U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Marine Fisheries Service

Lesson 19: Vertebrates I

Overview

Lesson 19 provides a survey of common marine vertebrates including reptiles, fish, sharks, rays and reptiles. It provides students with the basic taxonomy of these classes, with a focus on fish and the management of commercial fish populations. In the activity, students will apply their knowledge of fish populations to describe what it means to manage commercial fisheries "sustainably." Then, they will use NOAA's FishWatch program to evaluate seafood options at restaurants.

Lesson Objectives

Students will:

1. Describe some of the factors that influence commercial fish populations
2. Identify and give examples of organisms from major marine vertebrate classes
3. Use NOAA's FishWatch program to evaluate the sustainability of seafood restaurants

Lesson Contents

1. Teaching Lesson 19
2. Teacher's Edition: Sustainable Seafood
3. Student Activity: Sustainable Seafood
4. Student Handout
5. Mock Bowl Quiz

Standards Addressed

National Science Education Standards, Grades 9-12
Science in personal and social perspectives

Ocean Literacy Principles
The ocean supports a great diversity of life and ecosystems

The ocean is largely unexplored

DCPS, High School
Environmental Science
E.2.1 Understand and explain that human beings are part of Earth's ecosystems and that human activities can, deliberately or inadvertently, alter ecosystems.

Lesson Outline[1]

I. Introduction

Lead a brief activity on fisheries management to introduce this lesson. Materials and procedures for this demonstration are provided below:

Materials

- Two bags of gummy fish candies (e.g., Swedish fish)
- A rectangular glass (clear) baking dish (13 in x 9 in)
- 18 small paper cups (bathroom size)
- 3 spoons
- 3 pieces of paper
- One empty cup or jar

Procedure

1. Count the number of gummy fish in 2 large bags of Swedish fish (Remember the number)
2. Place them in the glass baking dish
3. Ask the students how many fish they think are in the baking dish
4. Record all guesses
5. Tell the students you are going to have them estimate the number of fish in the dish through a scientific process
6. Place 15 small cups face down on top of the Swedish fish in the dish so that they are covering all the fish and you have 3 rows of 5 cups
7. Along size the width of the dish use one of the sheets of paper to label the 3 rows of cups "A", "B", and "C"; Use another sheet of paper to label the columns "1" through "5".

8. Write out all 15 combinations of grid coordinates (e.g., A1, A2, A3, A4, A5, B1, B2, B3, and so forth) on the third piece of paper (see photo at left). Cut them out, fold them, and place them in an empty jar.
9. Ask for 3 volunteers and give each volunteer a paper cup and spoon.
10. Have each volunteer pick one of the grid coordinates out of the jar and then sample that section of the Swedish fish under the paper cup with that grid combination. The volunteers may use their spoons and cups to help count the number of fish at their "stations".

[1] Unless otherwise indicated, all websites provided or referenced in this guide were last accessed in November 2010.

11. Have a fourth volunteer find the "average number of fish per station" by adding the number of fish each of the first 3 volunteers counted and dividing by three.
12. To find the estimate of fish in the dish, multiply the average number of fish per station by 15 stations. You may wish to repeat this process to give other students a chance and also to multiple estimates.
13. Reveal the true number and compare the estimates.
14. Give an award to the student who came closest with his/her guess to the actual number of fish in the dish.
15. Discuss reasons for any variability. Reasons might include variability between samplers or a need to repeat the estimation process multiple times. You may want to discuss how well this sampling process would work with different marine species, say clams versus fish. If the clams are evenly distributed this sampling technique might work well. However if you are working with fish that school, this sampling technique might not work so well. For example, what if in your random sampling scheme, you sampled areas that didn't have any fish, your results may provide a population estimate that is artificially low. Likewise, if you happened to randomly sample only areas where fish were, the population estimate might be artificially high.
16. Other important discussion points:
    a. It is impossible to count every fish in the sea and to determine an exact number of how many fish exist. Therefore scientists must find statistically valid ways to estimate the number of fish in the sea.
    b. Ask students about what factors they think might influence the size of fish populations. Some possible responses might include:
        i. Birth of new fish (increase population)
        ii. Death of fish due to predation (decrease population)
        iii. Harvest of fish for food (decrease population)
    c. Scientists study and estimate the size of fish populations in order to determine the greatest number of fish that can be caught each year without impacting the long-term productivity of the fish population.
    d. There is a high demand for scientists who want to study the population dynamics of fish populations. A background in mathematics and biology is important to build a foundation for such careers.

