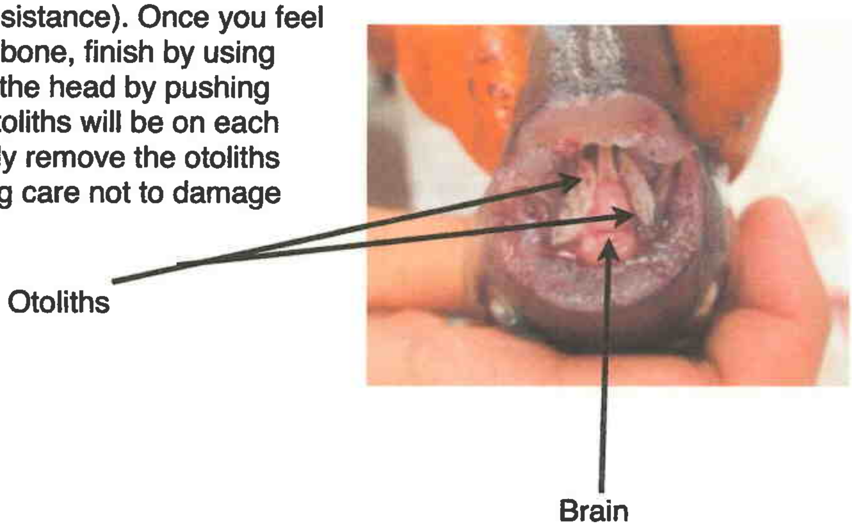
Otolith Extraction!

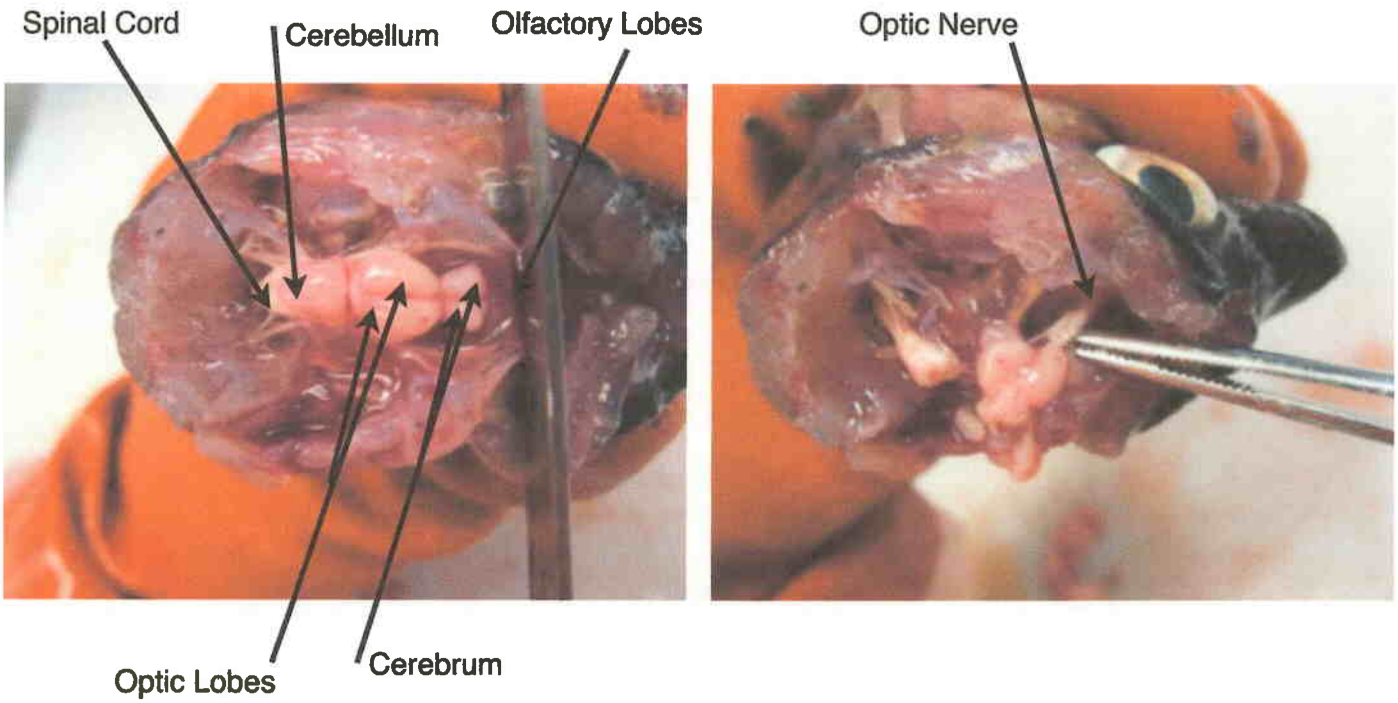
11. From the line of the gill opening is another small reddish line. Align your serrated steak knife just in front of this second line, closer to the eye, and parallel.

Rotate your knife so that it is positioned on the top of the head.

Carefully cut through the skin and just through the bone (you'll feel a little resistance). Once you feel as if you are through the bone, finish by using your hands and bending the head by pushing down on the nare. The otoliths will be on each side of the brain. Carefully remove the otoliths with your tweezers, taking care not to damage the brain.



12. With your serrated steak knife, carefully remove the top of the head. Take care to not cut into the brain!



13. Next, observe the eye. Notice the size of it and locate the pupil. Covering the eye is the cornea, a clear membrane. Now, cut the eye out of the socket. Cut through the cornea and remove the lens. What is the function of the lens?

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14. Now let's look at the vertebrate of the fish. Turn the fish over to the side we did not cut. From the tail fin, make a shallow slice. Next make a shallow cut that runs down the dorsal (top) side of the fish. Slice through the muscle and skin in a filet style and remove. Tip, you want to keep your knife next to the spine and parallel to it.

Describe or draw with labels what you see in the space below!

15. Remove a vertebrae and sketch it in the space below!

Post-Dissection Questions:

16. Sketch and **label** in order, the digestive tract of a Walleye Pollock, starting with the mouth and ending at the anus.

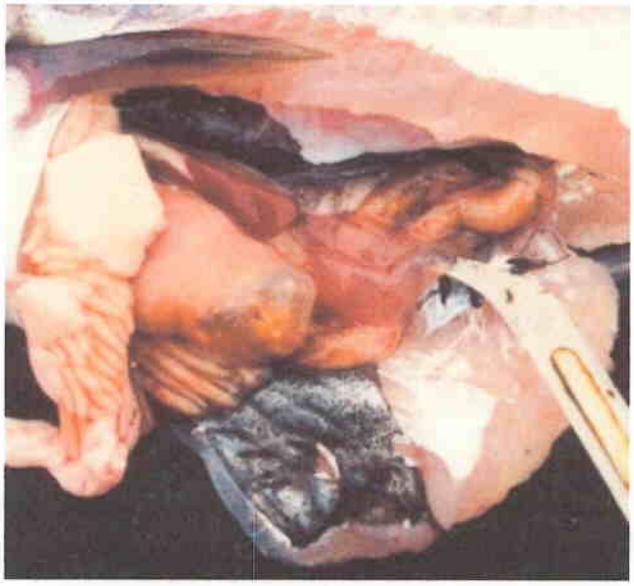
17. Determine the sexual maturity stage of your fish using the scale on the next page.

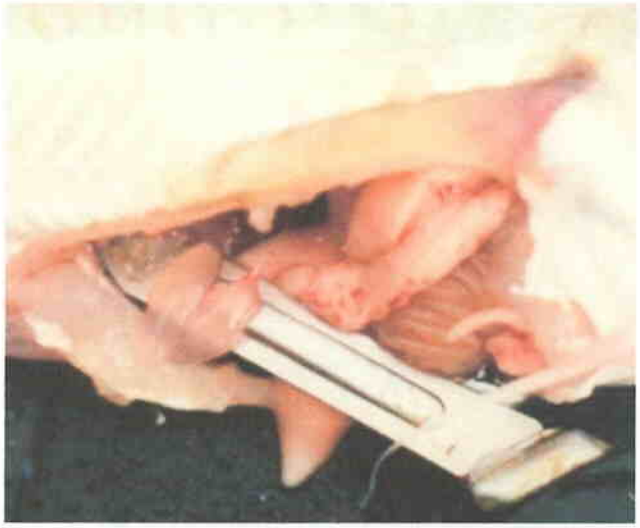
18. What surprised you when you were dissecting?

19. What curiosities or questions do you still have?

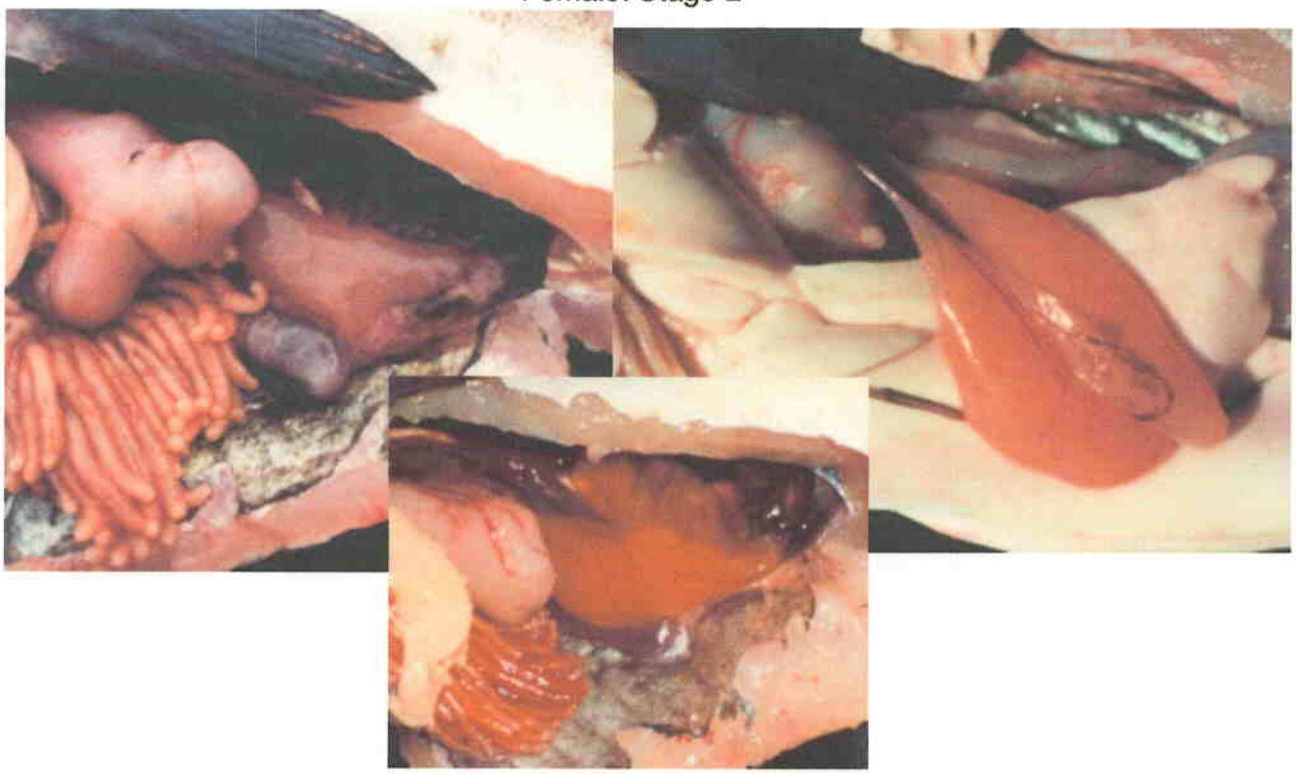
Sexual Maturity Chart

Female: Stage 1

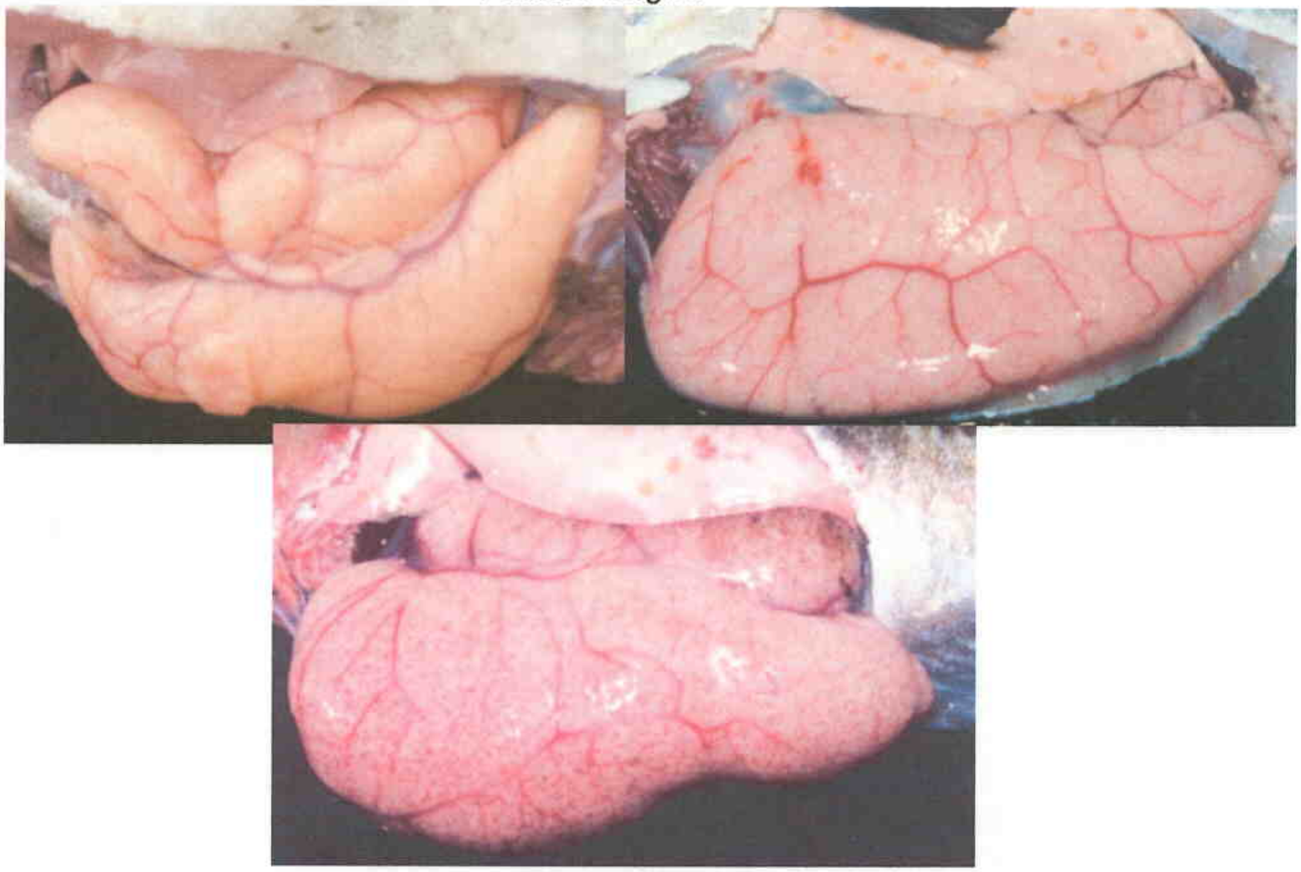




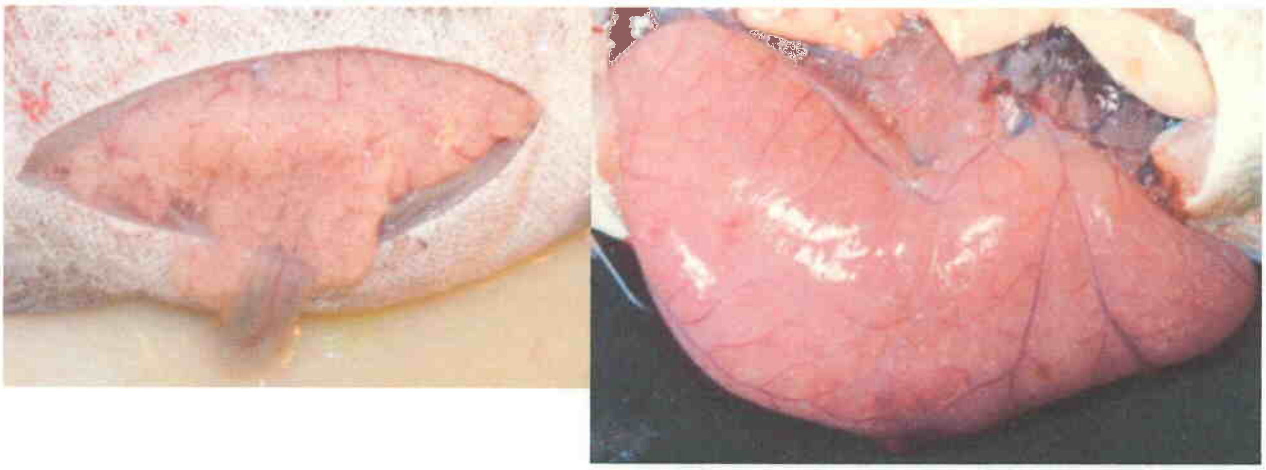
Female: Stage 2



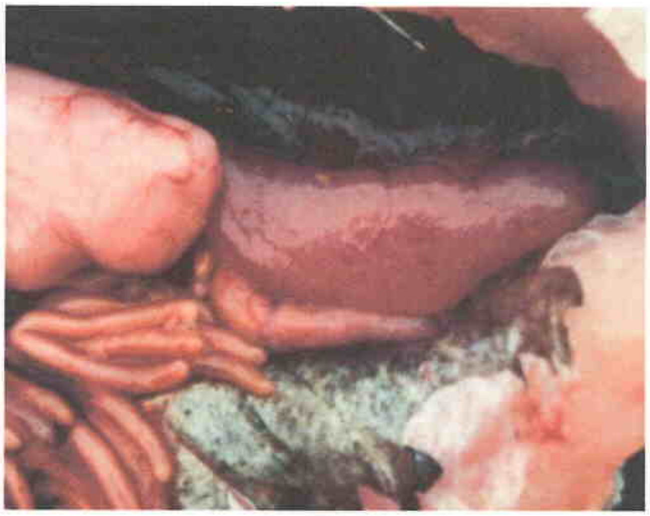
Female: Stage 3



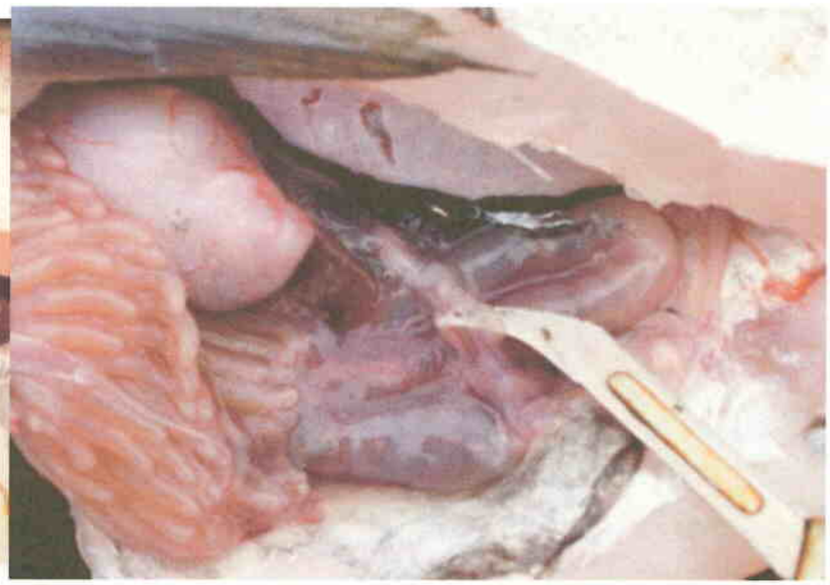
Female: Stage 4



Female: Stage 5

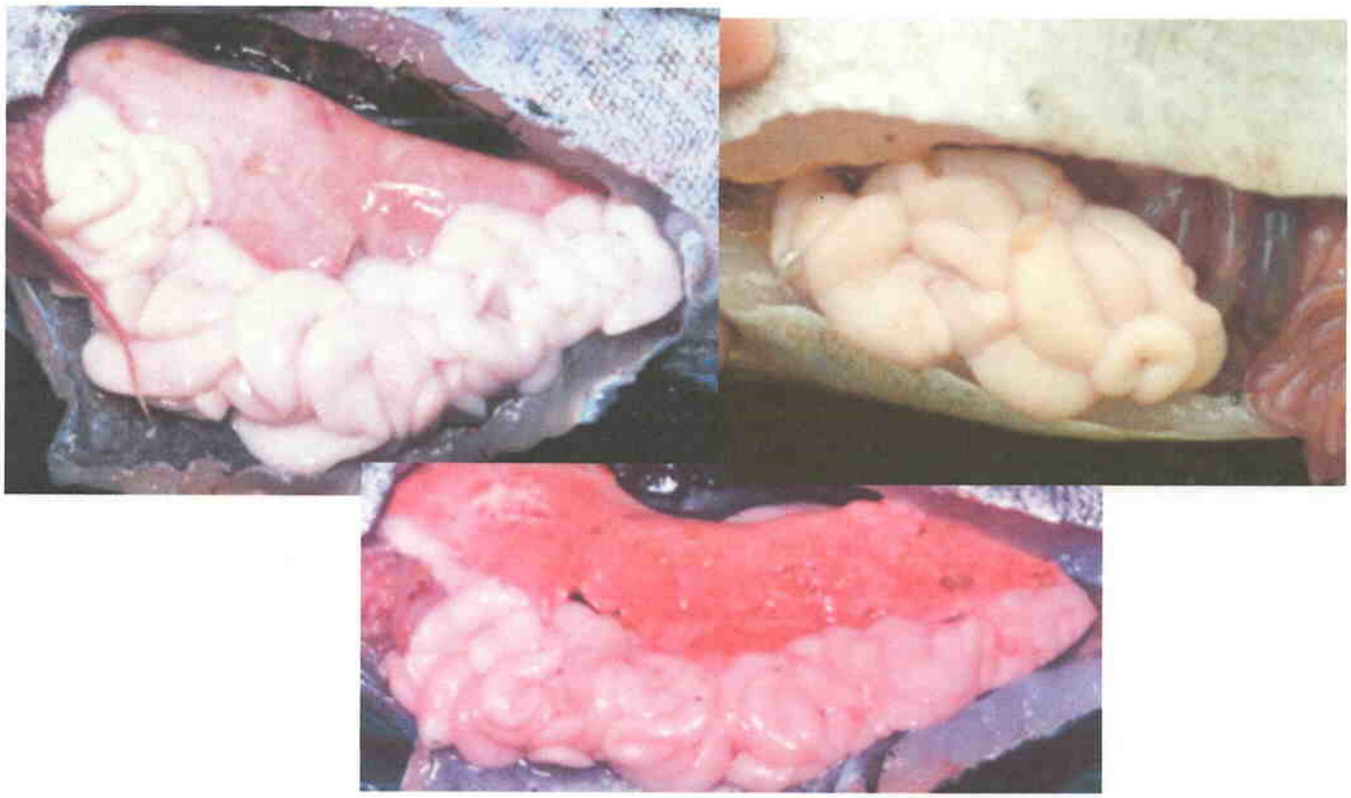


Male: Stage 1

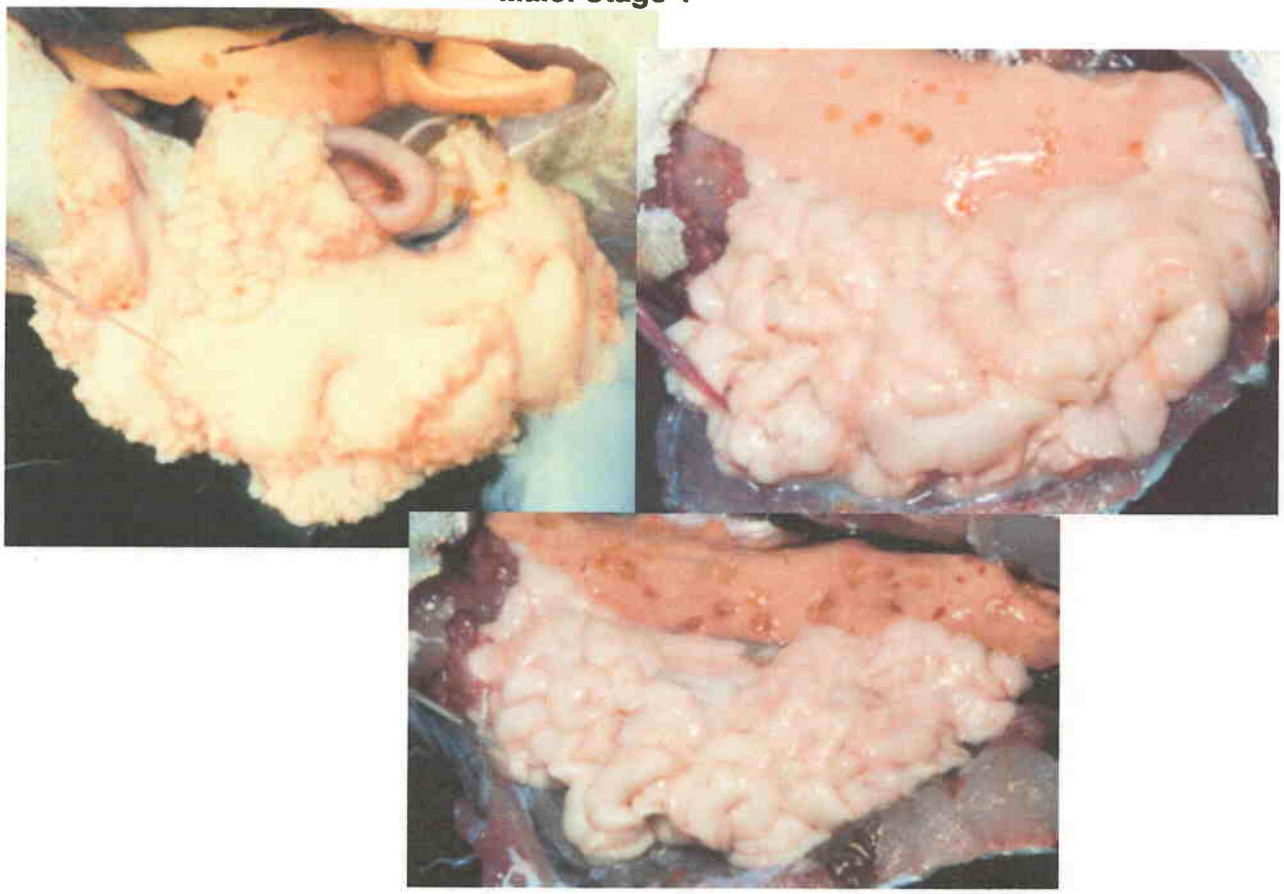


Male: Stage 2

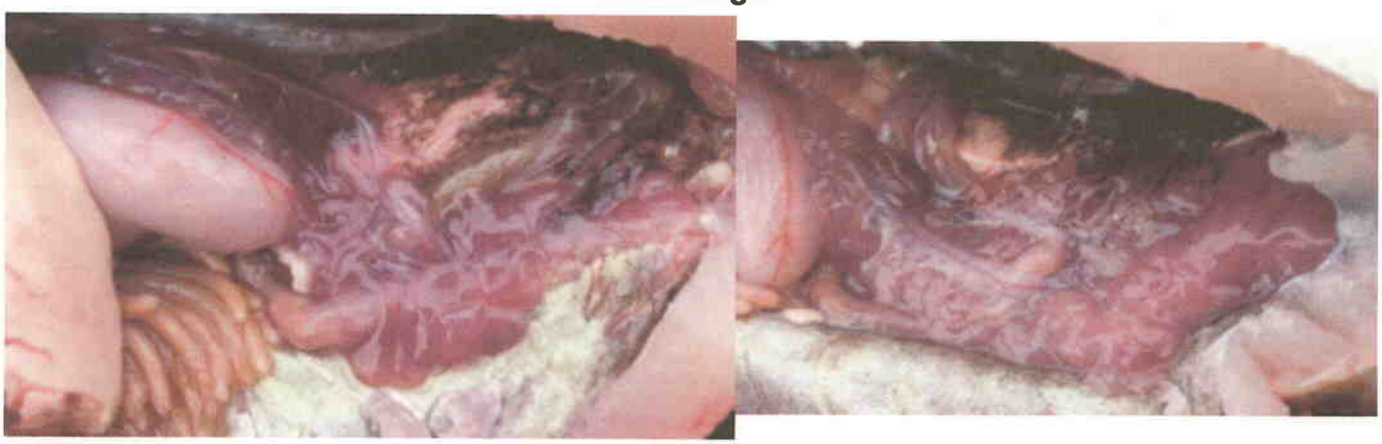
Male: Stage 3



Male: Stage 4



Male: Stage 5



Data Analysis Activity:

Percentage of Lengths of Bering Sea Walleye Pollock Per Sample Year

Length cm	% 1994	%1996	%1997	% 1999	% 2000	% 2002	% 2004	% 2006	% 2007	% 2008	% 2009
1-5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6-10	0.0	0.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.0	0.6
11-15	3.0	2.7	24.8	0.8	1.6	2.7	0.2	12.0	49.4	0.5	52.5
16-20	9.2	13.4	40.8	2.3	3.0	3.4	0.3	1.6	13.4	9.7	12.7
21-25	32.6	4.3	6.6	12.9	10.6	20.9	2.8	4.4	7.1	47.1	6.8
26-30	8.9	5.2	10.0	16.7	11.5	25.3	3.6	4.0	2.0	14.2	9.6
31-35	11.5	25.0	2.3	20.1	14.2	19.6	13.2	8.6	2.5	12.1	11.7
36-40	14.6	25.8	7.4	19.7	23.4	9.1	32.9	20.1	4.4	3.2	2.6
41-45	12.3	11.1	5.2	14.6	20.6	6.3	31.7	23.8	9.2	3.7	0.8
46-50	6.3	7.0	1.7	9.8	11.9	6.8	11.5	18.6	8.5	5.3	1.1
51-55	1.1	3.8	0.7	1.9	2.6	3.3	5.9	7.1	2.4	2.8	1.1
56-60	0.3	0.6	0.2	0.3	0.5	0.9	1.5	1.7	0.5	1.0	0.5
61-65	0.1	0.1	<0.1	<0.1	0.1	0.1	0.2	0.3	<0.1	0.3	0.1
66-70	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
71-75	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
76-80	<0.1	0.0	<0.1	<0.1	0.0	0.0	<0.1	<0.1	<0.1	<0.1	0.0
Estimated Total Fish in Millions	10,821	6,525	18,686	9,601	7,630	12,122	6,835	3,396	9,207	4,704	8,075

1. Scientists sample small amounts of fish and use ratios to estimate the number of fish in the sea. In 1997, scientists estimated that 10% of all Walleye Pollock in the Bering Sea that year had lengths ranging from 26 - 30 centimeters. **If there were 18,686 million pollock in the sea, write the number in standard form to see how many fish are estimated to have a length of 26-30 cm in the Bering Sea.**

2. **What is the actual number of fish estimated to be in the Bering Sea in 2002?**

3. In 1996, the percentage of pollock whose length ranged from 46 cm to 50 cm was 7%. This means that for every 100 fish, 7 of them had lengths from 46 cm to 50 cm. **In 2006, for every 100 fish, what percent fit between 11 - 15 cm? __________%**

4. **In 2009, 12.7% of estimated total fish fit lengths of 16-20 cm. Explain what the decimal means.**

5. Notice that all the numbers in the table have values in the tenths place. **Why would the scientists write the numbers in this form, rather than round to the nearest whole percent? (Hint: think about how the odds change with the inclusion of the decimal)**

6. Notice in the table, there are many zeros at the top. **Does this mean there are no fish in the sea the fit those sizes in that specific year? Explain.**

7. **What do you think the values < 0.1 mean in the table? Why wouldn't the scientists just write 0?**

8. **In your group place the histograms representing the pollock *Length Distributions by Percent* in chronological order on your table.**

9. **Draw lines between the bars on each graph to separate age groups using the following information:**

a. **Age 1 typically will fall between lengths 1cm to 20cm**
b. **Age 2 typically will fall between lengths 21cm to 25cm**
c. **Age 3 typically will fall between lengths 26cm to 35cm**
d. **Age 4 typically will fall between lengths 36cm +**

10. **In 1994, which age group had the highest percentage? ____________________**

a. **Predict what age group this tall bar will fall on in two years. ___________**

11. **In 1996, which age groups had the highest percentage? _______ & ________**

a. **Using your prediction in #3a, create a hypothesis that could explain the results you see in 1996. Be specific!**

12. **One year later, in 1997, which age group had the highest percentage? _______**

a. **Using the data from 1996, explain a possible reason for this change.**

13. **Two years later, in 1999, which age groups had the highest percentage?_____**

a. **Using the data from 1997 (two years earlier), explain a possible reason for this change.**

14. **From the year 1999 to 2006, which age group had the lowest percentage of fish? ______________________**

a. Scientists were surprised and intrigued by the results of this data. **Explain possible future problems scientists might have noticed when looking at the distribution of ages and their population numbers.**

b. **Name at least two events that could have caused these problems?**

c. Physical oceanographers analyzed sea temperature data and noticed that from the year 2000 to 2006 the sea temperature in the Bering Sea was warmer than in previous years. Additionally, they noticed that from 2007 to 2009 the sea temperatures became colder.

Using the information from your bar graphs and the above information, hypothesize a possible reason for this low percentage of fish.

d. Your answer for part c is called a correlation. This means that you put two sets of information, that seemed to be related, together. **Can we make an absolute conclusion that states why this low percentage occurred? Why or why not?**

15. **When looking at all the bar graphs, state at least one other observation you can make?**

16. **As a class, compile all the length and sexual maturity data.**

a. Total the number of male and female pollock.

Males	**Females**	**Total**

b. Calculate the percentage:

__________ / __________ = __________ x 100 = _______________ %
\# Males Total Percentage of Males

__________ / __________ = __________ x 100 = _______________ %
\# Females Total Percentage of Females

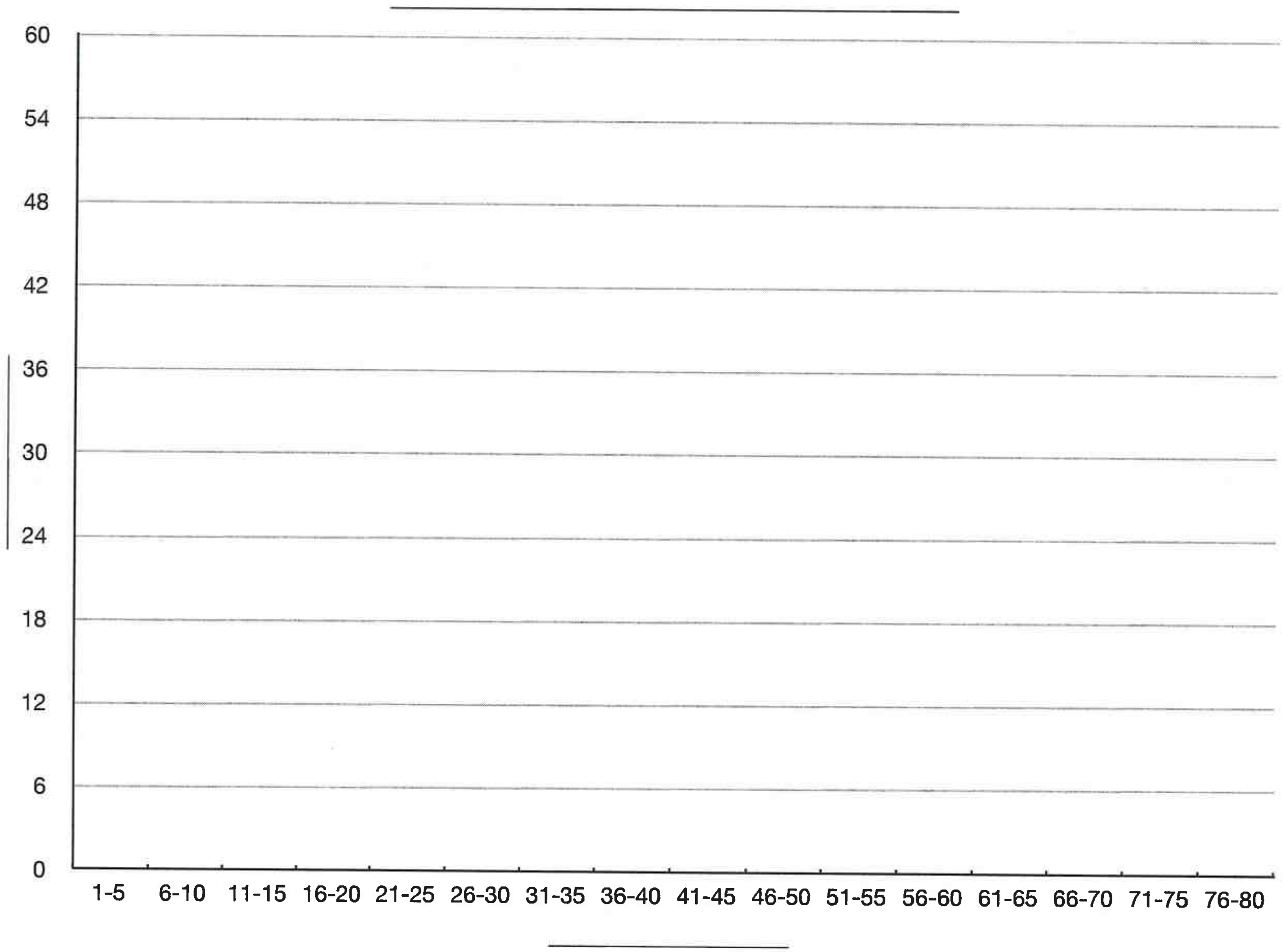
% Males	**% Females**

17. **Add the percent of males to the percent of females. Do you get 100%? Explain! If you do not get 100%, it doesn't necessarily mean you are wrong. What might have caused this result?**