II. Lecture Notes

Present the lecture material using the PowerPoint for Lesson 19 (File:Lesson 19 – Vertebrates I.ppt). Distribute the Student Handout so that students can take notes as you lecture.

III. Additional Resources

1. Marine vertebrates:
http://www.afsc.noaa.gov/nmml/species/index_pin.php

Going Green? Evaluating "Sustainable" Seafood

Overview
In this activity, students learn about the concept of sustainable seafood. They use information about common commercial species from NOAA's FishWatch program to evaluate the sustainability of selections on restaurant menus. Using criteria from NOAA's National Marine Fisheries Service FishWatch program, they will decide whether they think the restaurants live up to their claims to be sustainable. Then students will write a short newspaper article explaining their findings to interested consumers.

Background
Do you like seafood?

If you are like the average American, you eat around 16lbs of fish and shellfish per year[2]! That is good news for the many fishing and marine aquaculture operations that sell to markets and restaurants in the United States. However, factors such as overfishing and bycatch threaten the sustainability of some fisheries.

Commercial fisheries are managed at the stock level. A fish **stock** is a group of individuals of the same species that inhabit the same geographic region and interbreed when mature. The **Maximum Sustainable Yield (MSY)** is the greatest number of fish that can be caught each year without impacting the long-term productivity of the stock. **Overfishing** occurs when fishing mortality exceeds a specific threshold, usually set at a level to achieve MSY. **Bycatch** refers to organisms other than the primary target species that are caught incidentally. Bycatch may include other fish species or endangered and threatened species like sea turtles, whales and dolphins.

Fortunately, there has been a lot of attention to increasing sustainability of fisheries over the past several years. In general **sustainability** represents the ability of a fish stock to persist in the long term. If a fish stock remains at a constant level (or even grows) despite fishing pressure over a long time period, it is considered sustainable. The Sustainable Fisheries Act of 1996 (a set of amendments to the 1976 Magnuson-Stevens Fishery Conservation and Management Act, which authorizes NOAA to manage U.S. commercial and sport fisheries) gave fishery managers new mandates and tools to promote sustainable fisheries. The Magnuson-Stevens Reauthorization Act of 2006 included items designed to end overfishing, expand programs to promote sustainable fisheries management and improve the science used to monitor and manage fisheries.

As the concept of sustainability has gained visibility in fisheries management and policy, commercial vendors like markets and restaurants are increasingly interested in offering sustainable seafood to their customers. This is a promising development, but can consumers be sure that restaurants are living up to their claims of sustainability?

[2] NOAA FishNews July 2008

Materials

- Fishing Methods Facts (File: Fisheries Gear.pdf)
  - Also found online at http://www.nmfs.noaa.gov/fishwatch/fishinggears.htm; Accessed: April 2011
- Restaurant Menus (included in this document)
- Menu Data Sheets, **four per group** (included in this document)
- FishWatch species information (File: FishWatch.pdf)
  - Also found online at http://www.nmfs.noaa.gov/fishwatch/; Accessed: April 2011 (Click species names in left-hand panel.)

Procedure

1. Divide students into groups of 4.

2. Distribute a copy of the Student Activity to each student.

3. Distribute Fishing Methods Facts (1 per group), Restaurant Menus (1 of each per group) and Menu Data Sheets (1 per student) to student groups.

4. Tell students to read through the Student Activity worksheet and follow the instructions.

5. Students can start with some background research by visiting the FishWatch homepage found at the link below. Note that if you do not have internet access, you must distribute the hard copy of the FishWatch species information (File: FishWatch.pdf).
   http://www.nmfs.noaa.gov/fishwatch/

6. Divide the four restaurant menus among each group, assigning one or two students to one menu. These are selections based on actual restaurant menus with the names removed!

7. Each student should fill out a menu data sheet using information provided by FishWatch for each species. If you have internet access, you will see a list of species on the right hand side of the page. Click on species names to access information about each. If you do not have internet access, use the printed materials.

8. For each menu item, describe the current level of biomass (a measure of the quantity of the item, usually by weight), whether overfishing has occurred or is occurring and whether there is bycatch associated with the item. If the restaurant menu does not provide you enough information to decide how to fill out the data sheet, make sure to write that in your notes!
9. If a menu item contains more than one type of seafood, make sure students consider all types in the data sheet.

10. After each member is done evaluating a restaurant, groups should discuss their findings.

11. Finally, groups should write a short article for a local newspaper. The article should evaluate whether local "sustainable" seafood restaurants really live up to their claims. Students should answer all the following questions somewhere in the article:
    a. Why should a consumer care about the sustainability of seafood?

    b. How did you decide whether a restaurant is **sustainable** or not? (Hint: How does FishWatch define sustainability?)

    c. What were your findings: are most of the restaurants truly sustainable according to your determination or are most really not?
        i. How would you respond to the claim of restaurant A to be the "most sustainable restaurant in your city?"
        ii. How would you respond to the assertion that Restaurant D uses "only sustainable seafood?"

    d. Were all the menus clear about what type of fish the restaurant was offering?

    e. Was it possible in every case to determine if the fish were sustainable?

    f. What would you recommend to consumers who want to make sure that they are eating the most sustainable possible seafood? (Hint: Let consumers know what types of questions they should ask the restaurant to make sure they are getting a sustainably harvested item.)

Answer key

Answer keys for the menu data sheets are included here. Be aware that the stock status for different fish populations may change over time. If you see discrepancies between your students' answers and the answer key, you may want to look online to double-check the answers:

http://www.nmfs.noaa.gov/sfa/statusoffisheries/SOSmain.htm

The groups' articles will vary, but they should touch on some of the following key points:

- They should explain the concepts of sustainability and briefly touch on the problems of overfishing and bycatch
- They should explain how they decided if each restaurant was sustainable
- None of the restaurants offers entirely sustainable seafood (except perhaps restaurant B but it isn't possible to tell)
- In most cases, restaurants offer at least one item that should be avoided

- In many cases, restaurants aren't clear about the origin or type of fish they offer, which makes it impossible to determine whether the item is sustainably harvested
- Consumers should ask the restaurants about the origin of the fish they want (if unclear) and, when the fishing method makes a difference, ask the restaurants if they are aware of the harvesting method of their products

NOTE: If you are short on time, you can have your groups answer the questions for the article rather than writing the actual article. However, time permitting, it is a valuable exercise in communication.

Restaurant A

Menu item	**Biomass**	**Overfishing?**	**Bycatch?**	**Additional notes**
Mahi Mahi	No current estimates	No	Regulations in place to reduce bycatch	Menu did not specify the origin of the fish
Seafood Combination	Most of the choices have high biomass levels are rebuilding, but the origin of the crab is unspecified	Yes for some populations of American lobster, no for most types of crab	Some bycatch found in lobster traps	Did not specify the species of crab or the origin of the seafood
Pacific Halibut	High biomass	No	Some bycatch, regulations in effect	
Atlantic Salmon	Wild salmon are at very low levels	Yes, overfishing has occurred in the past. There are no current wild Atlantic salmon fisheries in the U.S.	No, as long as they are commercially farmed	Does not specify that the salmon is farmed

Restaurant B

Menu item	Biomass	Overfishing?	Bycatch?	Additional notes
Sea Scallops	Very high	No	Some bycatch of sea turtles, finfish and other scallops possible	
Seafood Volcano (Crab, Shrimp, Lobster)	Population levels of most items are high or rebuilding, but in some cases, this depends on the species	Yes for some populations of American lobster, no for most types of crab and shrimp	Some bycatch found in lobster traps For shrimp, bycatch depends on the area they are caught and the species, but bycatch can be a serious problem (in the Gulf of Mexico for example)	Menu did not specify origin or species of seafood
Fish and Chips	Cannot determine			Type of fish unclear
Red Snapper	Very low biomass	Yes	Bycatch thought to be minimal	

Restaurant C

Menu item	**Biomass**	**Overfishing?**	**Bycatch?**	**Additional notes**
Fried Atlantic Clams	High biomass	No	Significantly reduced bycatch	
Fisherman's Linguini (clams, Longfin squid & Pacific sardines)	Clams, squid and sardines all have high biomass	No	Marine mammal bycatch for squid, little bycatch for sardines	
Whole Fish	Cannot determine			Type of fish unclear
Black Sea Bass	Biomass very low in the South Atlantic but high in the Mid-Atlantic	Yes in the South Atlantic, uncertain in the mid-Atlantic	Some bycatch possible, it depends on the mesh size	Origin of fish unclear