18. **Find the percentage distribution of your sample by filling in the table below:**

Length (cm)	# of Pollock in Each Length Range	% of Pollock in Each Length Range (# pollock / Total = _____ x 100)
1 - 5		
6 - 10		
11 - 15		
16 - 20		
21 - 25		
26 - 30		
31 - 35		
36 - 40		
41 - 45		
46 - 60		
51 - 55		
56 - 60		
61 - 65		
66 - 70		
71 - 75		
76 - 80		
Total		

19. **Using a ruler and the above data, create a histogram on the following page. Be sure to title your graph and axes!**

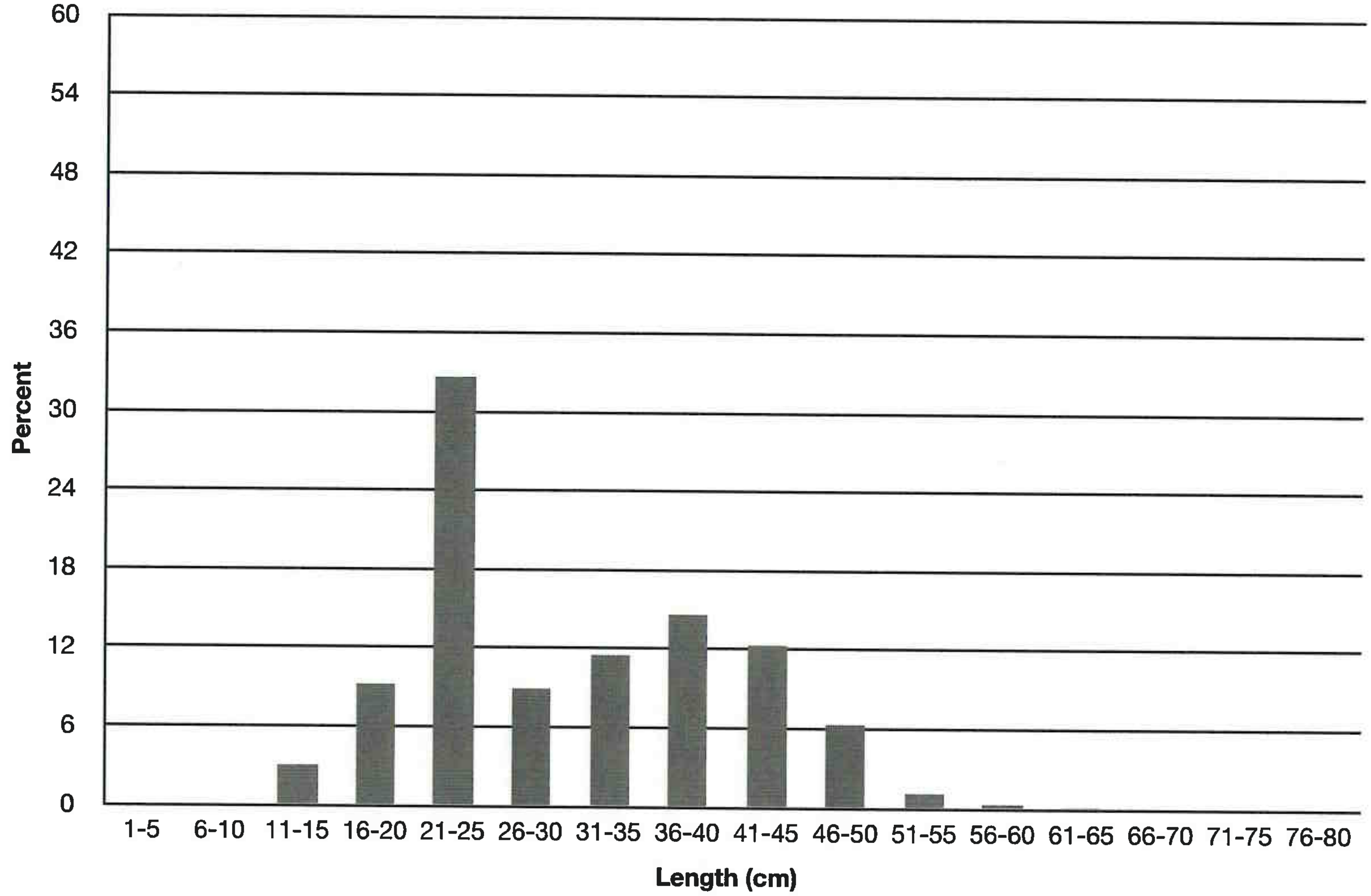

60
54
48
42
36
30
24
18
12
6
0
1-5
6-10
11-15
16-20
21-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66-70
71-75
76-80

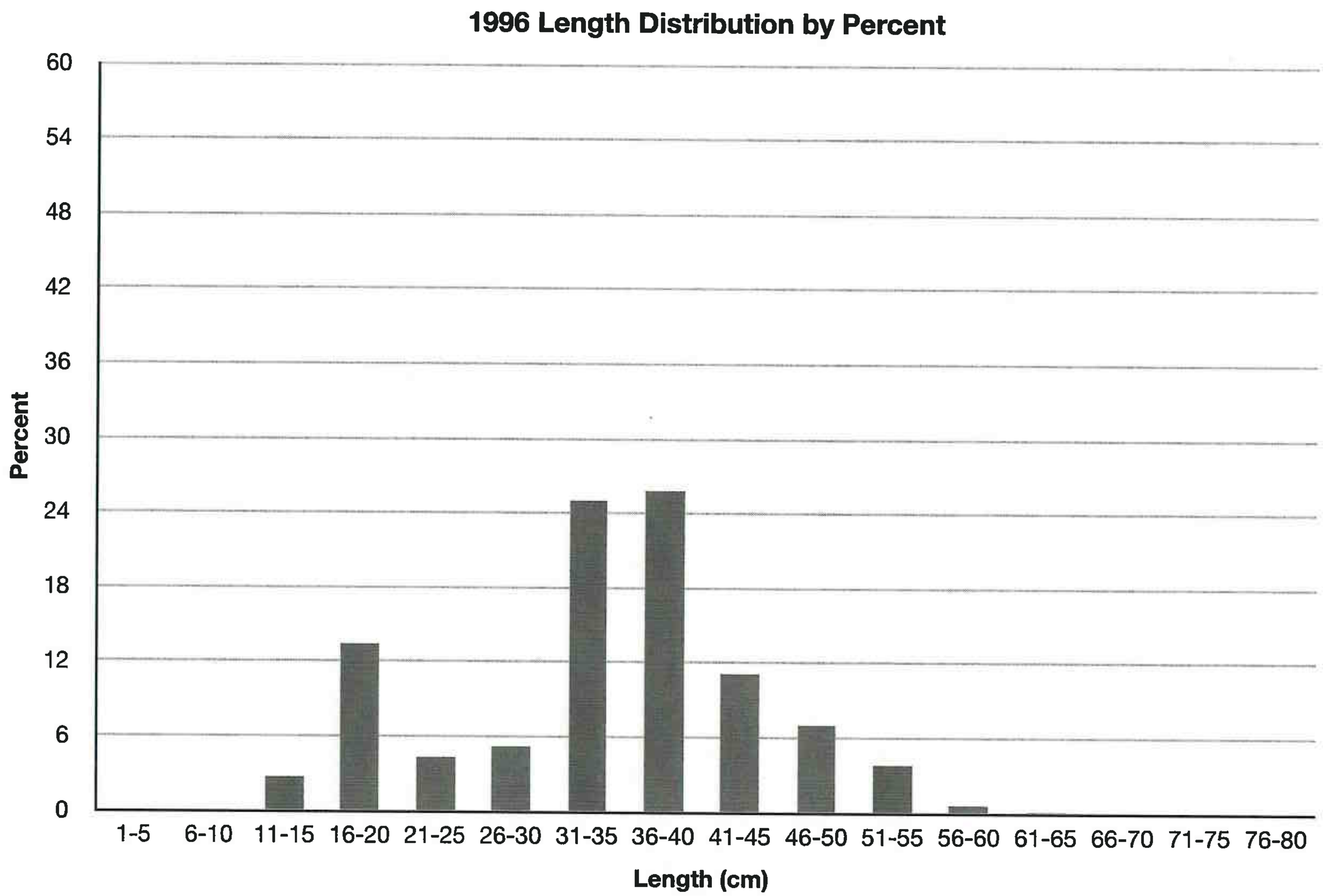
20. **Compare your graph to the data collected by the Bering Sea Project. What year does your sample look the most like, if at all? If your graph looks similar to another year use evidence from your graph and evidence from that year in your explanation. If your graph does not look like any of the other years, use evidence from your graph and from other years to explain why!**

21. **Because fishing is very important to many families in Dutch Harbor and Unalaska, as the Chief Scientific Team, it is your job to communicate the results of your research with the rest of the community. Write a one-page summary to turn into the newspaper that interprets your information on the current state of the Bering Sea Walleye Pollock.**

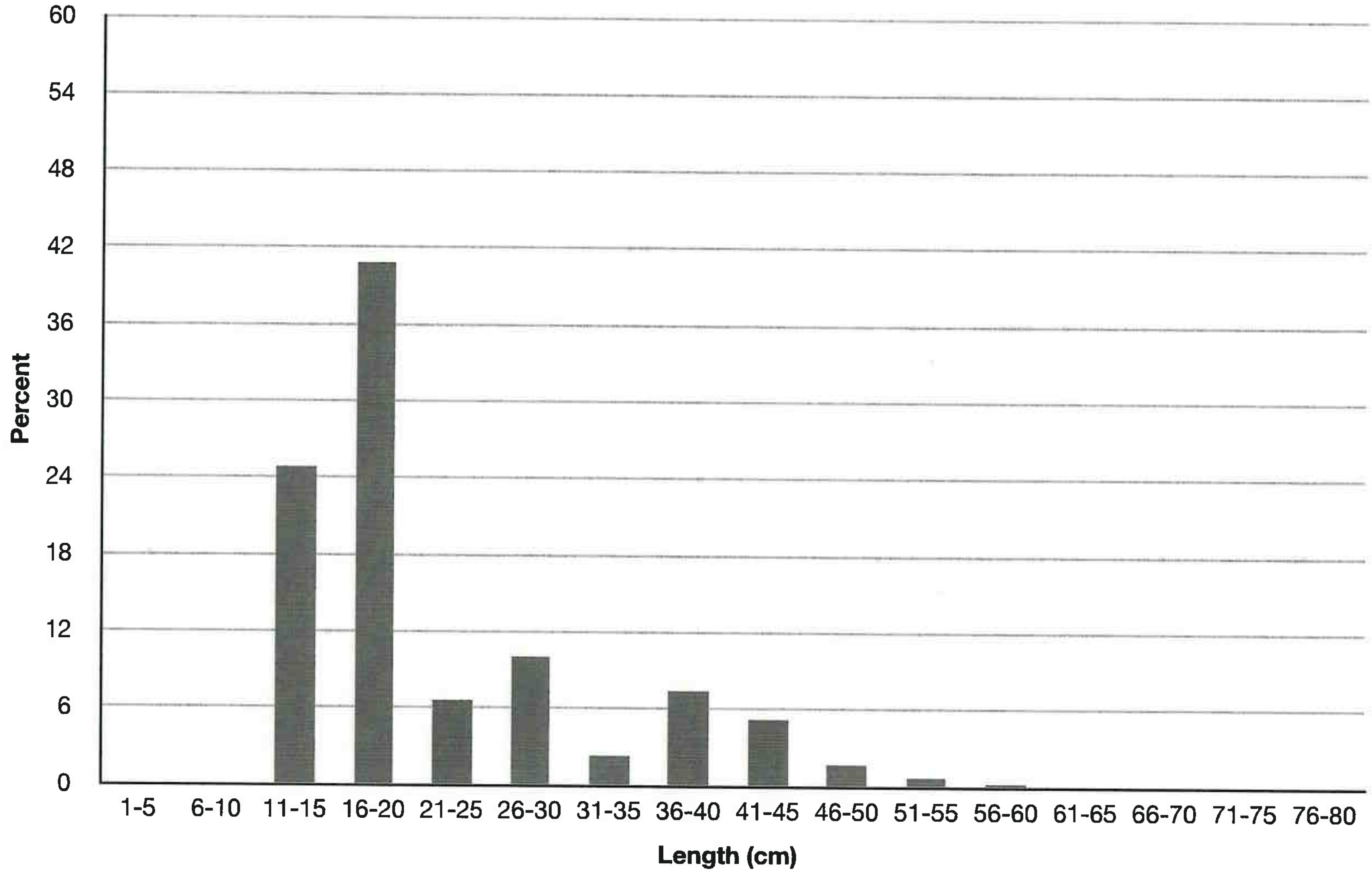
Length cm	% 1994	%1996	%1997	% 1999	% 2000	% 2002	% 2004	% 2006	% 2007	% 2008	% 2009	Length cm
1-5	0	0	0	0	0	0	0	0	0	0	0	1-5
6-10	0	0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0	0.6	6-10
11-15	3	2.7	24.8	0.8	1.6	2.7	0.2	12	49.4	0.5	52.5	11-15
16-20	9.2	13.4	40.8	2.3	3	3.4	0.3	1.6	13.4	9.7	12.7	16-20
21-25	32.6	4.3	6.6	12.9	10.6	20.9	2.8	4.4	7.1	47.1	6.8	21-25
26-30	8.9	5.2	10	16.7	11.5	25.3	3.6	4	2	14.2	9.6	26-30
31-35	11.5	25	2.3	20.1	14.2	19.6	13.2	8.6	2.5	12.1	11.7	31-35
36-40	14.6	25.8	7.4	19.7	23.4	9.1	32.9	20.1	4.4	3.2	2.6	36-40
41-45	12.3	11.1	5.2	14.6	20.6	6.3	31.7	23.8	9.2	3.7	0.8	41-45
46-50	6.3	7	1.7	9.8	11.9	6.8	11.5	18.6	8.5	5.3	1.1	46-50
51-55	1.1	3.8	0.7	1.9	2.6	3.3	5.9	7.1	2.4	2.8	1.1	51-55
56-60	0.3	0.6	0.2	0.3	0.5	0.9	1.5	1.7	0.5	1	0.5	56-60
61-65	0.1	0.1	<0.1	<0.1	0.1	0.1	0.2	0.3	<0.1	0.3	0.1	61-65
66-70	<0.1	<.01	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	66-70
71-75	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	71-75
76-80	<0.1	0	<0.1	<0.1	0	0	<0.1	<0.1	<0.1	<0.1	0	76-80

1994 Length Distribution by Percent

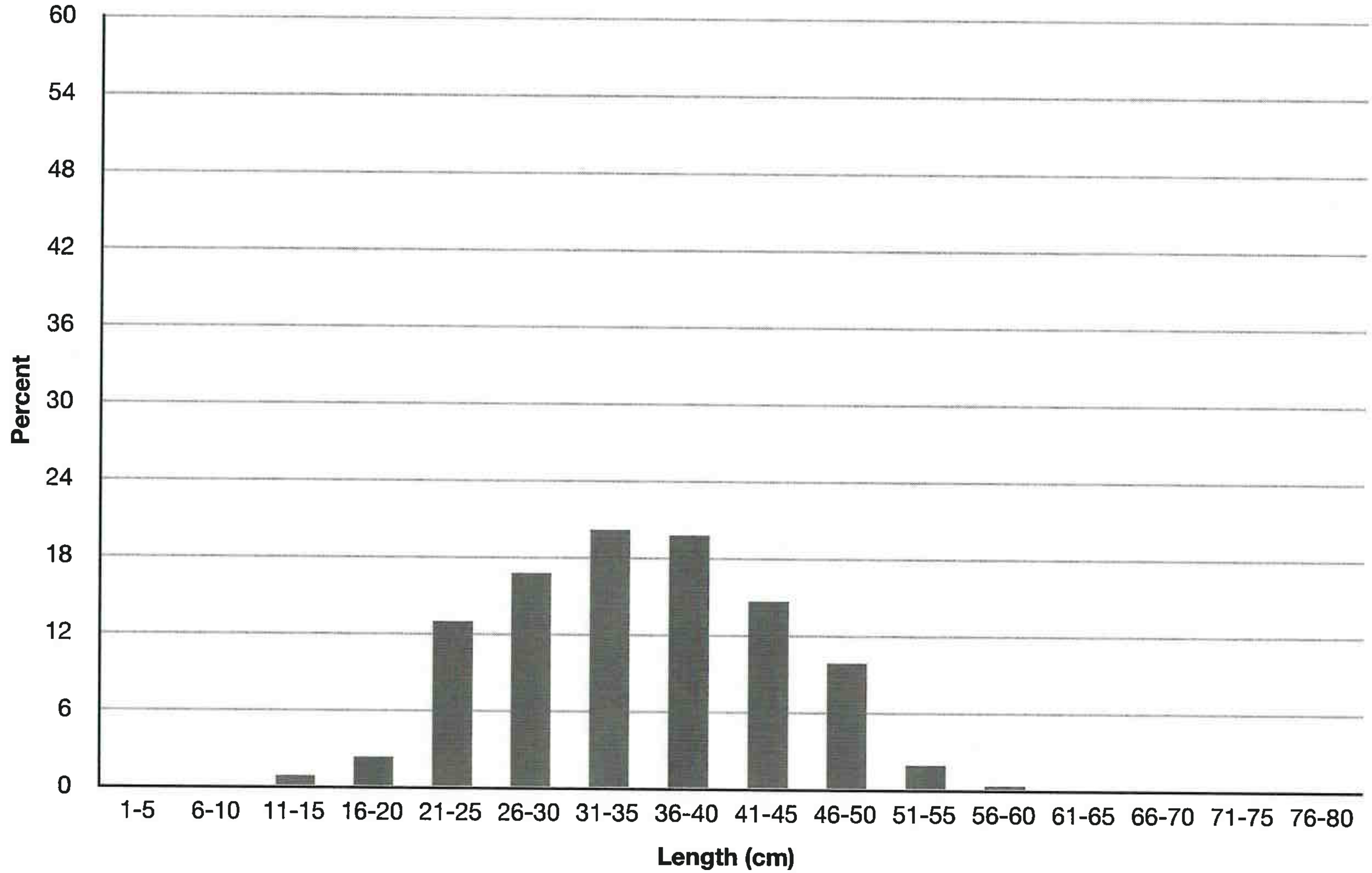



1996 Length Distribution by Percent
Percent
60
54
48
42
36
30
24
18
12
6
0
1-5
6-10
11-15
16-20
21-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66-70
71-75
76-80
Length (cm)