Restaurant D

Menu item	**Biomass?**	**Overfishing?**	**Bycatch?**	**Additional notes**
North Atlantic Albacore Tuna	Low	Yes	Longlines can take marine mammals, sea turtles and seabirds	
Stuffed Yellowfin Sole	High	No	Bycatch includes halibut, crab and other types of sole	
North Atlantic Swordfish	High biomass	No	Pelagic longlines can interfere with marine mammals, sea turtles and seabirds	
Red King Crab	Most populations of this type of crab are high	No, but there are some regions where overfishing is unknown	Some bycatch, methods to reduce bycatch in place	

Going Green? Evaluating "Sustainable" Seafood

Walleye pollock is a commercial species used in McDonald's fish fillet sandwiches

Photo: NOAA

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As the concept of sustainability has gained visibility in fisheries management and policy, commercial vendors like markets and restaurants are increasingly interested in offering sustainable seafood to their customers. This is a promising development, but can consumers be sure that restaurants are living up to their claims of sustainability?

Today, you and your team members are going to rate seafood restaurants that claim to be highly sustainable. You will evaluate a sample of menu options using NOAA's National Marine Fisheries Service (also referred to as NOAA Fisheries Service) FishWatch program. The NOAA Fisheries Service is the U.S. Government's primary agency responsible for the

[3] NOAA FishNews July 2008

stewardship of the nation's living marine resources and their habitats. The FishWatch program provides scientific information about different commercial marine species including population status, overfishing status and bycatch. This information is designed to help you make informed decisions about the seafood you eat.

Using FishWatch information, you will assess menus based on actual seafood restaurants that claim to serve sustainable fish. Using your results, you will write a short article to inform residents whether or not their favorite sustainable seafood restaurants are keeping their promises.

Procedure

1. Start with some background research. As a group, familiarize yourself with the information on the FishWatch homepage found at the link below. Note that if you do not have internet access, your teacher will provide you with printed materials to review.

   http://www.nmfs.noaa.gov/fishwatch/

2. Divide the four restaurant menus among your group, assigning one or two students to one menu. These are selections based on actual restaurant menus with the names removed!

3. In your small groups, fill out a menu data sheet using information provided by FishWatch for each species. If you have internet access, you will see a list of species on the right hand side of the page. Click on species names to access information about each. If you do not have internet access, use the printed materials provided by your teacher.

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5. If a menu item contains more than one type of seafood, make sure you consider all types in your data sheet.

6. After each member is done evaluating a restaurant, discuss your findings as a group.

7. Finally, write a short article for a local newspaper. The article should evaluate whether local "sustainable" seafood restaurants really live up to their claims. Remember that the story is for a general audience, so make sure that you explain

any scientific terms in non-technical language. Make sure you answer all the following questions somewhere in the article:

a. Why should a consumer care about the sustainability of seafood?

b. How did you decide whether a restaurant is **sustainable** or not? (Hint: How does FishWatch define sustainability?)

c. What were your findings: are most of the restaurants truly sustainable according to your determination or are most really not?
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f. What would you recommend to consumers who want to make sure that they are eating the most sustainable possible seafood? (Hint: Let consumers know what types of questions they should ask the restaurant to make sure they are getting a sustainably harvested item.)

Restaurant A – Menu	
First course	
Mahi Mahi	$8
Seafood Combination (American lobster, clams, crabs)	$42
Second course	
Pacific Halibut	$24
Atlantic Salmon	$28

Restaurant B – Menu	
Appetizers	
Sea Scallops	$10
Seafood Volcano (crab, shrimp, lobster)	$38
Entrees	
Pub Fish and Chips	$12
Red Snapper	Market price

Restaurant C – Menu	
Appetizers	
Fried Atlantic Clams	$12
Entrees	
Fisherman's Linguini (clams, Longfin squid, Pacific sardines)	$23
Whole Fish	Market price
Black Sea Bass	$28

Restaurant D – Menu	
Appetizers	
Red King Crab Legs	$8
Entrees	
Stuffed Yellowfin Sole	Market price
North Atlantic Swordfish	Market price
North Atlantic Albacore Tuna	Market price

Menu Data Sheet (one per restaurant)

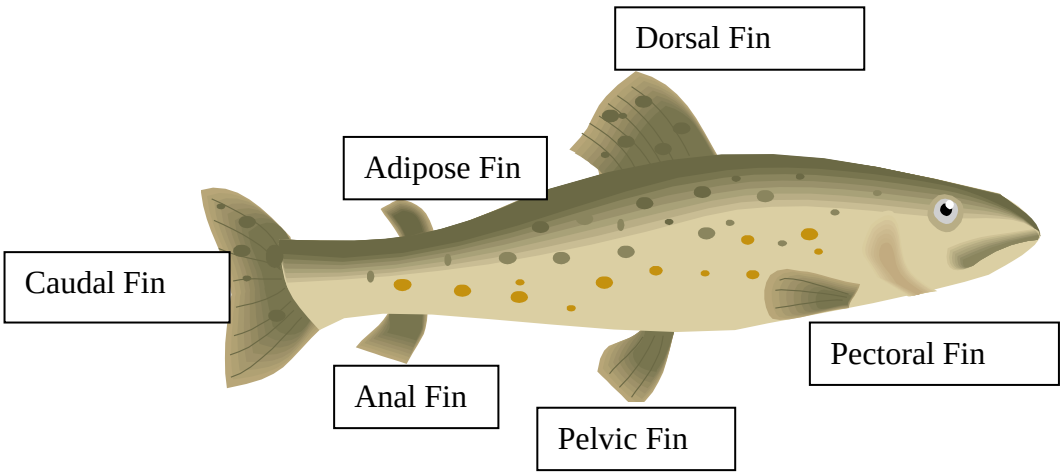
Menu item	Biomass	Overfishing?	Bycatch?	Additional notes

Tips for the Bowl – Vertebrates I

Know your taxonomy
During your teacher's lecture, write down some characteristics and examples of each of the vertebrate classes listed below.

Class or Superclass	**Characteristics**	**Examples**
Agnatha		
Chondrichthyes		
Osteichthyes		
Reptilia		

Know your fish anatomy



Know your fisheries terminology
Write down definitions from your teacher's lecture:
Stock:
Overfishing:
Overfished:
Biomass:
Maximum Sustainable Yield(MSY):
Fishing Mortality:
Sustainable:

Vertebrates I

1. Reminder Question: The blue crab is most closely related to a:
    w. Fish
    x. Squid
    y. Lobster
    z. Shark

2. This shark is the largest in the world:
    w. Whale shark
    x. Great White shark
    y. Basking shark
    z. Megamouth shark

3. **Ampullae of Lorenzini** are adaptive characteristics of rays and skates that help them find prey by:
    w. Hearing noise made by other organisms
    x. Mimicking the bioluminescence patterns of other organisms
    y. Detecting electromagnetic currents of other organisms
    z. Seeing other organisms in the dark

4. Eels are most closely related to:
    w. Flounder
    x. Rays
    y. Sharks
    z. Marine iguanas

5. Short answer: What reptilian feature explains why iguanas bask in the sun after feeding in the water?
    Answer: They are cold-blooded and must bask in the sun to warm up

6. Sea turtles reproduce by:
    w. Budding
    x. Laying eggs on shore
    y. Releasing sex cells (gametes) into the water
    z. Live birth

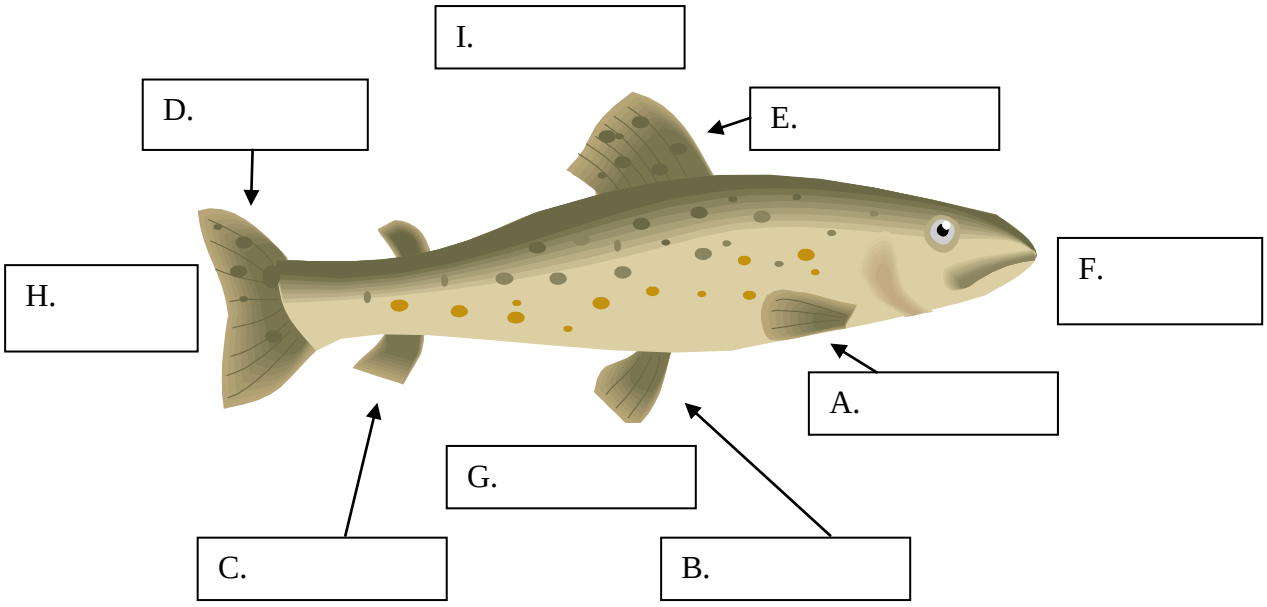
7. Reminder question: The highest and lowest tides which occur when the moon and sun are lined up with the Earth are:
    w. Neap Tides
    x. Winter Tides
    y. Spring Tides
    z. Summer Tides