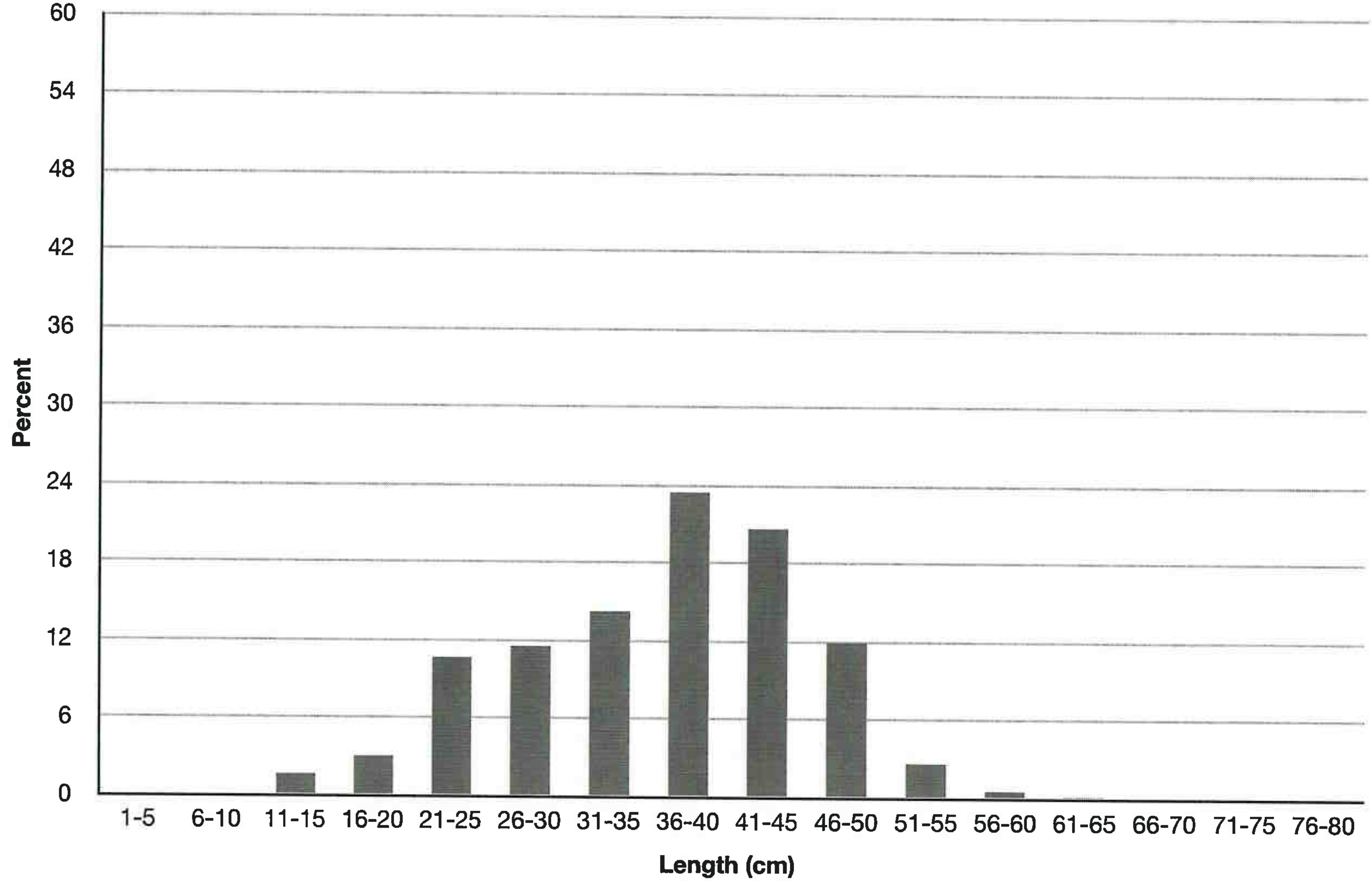
1997 Length Distribution by Percent



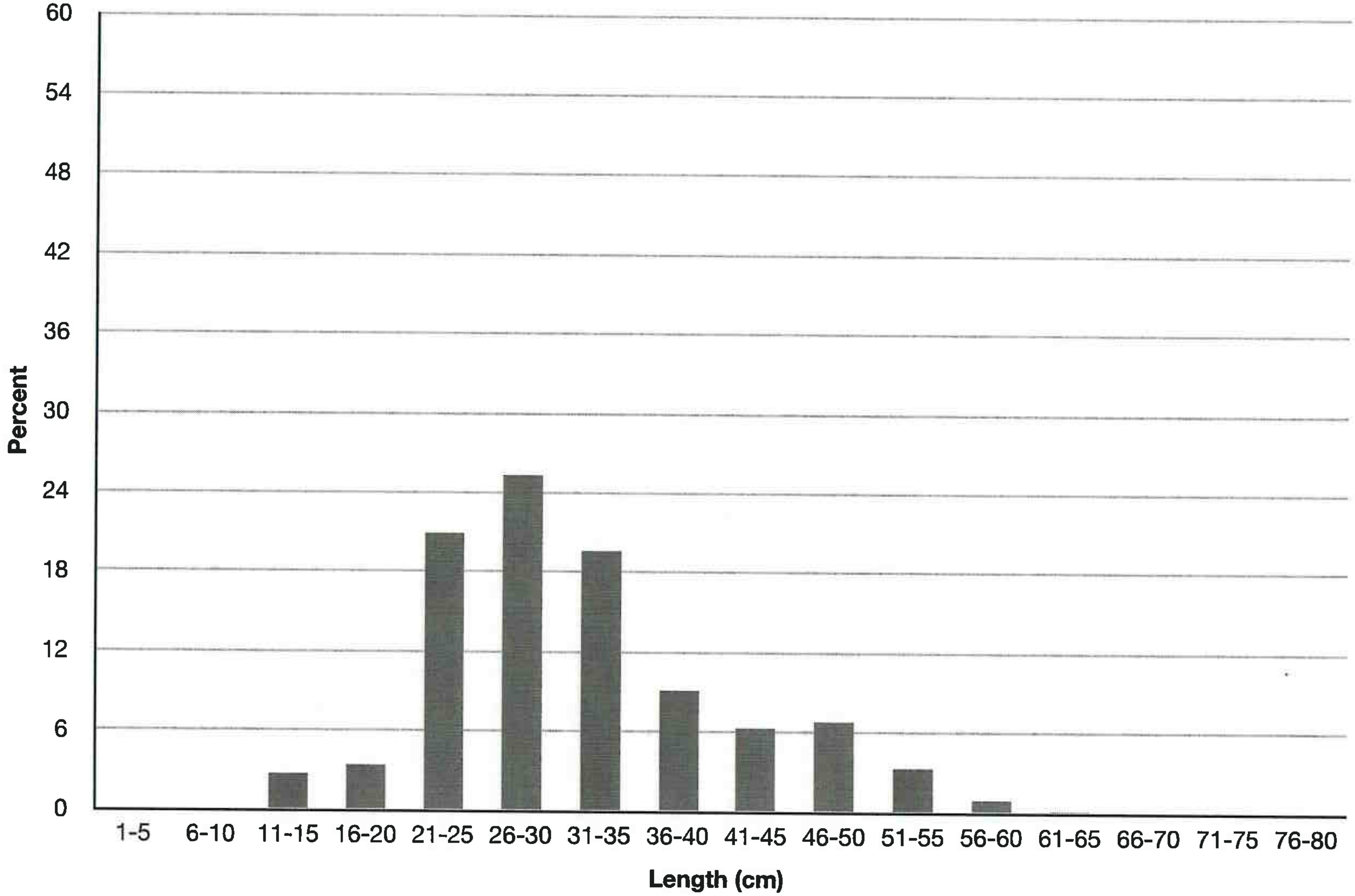
1999 Length Distribution by Percent



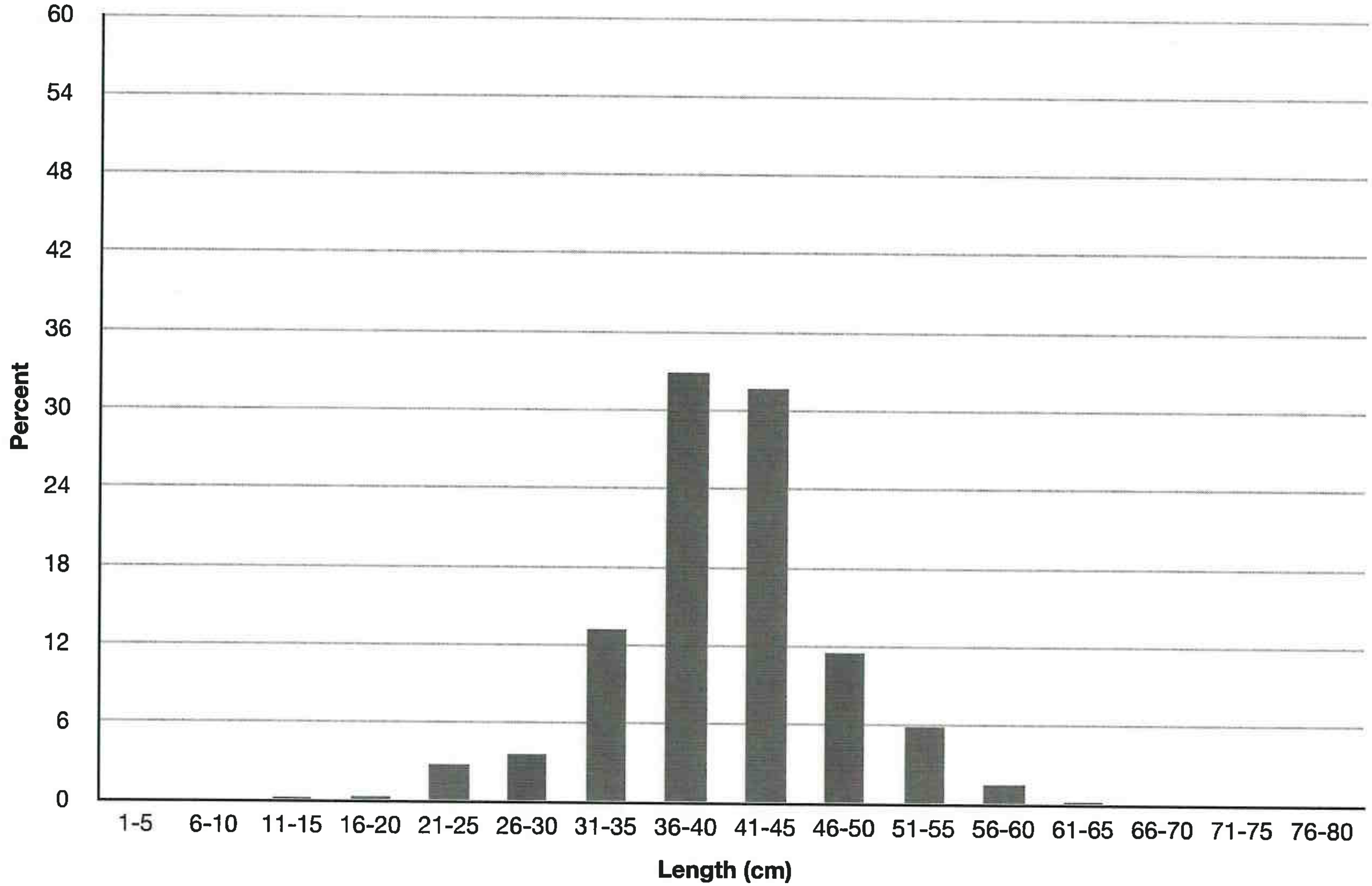
2000 Length Distribution by Percent

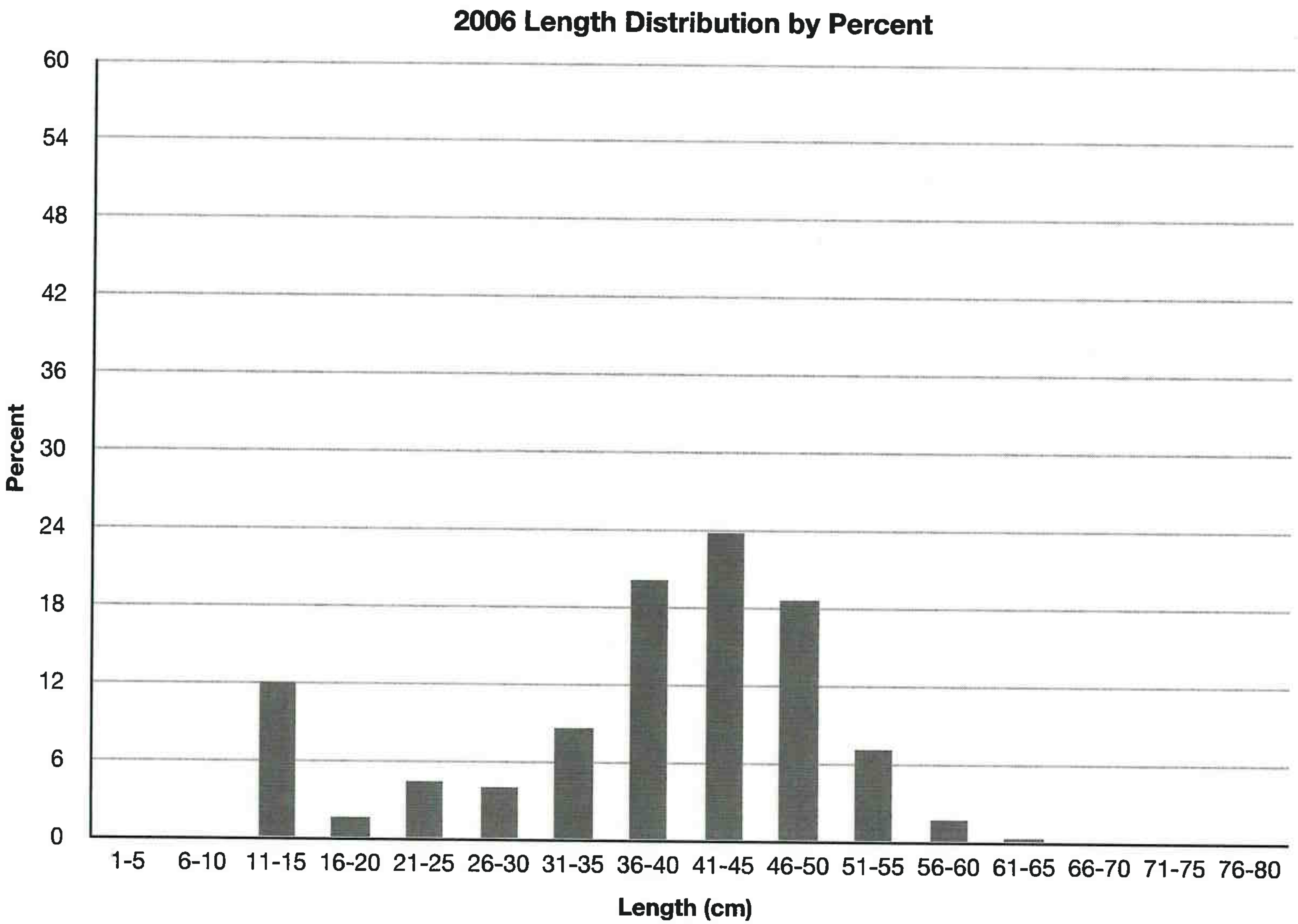


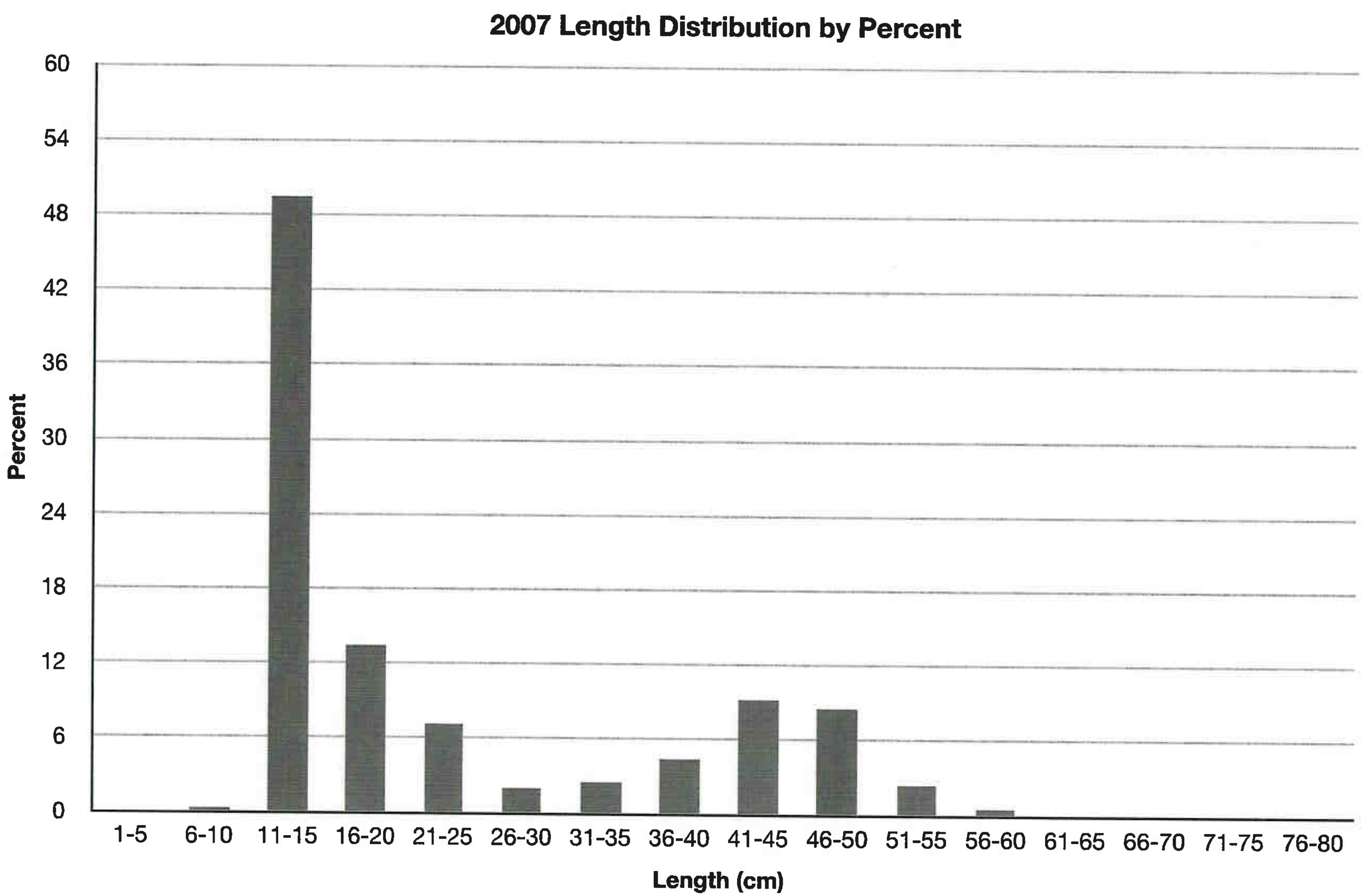
2002 Length Distribution by Percent



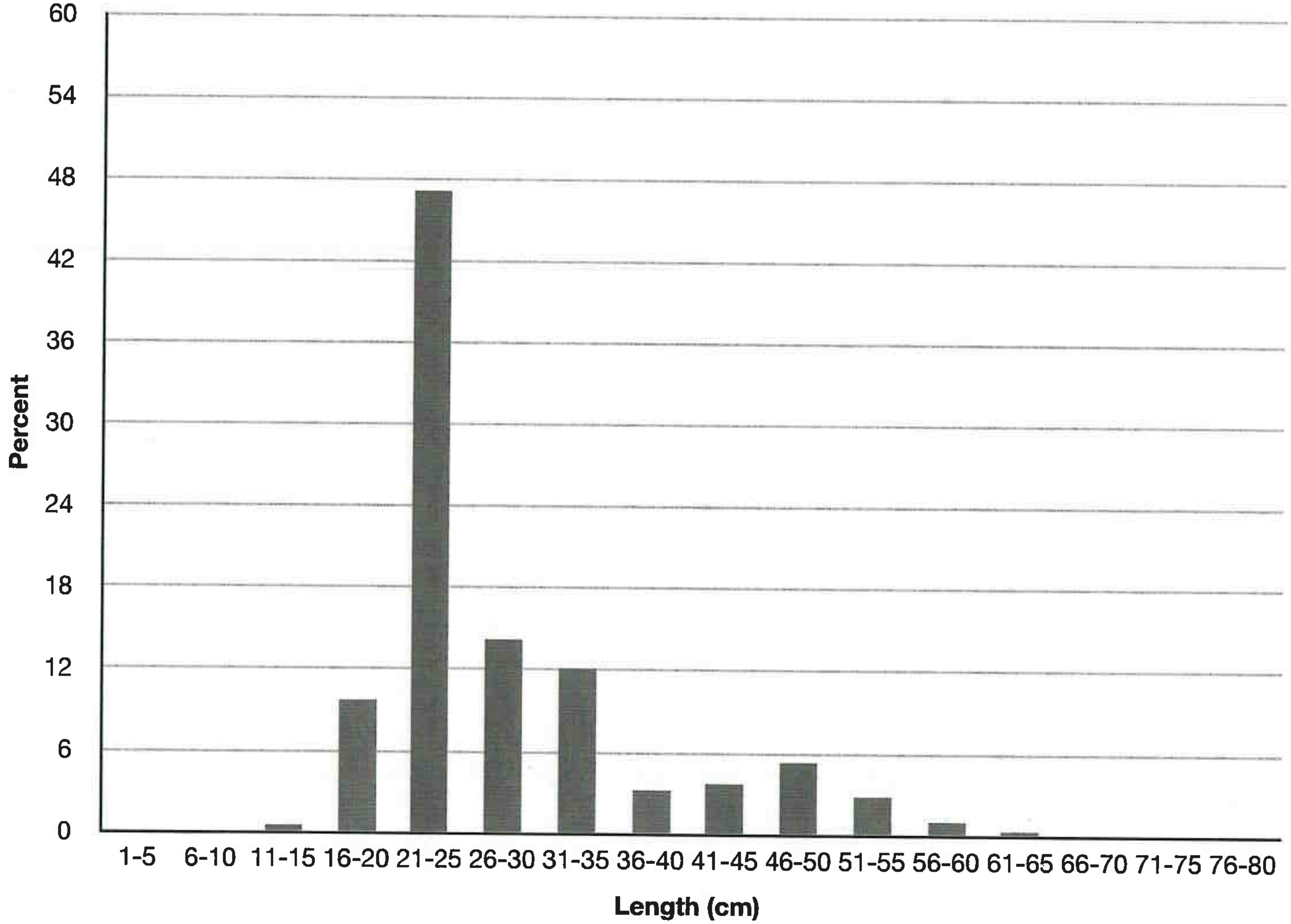
2004 Length Distribution by Percent

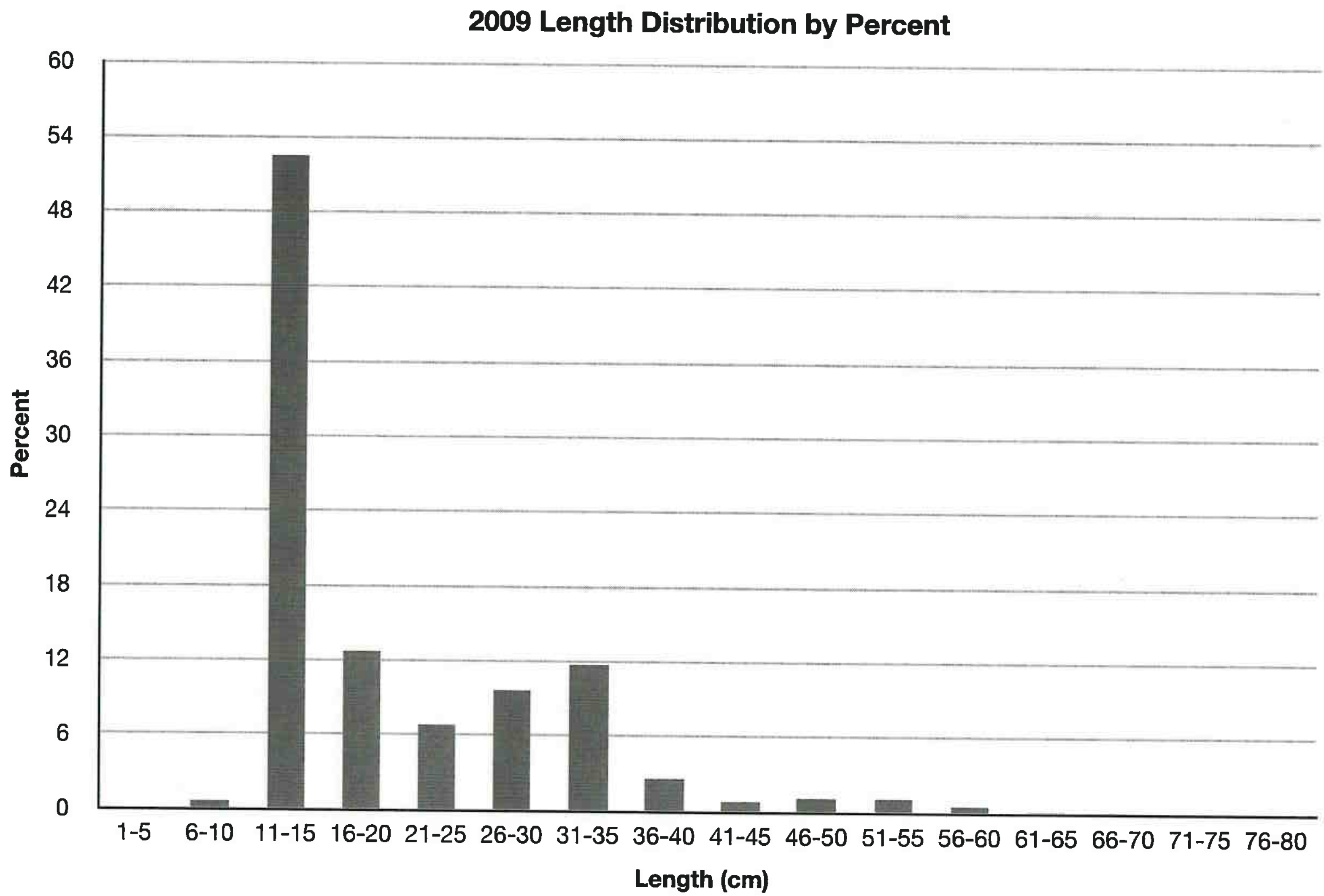



2006 Length Distribution by Percent
Percent
60
54
48
42
36
30
24
18
12
6
0
1-5
6-10
11-15
16-20
21-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66-70
71-75
76-80
Length (cm)


2007 Length Distribution by Percent
Percent
60
54
48
42
36
30
24
18
12
6
0
1-5
6-10
11-15
16-20
21-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66-70
71-75
76-80
Length (cm)

2008 Length Distribution by Percent

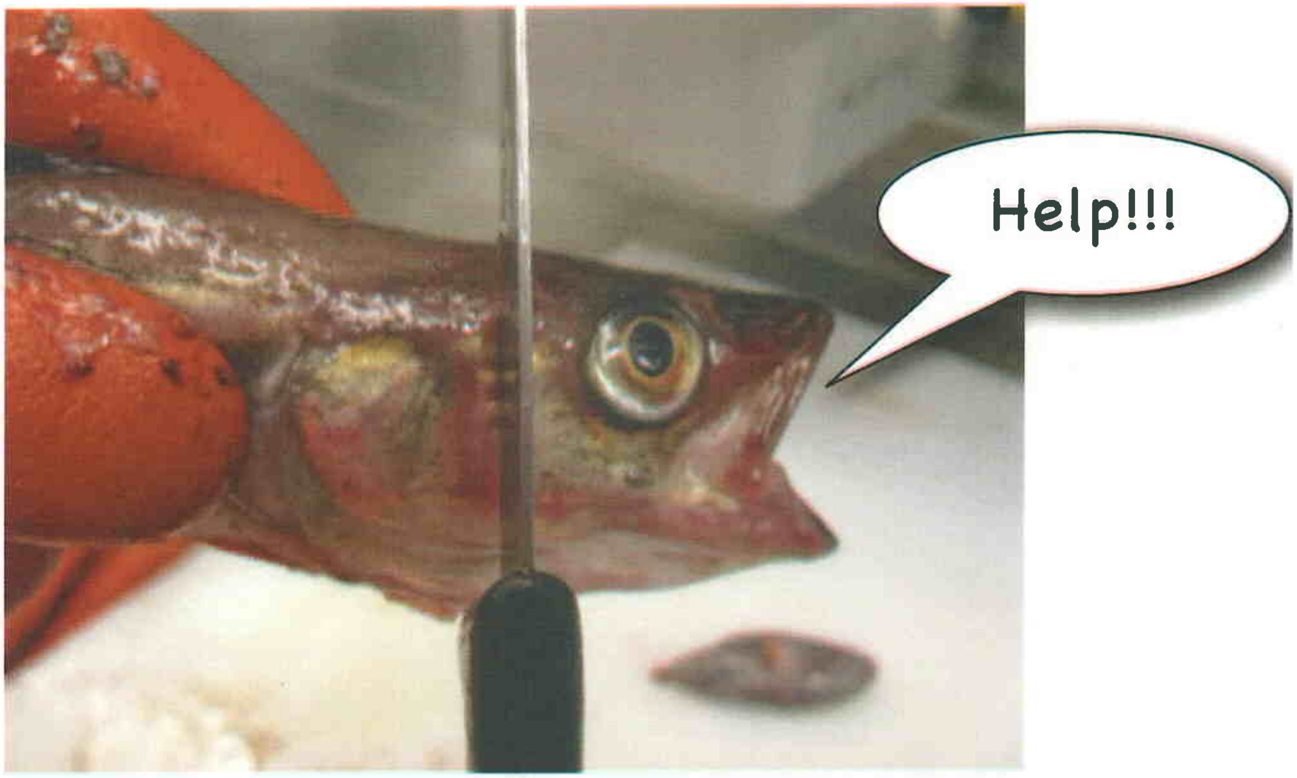




2009 Length Distribution by Percent
Percent
60
54
48
42
36
30
24
18
12
6
0
1-5
6-10
11-15
16-20
21-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66-70
71-75
76-80
Length (cm)

Dissection Guide for Walleye Pollock

(*Theragra chalcogramma*)



Created by NOAA Teacher At Sea
Story Miller
Unalaska City School District

Pre-dissection:

1. Place the small board perpendicular to the table. Press the nare of the fish against the board. The fish will be stiff but do your best to have the mouth closed and body pressed flat so that the tail fin is also flat. Measure the length from the nose to the fork in the middle of the tail in centimeters (include the decimal).

Length: ________varies________________

2. Next, weigh the fish in kilograms. Round to the nearest gram!

Weight: ________varies________________ Students may have to measure in grams

3. Make a quick sketch of your pollock. Label all parts of the fish you already know.

Sketch should include a drawing that at the very least, includes the eyes, the nose, mouth, gills, fins, and scales

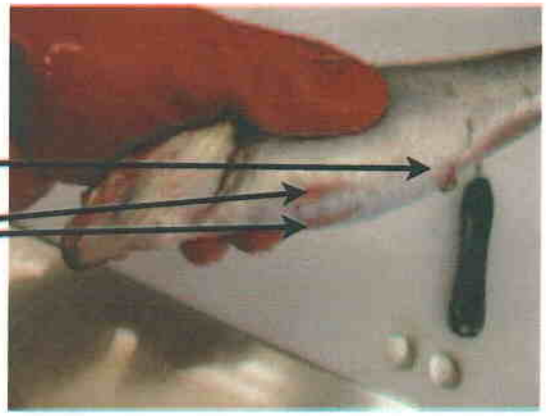
Dissection!

1. If you are right-handed, it will be beneficial to position the fish as seen in Figure 1 where you are holding the fish with your left hand and the scalpel with your right. If you are left-handed, position the fish in your right hand.

2. Turn the fish over and locate the **Anus** and **Pelvic Fins**. **Label the arrows.**

a. anus

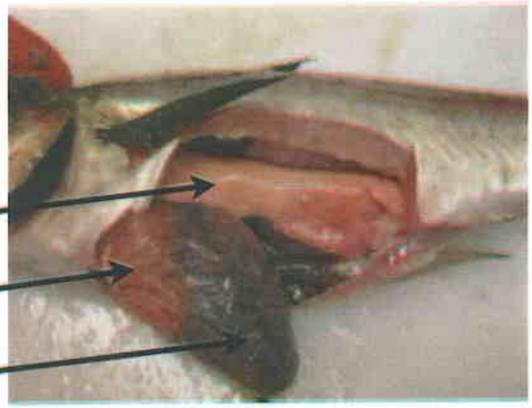
b. pelvic fins



Locate a second opening behind the anus. This is the urogenital opening where eggs and sperm are released.

3. Using the scalpel make a shallow (not very deep) cut from the anus to the pelvic fins. Be careful with your cut so that you do not accidently slice the stomach open!

4. Locate the liver, pyloric caeca, and the stomach. Label the arrows and write how you knew what each body organ was. Figure 4. With your fingers, gently feel the liver and describe its color and texture.



a. liver

b. pyloric caeca

c. stomach

How did you figure out what each body part was? Explain using evidence and previous knowledge:

Varies: Sample answer: We used the picture and located it in the body. The stomach has two tubes, one for entry and one for an exit. The stomach had food inside. We discussed in class how the liver is pink.

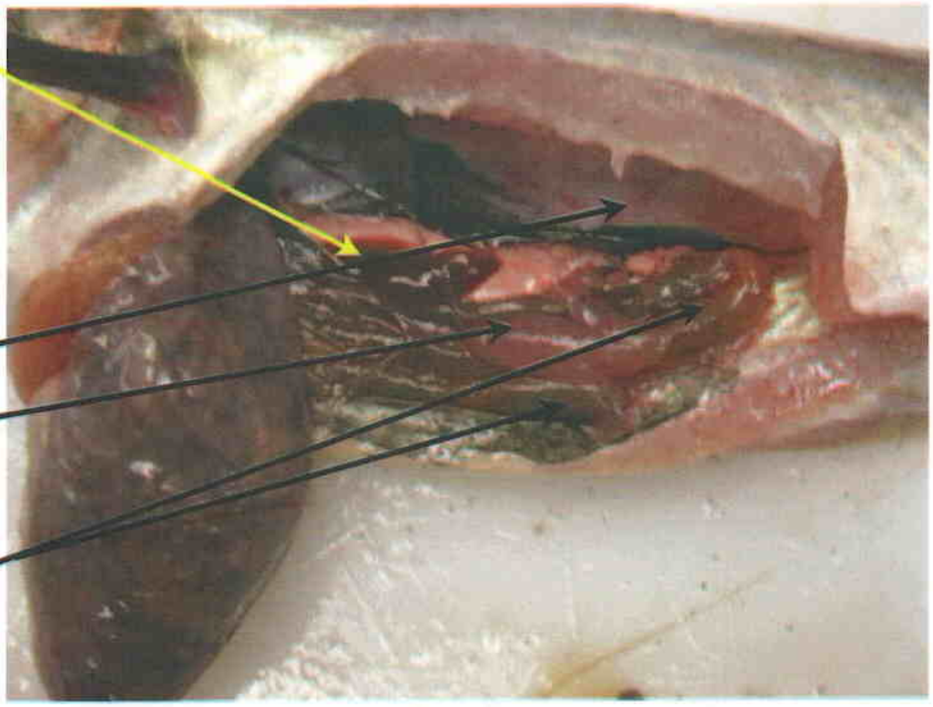
5. When finished, using your fingers and scissors, detach the liver from the body. Careful not to cut the stomach! Find the pancreas, ovaries or testes, swim bladder and the intestines. Whether you have a male fish or a female, make sure to label all the parts on this sheet!

a. pancreas

b. swim bladder

c. ovaries

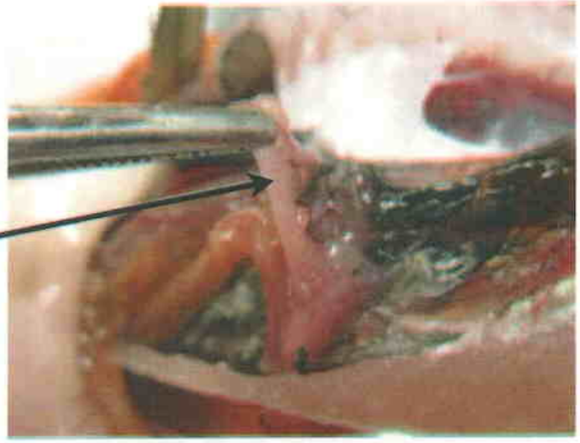
d. intestines



Female

testes

e.