8. Short answer: What is the class of a stingray?
   Answer: Chondrichthyes

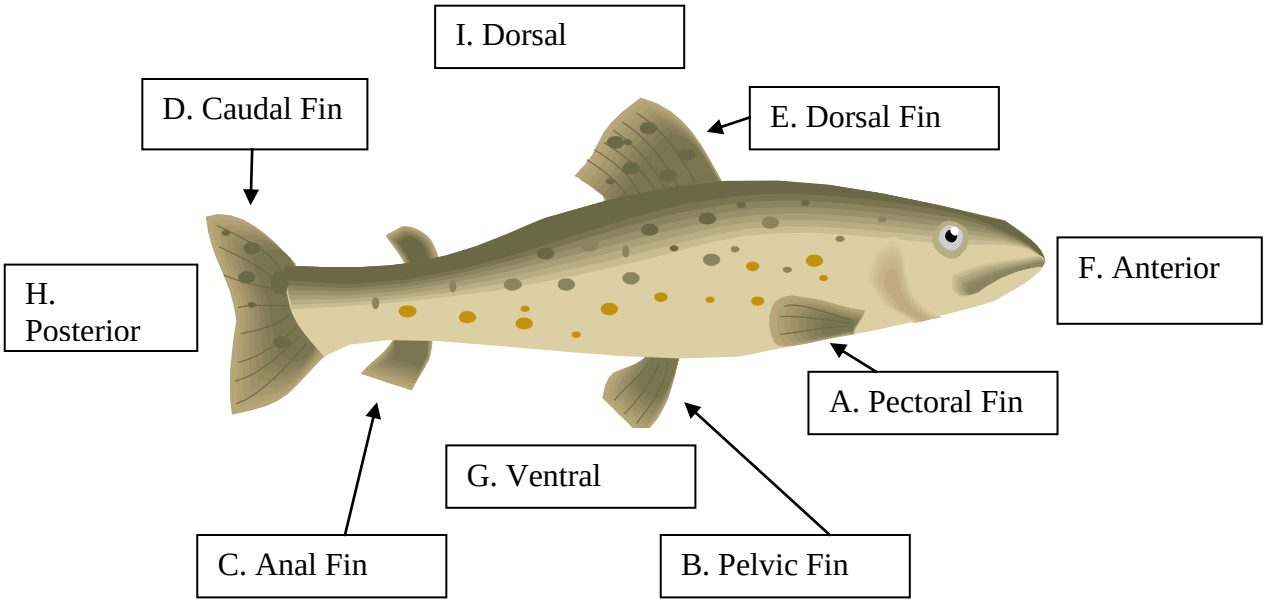
9. Which of the following is true of sharks and ray-finned fish?
   w. They are in the same class
   x. They are in different phyla
   y. They both have swim bladders
   z. They have different types of bone

10. Team Challenge Question

1. Identify the structures labeled A-E on the fish diagram below. (5pt)
2. Labels F, G, H and I represent the posterior, ventral, anterior and dorsal sides of the fish. Fill in the appropriate terms on the diagram below. (4pt)



ANSWER


I. Dorsal
D. Caudal Fin
E. Dorsal Fin
H. Posterior
F. Anterior
A. Pectoral Fin
G. Ventral
C. Anal Fin
B. Pelvic Fin