Male

Explain how you knew what each body part was. Make sure to include any evidence you thought of to make your decision!

Varies. Sample Answer: Fish intestines look much like human intestines so that was our hypothesis. We recognized the ovaries because some had eggs in them and it looked like tobiko at the sushi restaurant! We also knew that the pancreas is much smaller than the other organs.

6. Carefully extract the stomach by grabbing the connection near the head with the tweezers and snipping it off using the scissors. Note that you will need to cut twice! Make an incision in the stomach and take out its contents. What did your Walleye Pollock have for its last meal? Usually pollock feed on amphipods, copepods, euphausiids, and small fish.

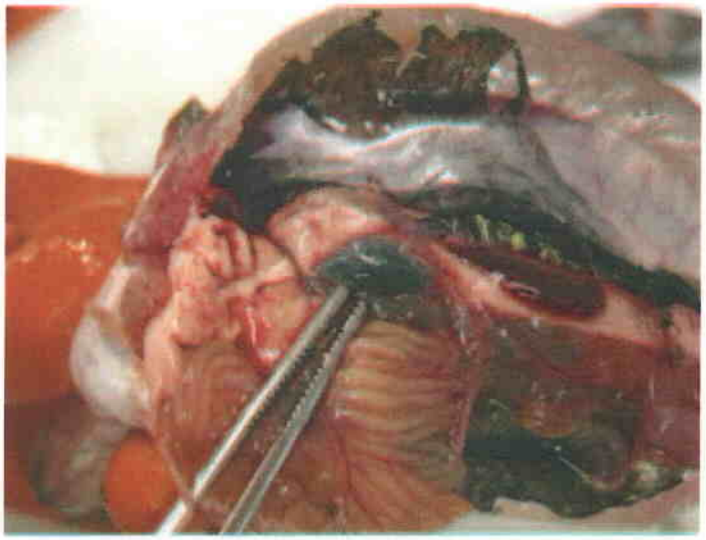
Describe what you see. Give details!
Varies

The stomach contents include small shrimp like animals that are purple and partially digested. They are also stringy, pink and orange splotches that are visible.

My pollock had the following for dinner:

Varies: After seeing pictures of these animals, my pollock ate shrimp, krill, and copepods.

7. Inspect a tiny greenish, blue sac near the pyloric caeca. Make a hypothesis about what this body organ is. As you go through the dissection lab, you may decide to change your answer. If you must change your answer, write it on the line below your hypothesis and explain the function of the correct part.



Hypothesis:

_____ Varies__________

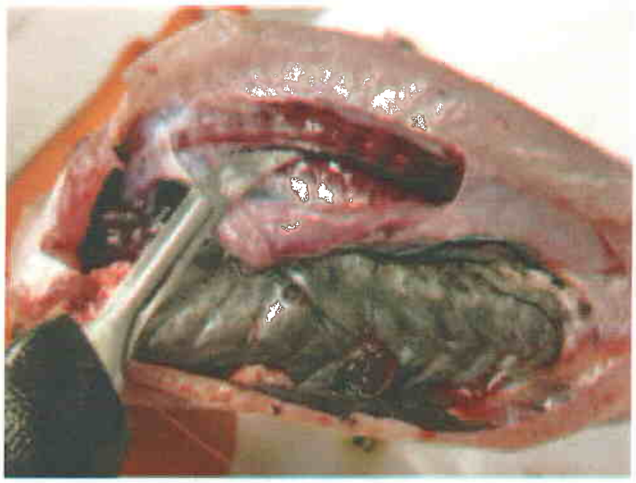
Correct ID:

______ Spleen_________________

Function: We looked in our Life Science book and found that the spleen in humans filters the blood by removing worn out and damaged red blood cells. Cells in the splen destroy bacteria that invade your body.

8. Very carefully, using your tweezers and scissors, cut away the swim bladder to reveal the kidneys.

You can discuss the function of the kidneys by having students look in a Life Science book.



9. Inspect the gills. Lift the operculum and look at the gills. Now cut the operculum away at its base, exposing the gills. With your scissors, you may cut out the gills but do not poke too far inside! Only do this on ONE side!

Sketch the gills you see in the space next to the picture.

Describe the shape and texture of the gills. What are gills used for?

Varies: The gills look mainly like a filtering system and they are fibery, stringy and soft. Some sorta look like fans. Parts of the gils aslo look like they are connected to bone. The gills are used to filter out oxygen in the water. the gils also have a red texture and feels like meat! When a fish takes water into it's mouth, the water passes over the gills, where the oxygen from the water is exchanged with carbon dioxide in it's blood.

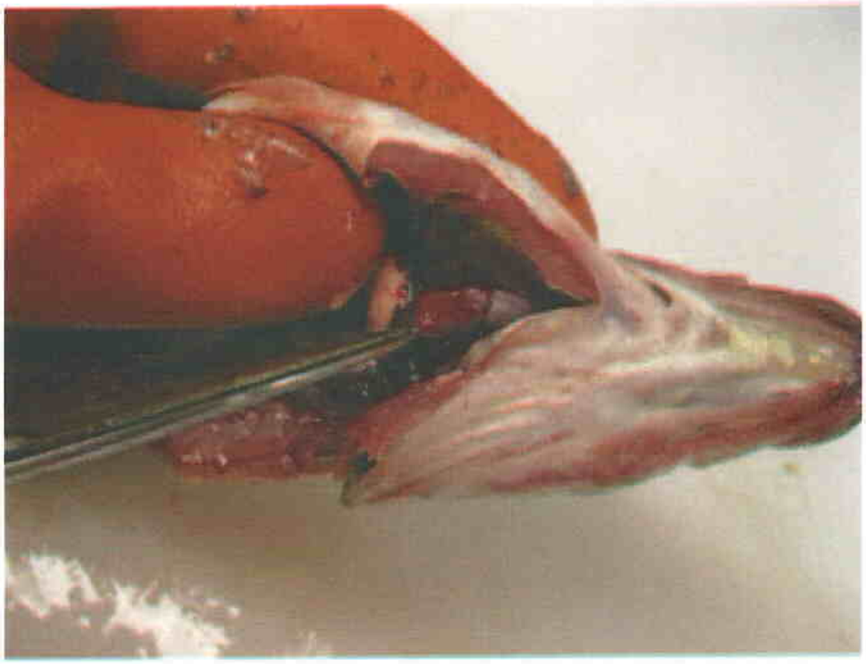
How does the shape and texture form help with their function (what the gills are supposed to do)?

Varies: The stringy texture allows the fish to filter out the oxygen as it breathes in water. The red texture says there is oxygenated blood inside. The layers help with the filtering process.

10. To see the heart, you must be extremely careful with your cuts or you will accidently cut the heart!

Starting between the pelvic fins, use your scissors and make a shallow cut up to the middle of the jaw.

Using your fingers, pull back the body to see the heart.



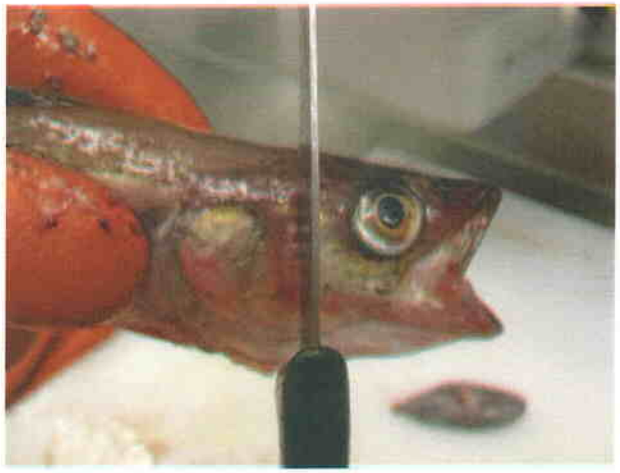
A human heart is found in the chest cavity. Why do you think that it is advantageous for the heart of a fish to be close to the front of the head? To guide your explanation, think about what the heart does when it pumps blood! Also consider what body organs the heart is next to!

Varies: We think that it is an advantage that the heart is closer to the head for many reasons: If an animal is chasing the fish, the enemy fish is more likely to catch the tail. The heart is also way more prtected next to the head, rather than by it's chest. The heart has an advantage by being closer to the gills as well. The gills can pump oxygen-filled blood faster to the heart and the brain. It is important for the oxygen to get to the heart so that the heart can pump oxygen filled blood through the body.

TIP: I had students look in their Life Science textbook and compare the location of a fish heart to that of a human.

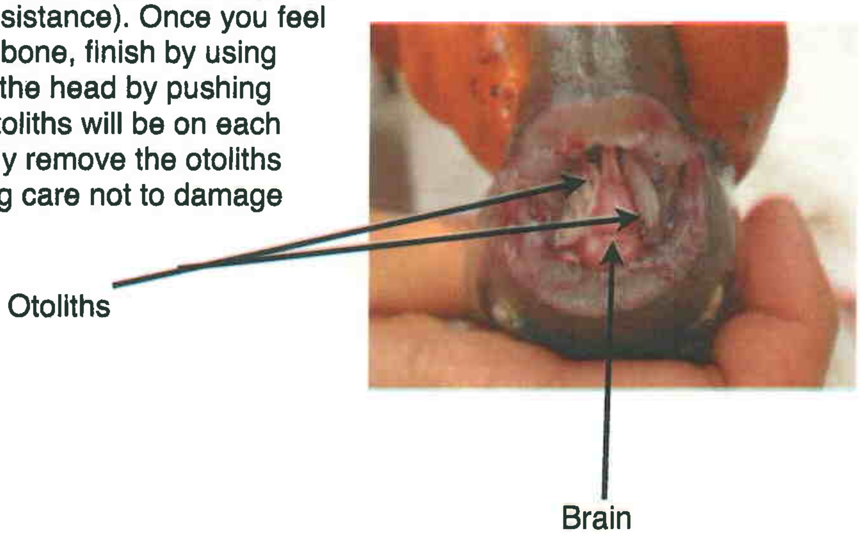
Otolith Extraction!

11. From the line of the gill opening is another small reddish line. Align your serrated steak knife just in front of this second line, closer to the eye, and parallel.

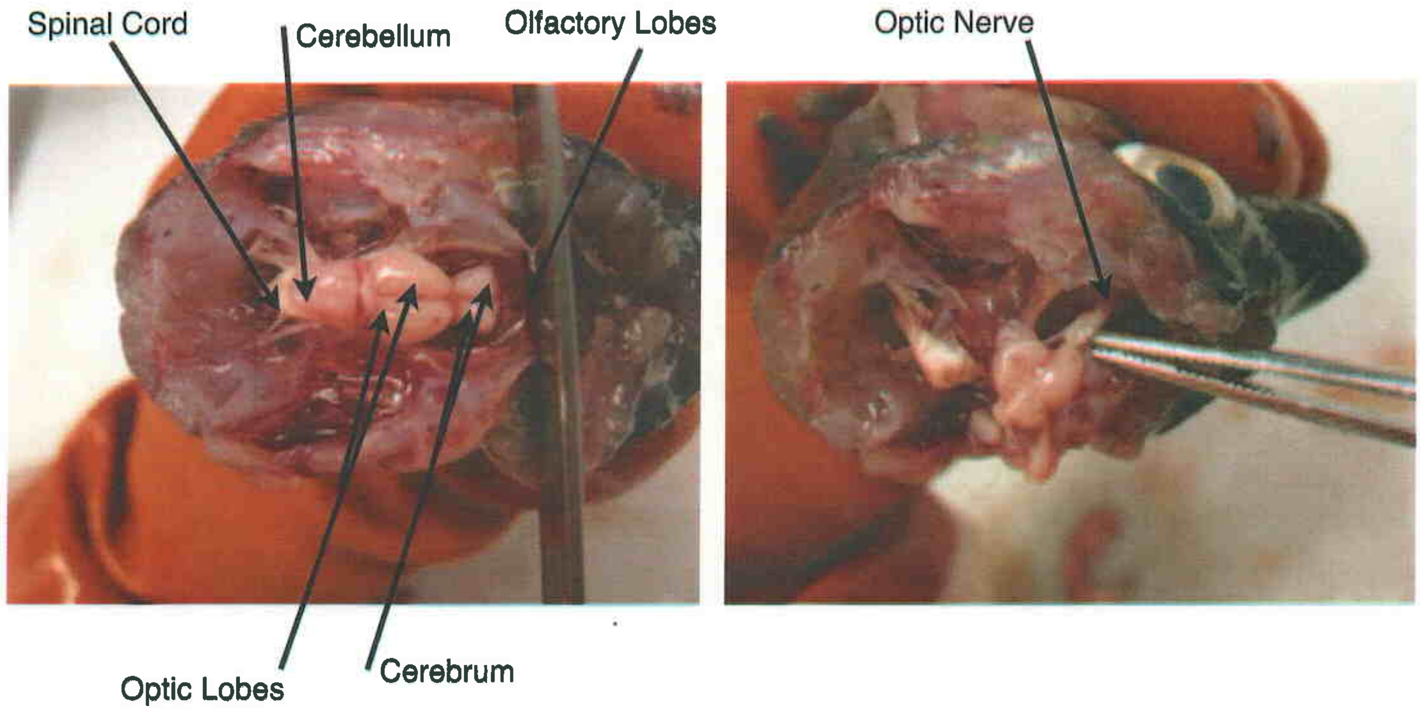


Rotate your knife so that it is positioned on the top of the head.

Carefully cut through the skin and just through the bone (you'll feel a little resistance). Once you feel as if you are through the bone, finish by using your hands and bending the head by pushing down on the nare. The otoliths will be on each side of the brain. Carefully remove the otoliths with your tweezers, taking care not to damage the brain.



12. With your serrated steak knife, carefully remove the top of the head. Take care to not cut into the brain!



You can use a textbook to learn about the Cerebellum and Cerebrum and the optic nerves so students can understand their function too!

13. Next, observe the eye. Notice the size of it and locate the pupil. Covering the eye is the cornea, a clear membrane. Now, cut the eye out of the socket. Cut through the cornea and remove the lens. What is the function of the lens?

Varies: the function of the lens is to hold the contents of the yey in place and provide better eyesight. It helps magnify and focus on objects.

14. Now let's look at the vertebrate of the fish. Turn the fish over to the side we did not cut. From the tail fin, make a shallow slice. Next make a shallow cut that runs down the dorsal (top) side of the fish. Slice through the muscle and skin in a filet style and remove. Tip, you want to keep your knife next to the spine and parallel to it.

Describe or draw with labels what you see in the space below!

Varies but should show how the vertebrae are linked and how there are bones that stick out from them.

15. Remove a vertebrae and sketch it in the space below!

Varies

Post-Dissection Questions:

16. Sketch and **label** in order, the digestive tract of a Walleye Pollock, starting with the mouth and ending at the anus.

Varies but should include the following: mouth, stomach, intestines, anus

17. Determine the sexual maturity stage of your fish using the scale on the next page.

Varies

18. What surprised you when you were dissecting?

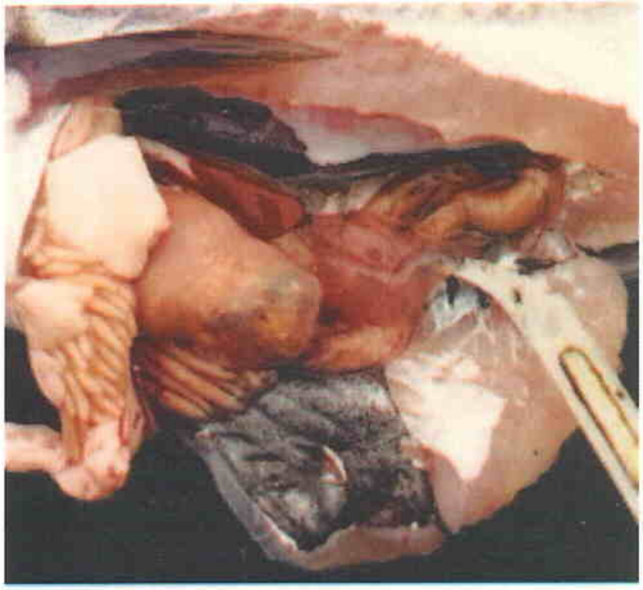
Varies - Sample Student Answers: We were surprised to find parasites in the liver. We were also surprised to see the ovaries and the eggs inside ooze out. We were also surprised at how similar the organs in a human were to a pollock! The ootoliths were awesome to extract!

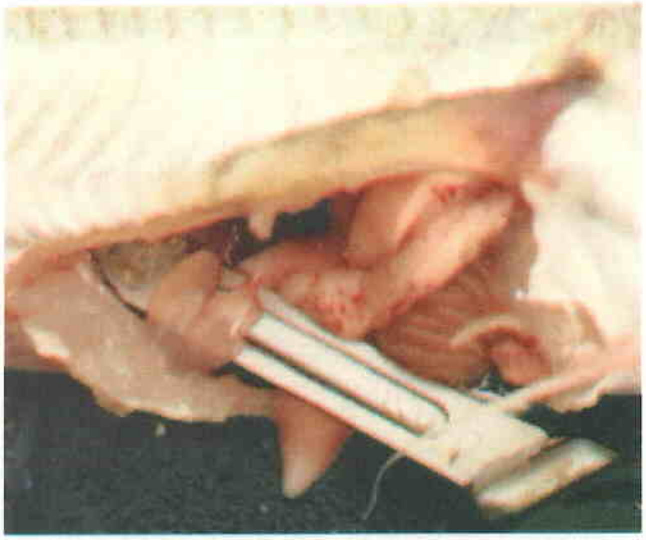
19. What curiosities or questions do you still have?

Varies

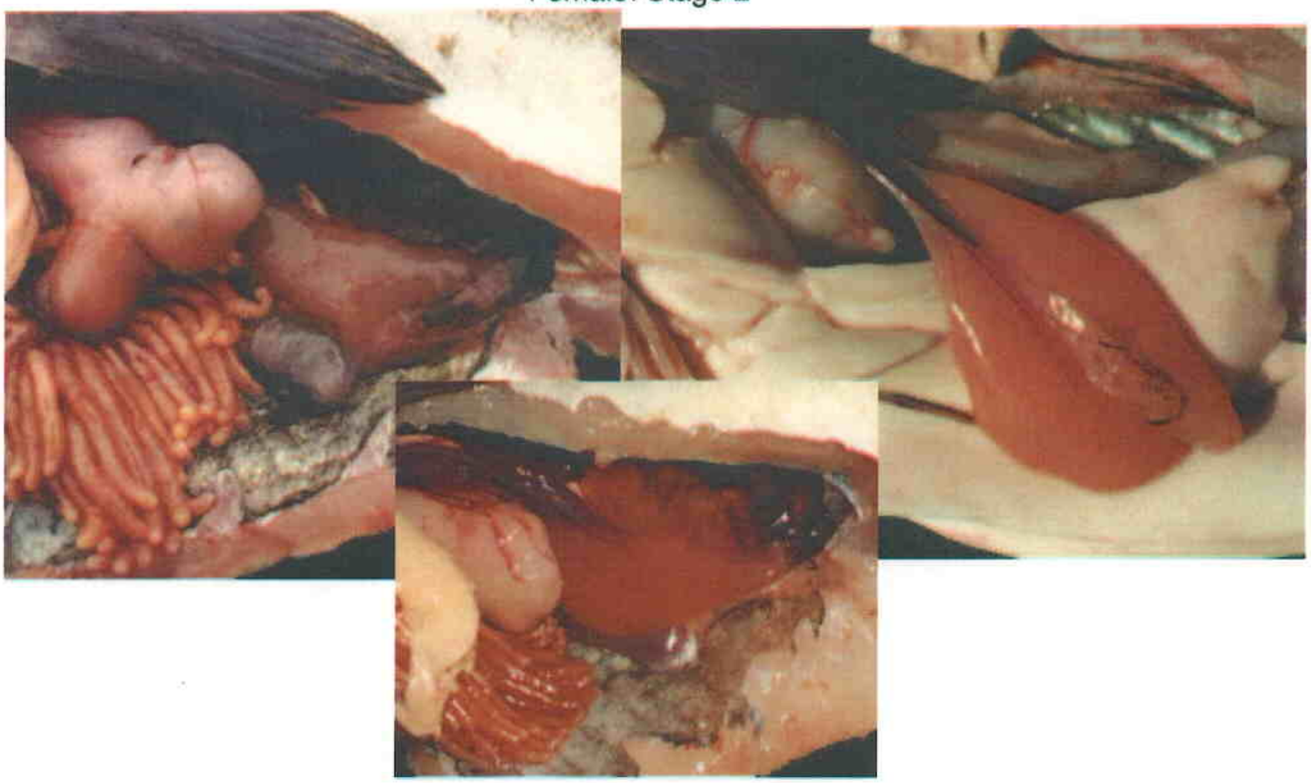
Sexual Maturity Chart

Female: Stage 1

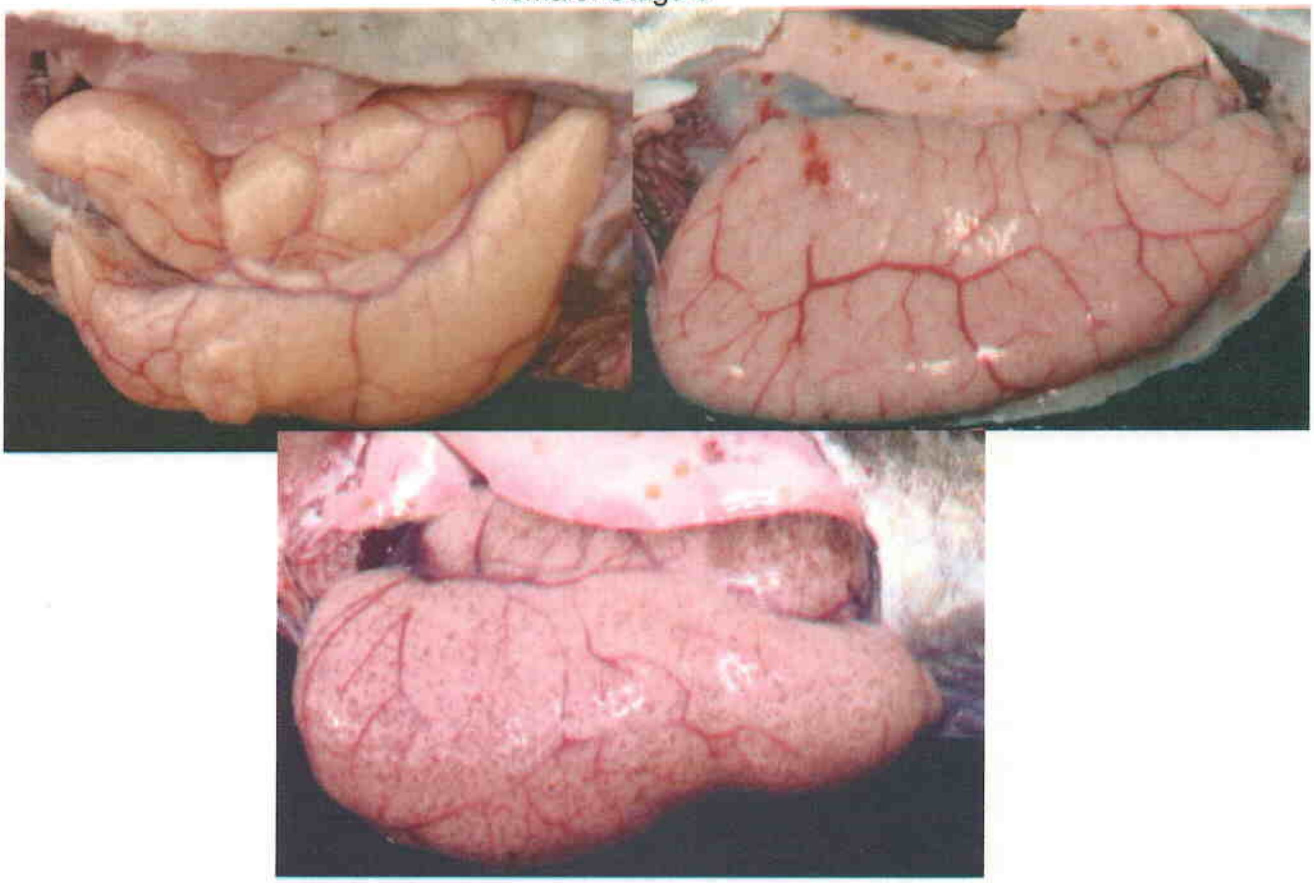




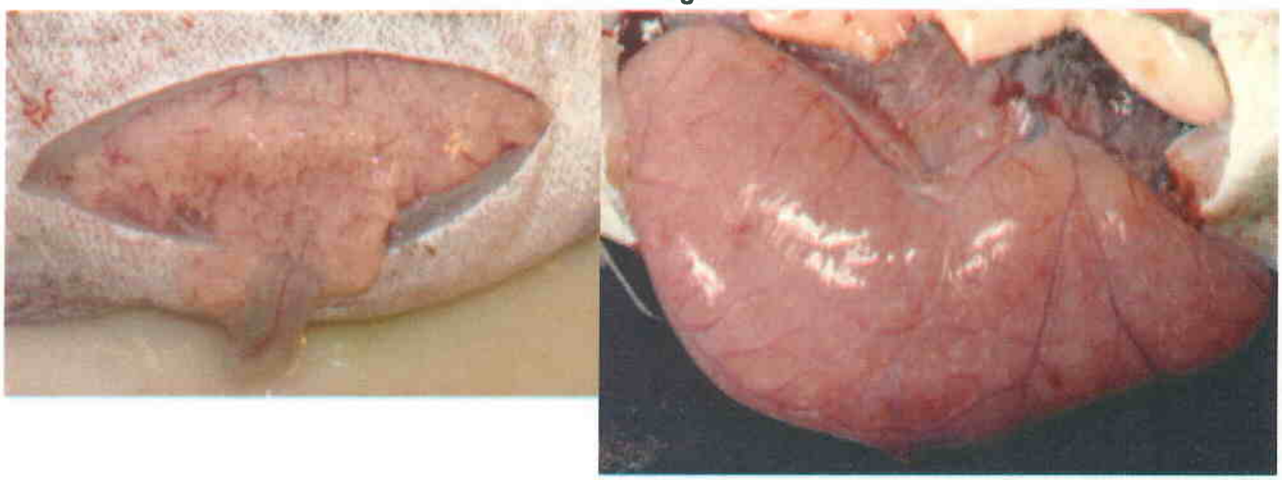
Female: Stage 2



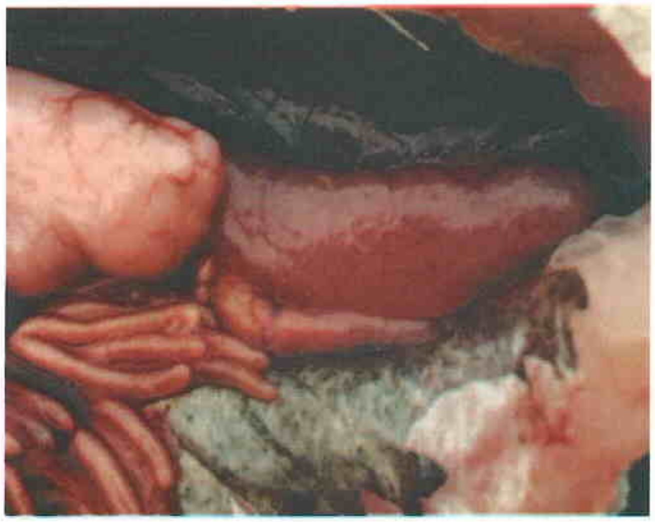
Female: Stage 3



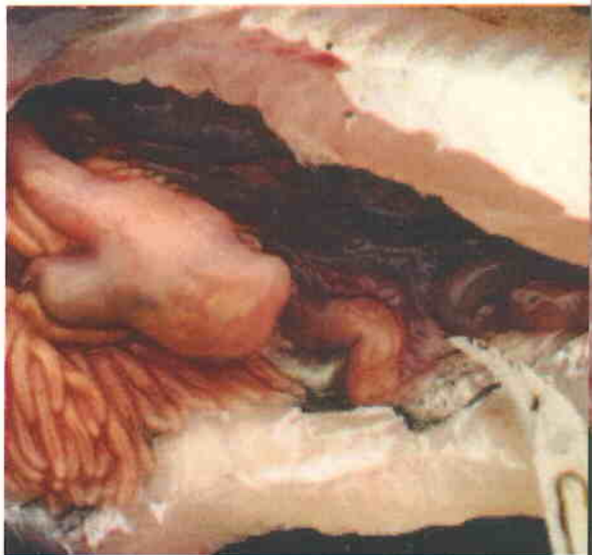
Female: Stage 4

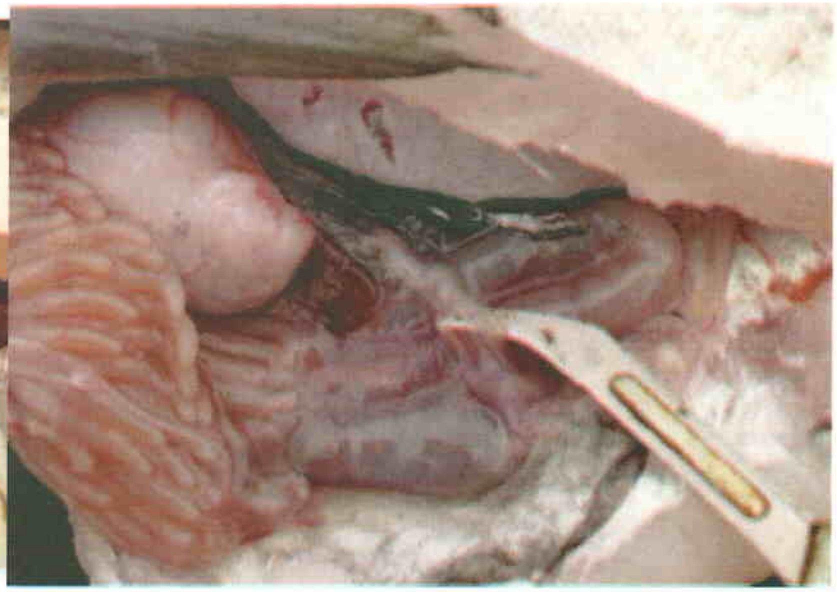


Female: Stage 5

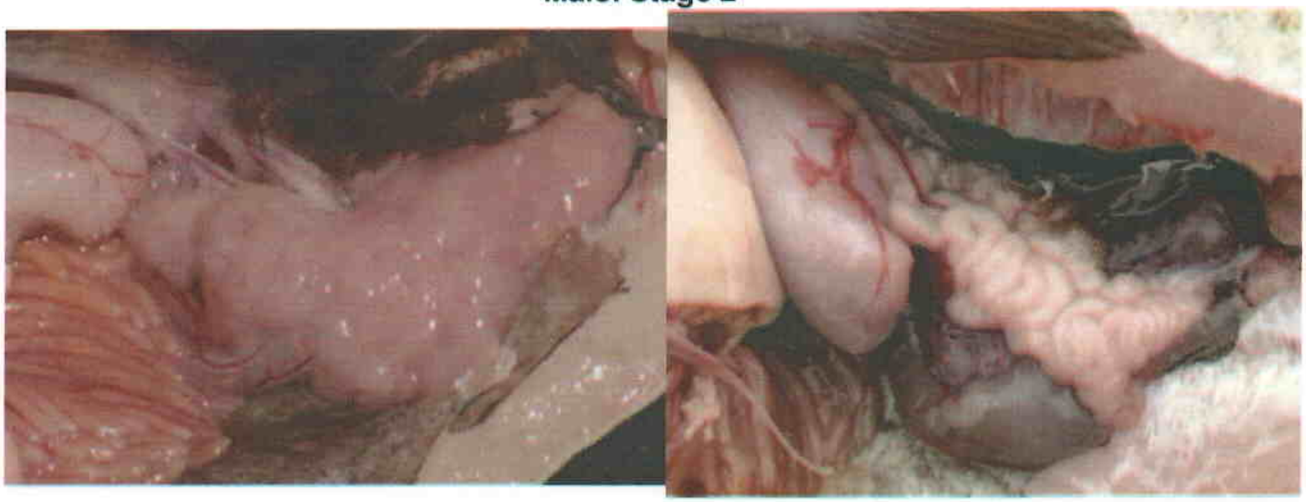


Male: Stage 1

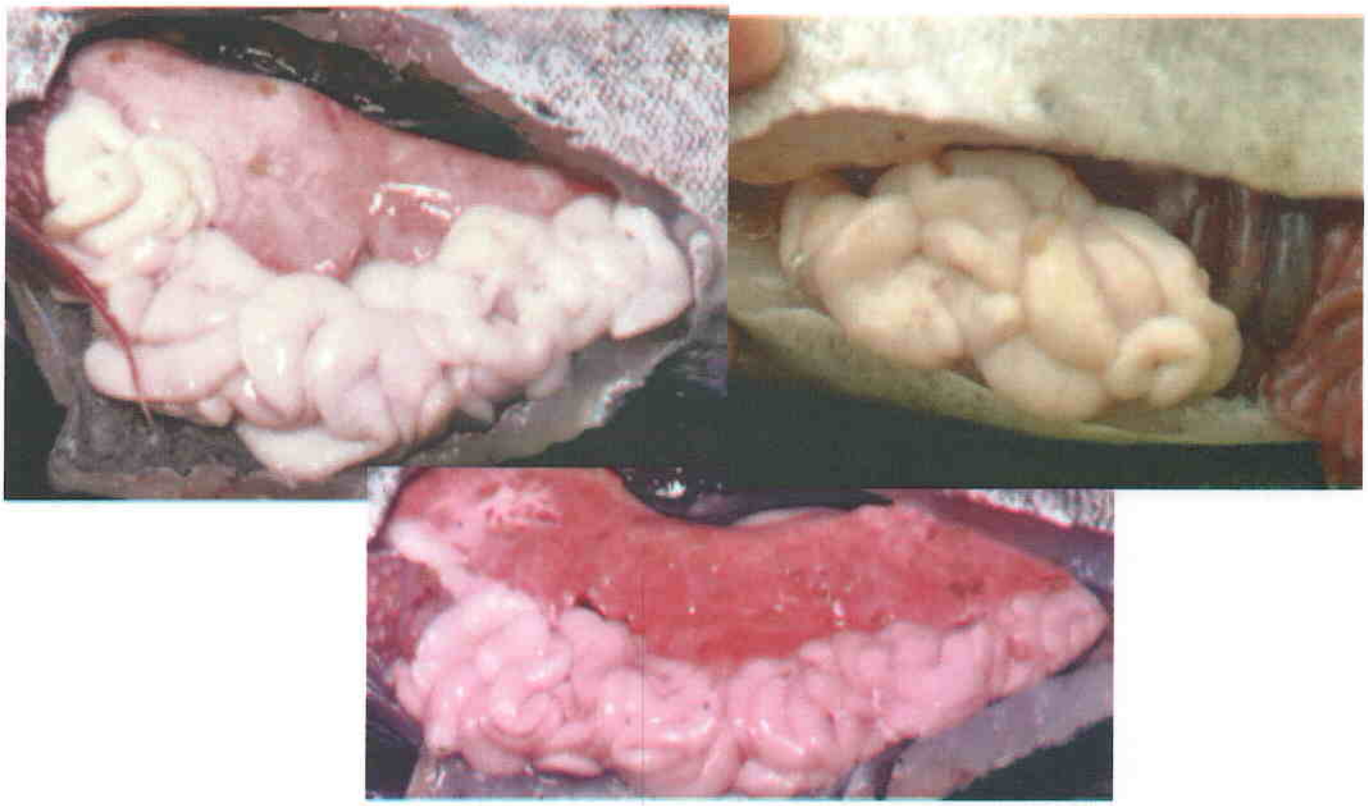




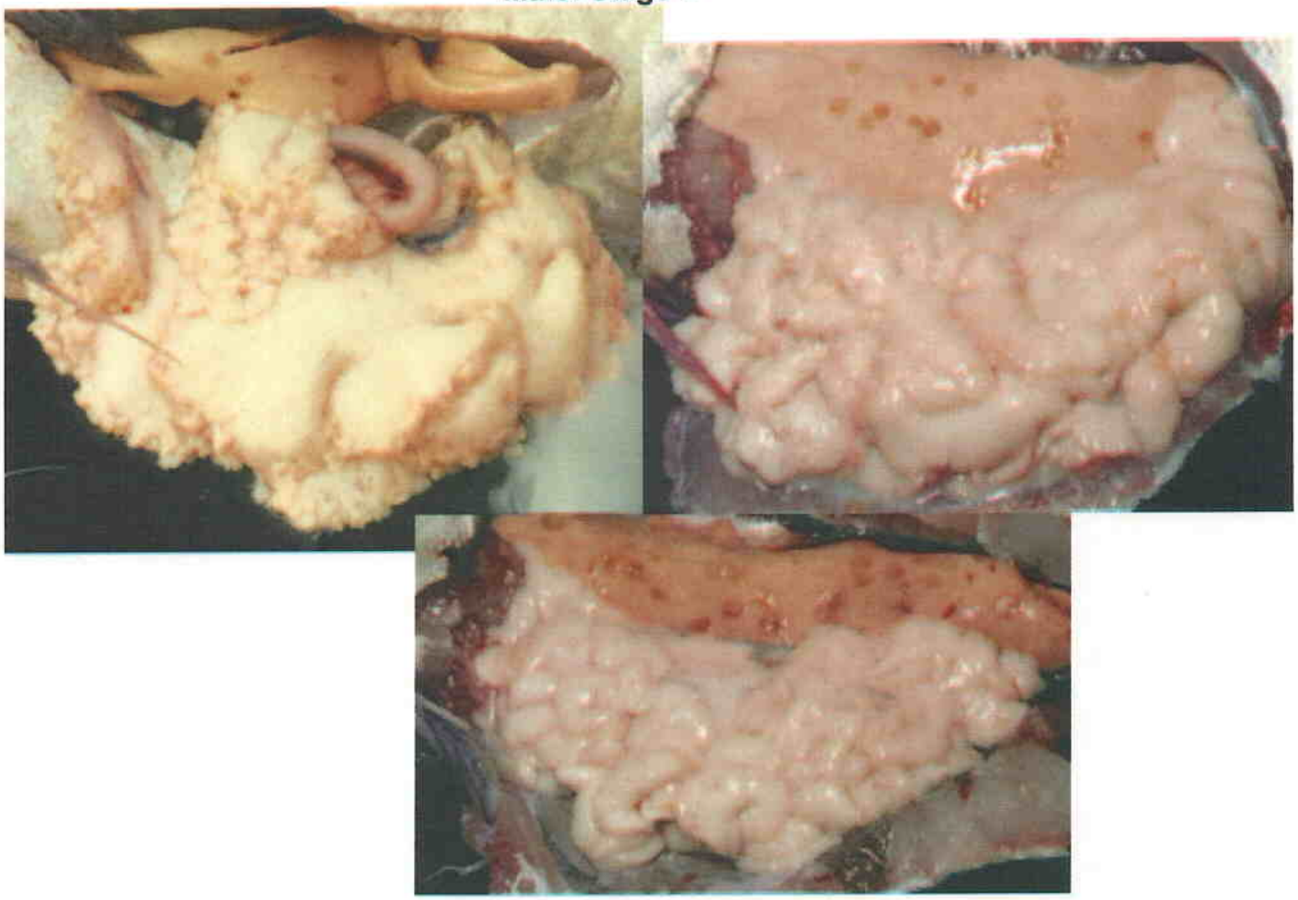
Male: Stage 2



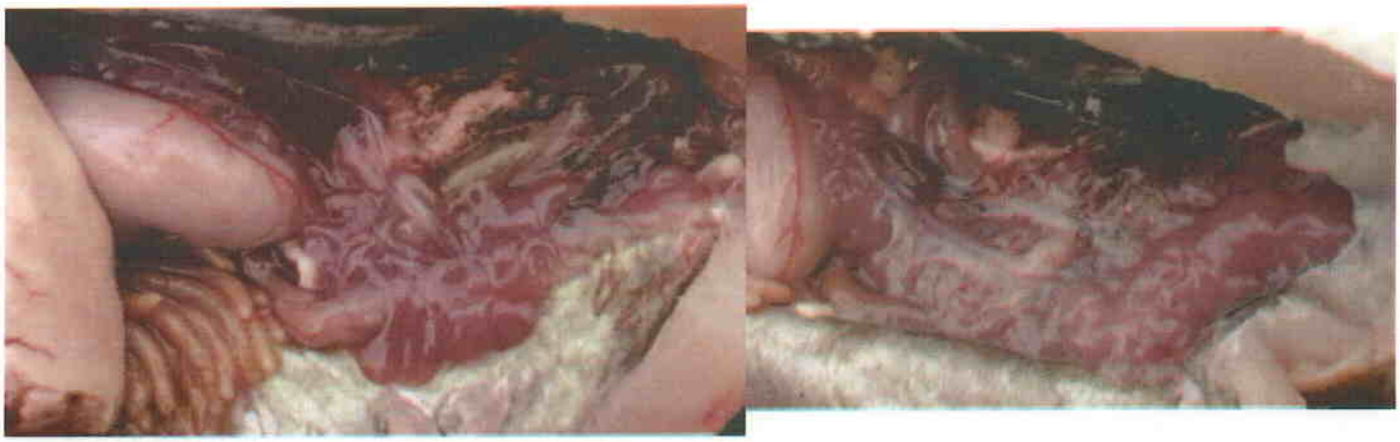
Male: Stage 3



Male: Stage 4



Male: Stage 5



Data Analysis Activity:

Percentage of Lengths of Bering Sea Walleye Pollock Per Sample Year

Length cm	% 1994	%1996	%1997	% 1999	% 2000	% 2002	% 2004	% 2006	% 2007	% 2008	% 2009
1-5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6-10	0.0	0.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.0	0.6
11-15	3.0	2.7	24.8	0.8	1.6	2.7	0.2	12.0	49.4	0.5	52.5
16-20	9.2	13.4	40.8	2.3	3.0	3.4	0.3	1.6	13.4	9.7	12.7
21-25	32.6	4.3	6.6	12.9	10.6	20.9	2.8	4.4	7.1	47.1	6.8
26-30	8.9	5.2	10.0	16.7	11.5	25.3	3.6	4.0	2.0	14.2	9.6
31-35	11.5	25.0	2.3	20.1	14.2	19.6	13.2	8.6	2.5	12.1	11.7
36-40	14.6	25.8	7.4	19.7	23.4	9.1	32.9	20.1	4.4	3.2	2.6
41-45	12.3	11.1	5.2	14.6	20.6	6.3	31.7	23.8	9.2	3.7	0.8
46-50	6.3	7.0	1.7	9.8	11.9	6.8	11.5	18.6	8.5	5.3	1.1
51-55	1.1	3.8	0.7	1.9	2.6	3.3	5.9	7.1	2.4	2.8	1.1
56-60	0.3	0.6	0.2	0.3	0.5	0.9	1.5	1.7	0.5	1.0	0.5
61-65	0.1	0.1	<0.1	<0.1	0.1	0.1	0.2	0.3	<0.1	0.3	0.1
66-70	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
71-75	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
76-80	<0.1	0.0	<0.1	<0.1	0.0	0.0	<0.1	<0.1	<0.1	<0.1	0.0
Estimated Total Fish in Millions	10,821	6,525	18,686	9,601	7,630	12,122	6,835	3,396	9,207	4,704	8,075

1. Scientists sample small amounts of fish and use ratios to estimate the number of fish in the sea. In 1997, scientists estimated that 10% of all Walleye Pollock in the Bering Sea that year had lengths ranging from 26 - 30 centimeters. **If there were 18,686 million pollock in the sea, write the number in standard form to see how many fish are estimated to have a length of 26-30 cm in the Bering Sea.**

18,686 x 0.10 = 1868.6 million fish = 1,868,600,000 Walleye Pollock!

***2.* What is the actual number of fish estimated to be in the Bering Sea in 2002?**

12,122,000,000 Walleye Pollock

3. In 1996, the percentage of pollock whose length ranged from 46 cm to 50 cm was 7%. This means that for every 100 fish, 7 of them had lengths from 46 cm to 50 cm. **In 2006, for every 100 fish, what percent fit between 11 - 15 cm? ____** 12 **%**

4. **In 2009, 12.7% of estimated total fish fit lengths of 16-20 cm. Explain what the decimal means.** The 7 means seven-tenths of a percent which is really 7 out of 1000. So when there are 12.7% of fish, this means there are 127/1000 Walleye Pollock that have the length 16-20 cm.

5. Notice that all the numbers in the table have values in the tenths place. **Why would the scientists write the numbers in this form, rather than round to the nearest whole percent? (Hint: think about how the odds change with the inclusion of the decimal)** All the numbers are in the tenths place because it includes that small percentage of fish that exist in the Bering Sea. For example) 0.1% means that there is a prediction of 1 fish out of every 1000 that fits the criteria being measured.

6. Notice in the table, there are many zeros at the top. **Does this mean there are no fish in the sea the fit those sizes in that specific year? Explain.** Varies

No it doesn't mean there aren't any fish. Maybe the small fish already grew in size, like a late season. Maybe they were also too small to be caught in the codend net. Or maybe that size of baby hangs out in a different location, perhaps closer to the surface than the other fish.

7. **What do you think the values < 0.1 mean in the table? Why wouldn't the scientists just write 0?** Varies

The scientists wouldn't just say 0 because they possibly might have just caught only 1 or 2 fish and the data number was just so small. It could also mean that maybe the % of those fish is smaller that 0.01%. For example, 0.01% of fish would mean that there is one out of every 10,000 in the ocean!

_8._ In your group place the histograms representing the pollock _Length Distributions by Percent_ in chronological order on your table.

_9._ Draw lines between the bars on each graph to separate age groups using the following information:

- **_a._ Age 1 typically will fall between lengths 1cm to 20cm**
- **_b._ Age 2 typically will fall between lengths 21cm to 25cm**
- **_c._ Age 3 typically will fall between lengths 26cm to 35cm**
- **_d._ Age 4 typically will fall between lengths 36cm +**

_10._ In 1994, which age group had the highest percentage? ______ 2 years

_a._ Predict what age group this tall bar will fall on in two years. Stage 4

_11._ In 1996, which age groups had the highest percentage? 3 **&** 4

_a._ Using your prediction in #3a, create a hypothesis that could explain the results you see in 1996. Be specific!

Varies: Some groups did not grow and some didn't because the bar represents how much of them were that length. There were many 2 year-olds in the tallest and in the 4 year olds, that was one of the tallest bars. Because size varies, perhaps some of the fish were large 1 year olds or just young 2 year olds. Basing age on size is an approximation technique.

_12._ One year later, in 1997, which age group had the highest percentage? 1 year

_a._ Using the data from 1996, explain a possible reason for this change.

Varies: All the 3 & 4 year olds reproduced and the result was a boom in babies in the following year

_13._ Two years later, in 1999, which age groups had the highest percentage? 3 & 4

_a._ Using the data from 1997 (two years earlier), explain a possible reason for this change. Varies

The one year-olds survived and were categorized as 3 & 4 year-olds. The younger groups grew in size over the two year period, which they are now 4 years old. The babies grow in various sizes and rates during the years. Less parents means less babies because the two years before, there weren't as many 1 year olds because there weren't as many parents the year before that.

_14._ From the year 1999 to 2006, which age group had the lowest percentage of fish? 1 - 2 year olds

_a._ Scientists were surprised and intrigued by the results of this data. **Explain possible future problems scientists might have noticed when looking at the distribution of ages and their population numbers.** Varies: If there are few babies in a 6 year period, this means reproduction is low.

_b._ Name at least two events that could have caused these problems? Varies: The scientists noticed that there weren't much mabies being produced. They might be worried the population distribution is getting low. The older fish are dying and aren't producing as much. This could have a huge impact on the number of pollock that are alive in the ocean. Not to mention that fishermen who fish for these fish will take a hit in their profits.

c. Physical oceanographers analyzed sea temperature data and noticed that from the year 2000 to 2006 the sea temperature in the Bering Sea was warmer than in previous years. Additionally, they noticed that from 2007 to 2009 the sea temperatures became colder.

Using the information from your bar graphs and the above information, hypothesize a possible reason for this low percentage of fish.

Varies: The goal is to direct kids to think of what could be affecting the babies being born.

We might have been overfishing the older fish and the other fish. OR the babies might have died when they were first being born. Something is affecting the birthing and/or survival of the babies.

d. Your answer for part c is called a correlation. This means that you put two sets of information, that seemed to be related, together. **Can we make an absolute conclusion that states why this low percentage occurred? Why or why not?**

Varies: No we cannot make an absolute conclusion of why this occurred because there might be other variables in the ocean that caused the time period of decrease and increase. However, there appears to be a relationship so maybe scientists should do an experiment (like we do in science fair) to see if varying temperatures really do affect egg hatching. Then they can compare the actual temperature of the ocean to those results to figure out if there is a strong correlation or not. They should also get information on ocean acidity during those years.

15. When looking at all the bar graphs, state at least one other observation you can make?

Varies but answers should discuss trends in age groups.

16. As a class, compile all the length and sexual maturity data.

This part works well if you have at least 30 samples. For me, I combined all three class' data and wrote it on the board.

a. Total the number of male and female pollock.

Males	Females	Total

b. Calculate the percentage:

__________ / __________ = __________ x 100 = ______________%

\# Males Total Percentage of Males

__________ / __________ = __________ x 100 = ______________%

\# Females Total Percentage of Females

% Males	% Females

17. Add the percent of males to the percent of females. Do you get 100%? Explain! If you do not get 100%, it doesn't necessarily mean you are wrong. What might have caused this result?

Varies

Yes: Because 100% means that we accounted for all the fish. Both males and females are near 50/50 because if we made a Punnett square of XX (female) and XY (male) we get a theoretical probability of 50/50 of males and females.

No: Because we rounded our percents. As long as we are close, like 99.9% we are good.

***18.* Find the percentage distribution of your sample by filling in the table below:**

Length (cm)	# of Pollock in Each Length Range	% of Pollock in Each Length Range (# pollock / Total = ______ x 100)
1 - 5		
6 - 10		
11 - 15		
16 - 20		
21 - 25		
26 - 30		
31 - 35		
36 - 40		
41 - 45		
46 - 60		
51 - 55		
56 - 60		
61 - 65		
66 - 70		
71 - 75		
76 - 80		
Total		

***19.* Using a ruler and the above data, create a histogram on the following page. Be sure to title your graph and axes!**

Make sure students title their graphs like the histograms provided. They should also draw age distribution likes to help them compare!

20. Compare your graph to the data collected by the Bering Sea Project. What year does your sample look the most like, if at all? If your graph looks similar to another year use evidence from your graph and evidence from that year in your explanation. If your graph does not look like any of the other years, use evidence from your graph and from other years to explain why!

Varies but students should include specific data to back up their answers.

21. Because fishing is very important to many families in Dutch Harbor and Unalaska, as the Chief Scientific Team, it is your job to communicate the results of your research with the rest of the community. Write a one-page summary to turn into the newspaper that interprets your information on the current state of the Bering Sea Walleye Pollock.

Varies: It may be a good idea to have students look at a few of the websites provided in the Teacher Guide to gain further understanding if they are not familiar with the Bering Sea and fishing practices. Some highlights that could be talked about are:

- Predicting the future of fish in 2011 and 2012
- Sea temperature and babies born correlation
- Trends and the life cycle
- Solutions on pollution and management

The goal is not to write about abolishing fishing. The goal is to discuss responsible management and careful observation so that the public is more knowledgeable about this fish.

Sample 8th grade Student Essay (words, spelling, grammar have not been altered):

For more than over 15 years, researchers have been gathering research, information, and samples of the Walleye Pollock in the Bering Sea. They've been gathering this information to make estimations and percentages of the population of pollock according to certain ages.

According to the data that our researchers have collected, we predict that the future population of the Walleye Pollock will go up and down. In 2007, there was a huge spike in the population of the baby pollock. This means there will be more adult fish which would also mean in the increase of baby fish being produced. So we say that the population will be very right in the population of fish in the years 2010, 2011, and in the year 2012.

In the years 1999-2006 the population of the Walleye Pollock experienced a dramatic decrease of the baby pollock being born. But we've also observed that at the same time, the sea temperature was also very high. We've made a correlation that the temperature of the water affects the outcome of the birth of the pollock. If the water is warm, many of the baby pollock may die, bit fi cold, the are born healthier.

This situation might also help us to choose what and what not to do. I say this because the increase of temperature might have been caused by us pollution the water and global warming. This could be prevented if we as a society learn how to dispose of our trash, recycle, and to learn how to treat the Earth right.

Sample 8th grade Student Essay (words, spelling, grammar have not been altered):

I am a student enrolled in Unalaska City High School who is part of the Chief Scientific Team. Recently my colleagues and I in the team have been analyzing data from a NOAA observation Vessel containing information about Walleye Pollock in the Bering Sea. As many may know, pollock is Unalaska's main source of revenue and is one of the most widely eaten fish in the US, from fish sticks to the meat used in imitation crab! The observation data has been collected for 15 years since 1990! The data shows Walleye Pollock population and lengths.

Throughout the years, as the data implies, the populations for younger pollock as opposed to older pollock has risen greatly, decreased immensely, then raised greatly again. The older pollock's population has started at a safe percentage, raised drastically, and then dropped drastically. The younger pollock had a smaller variety of lengths as opposed to the older pollock lengths. The reason for the younger pollock's single length range of 16-20 and 21-25 is because if the pollock were any smaller than 16cm, those small fry would be able to successfully swim through margins in the net.

There are several reason for why pollock populations have been varied so uch. Reason one is because of the water temperature. Walleye Pollock live in colder waters because when the babies spawn, they can't take the temperature. Reason two is that predators are preying on the babies more and the adults less. Reason three is pollution and ocean warming. The pollution affects the water and its pH and salinity. Global Warming heats the water up and we think this may have had an effect on the babies and the eggs from data correlations from 1999 - 2006.

The 2010 population percentages for pollock are 6.97% for 1-2 year olds, 34.67 for 3-year olds, and 44.84% for 4 year olds. The reason for the low baby population is possibly because global warming is heating up the oceans and throwing the environment off balance. I infer for the future, if the trend continues, that there will be an extremely low percentage of babies and an even higher population for the 3 & 4 year olds. If this continues, the pollock babies may die out completely. We need to be careful and responsible!

Sample 8th grade Student Essay (words, spelling, grammar have not been altered):

By using data of the length distribution by percent of pollock, I am able to make many observations and compare this data with that of 2010. I have observed that the percentages of pollock overall have decreased since the year 1994, especially the amount of baby pollock being born. For example, in 1997, the baby pollock (1 year old and 1-20 cm long) spiked up to about 40%, while in year 2006 the one year old pollock only reached 12%. Through this data, we know that something is causing (overall) less pollock to be born.

Using the data that we already have, we know that the sea temperature from year 2000 to 2006 (in which there were very little babies compared to other ranges of years) was warmer than the previous years. In addition to this, the sea temperature from 2007 to 2009 (in which there was a dramatic increase in babies) became colder. The rising sea temperature could most definitely be a factor for why there are less pollock being born because they cannot tolerate the temperatures. But we should keep in mind that this factory is the only thing possibly affecting the birth rate of the pollock. There's also acidity in the water, a possible fertilization defect, habitat difficulties, and pollution that is sure to also affect the babies.

Since there are currently less pollock being born than the actual population, we can infer that the population will continue to decrease. We need a solution to this problem. To do this, we need to observe further to find this solution.