Reports

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Dichotomous Keys: An Essential Tool for Fish Detectives

Jackson Martinez

Virginia Institute of Marine Science

DICHOTOMOUS KEYS

AN ESSENTIAL TOOL
FOR FISH DETECTIVES

Jackson Martinez
Virginia Institute of Marine Science

Grade Level
7th Grade

Subject Area
Life Science

Activity Title: Dichotomous Keys: An Essential Tool for Fish Detectives

Focus: Identifying fishes and their trophic roles within the Chesapeake Bay through dichotomous keys, adaptations, and trophic levels.

Grade Levels/Subject: 7th grade Life Science

VA Science Standard(s) addressed:
- LS.4: The student will investigate and understand how organisms can be classified.
- LS.6: The student will investigate and understand that organisms within an ecosystem are dependent on one another and on nonliving components of the environment.
- LS.8: The student will investigate and understand interactions among populations in a biological community.

Learning objectives/outcomes:
- Students will utilize a dichotomous key to identify common mid-Atlantic fishes to species level, based on morphological characters.
- After species identification, students will characterize their fishes' trophic level and work together to build a food chain, showing the relationships between species.

Total length of time required for the lesson: 45 minutes

Key words, vocabulary:

Classification – the process of identifying shared characteristics or qualities to assign an object or organism to a group

Dichotomous key – a classification tool used to identify an object or organism based on a series of contrasting physical characteristics that become more specififc, leading to the point of identification

Taxonomy – the branch of science that deals with the classification of organisms

Species – a group of organisms that can interbreed and successfully create fertile offspring

Binomial nomenclature – The system of naming organisms with two terms, one for its genus, and one for its species

Fish – refers to a single species or multiple individuals of a single species

Fishes – refers to more than one/multiple different species of fish

Morphology – the branch of biology that deals with the form and function of organisms

Posterior – behind or towards the back end of the body

Anterior – in front of or towards the front end of the body

Dorsal – toward or near the back or upper portion/surface of the body

Ventral – toward or near the bottom or under portion/surface of the body

Superior (mouth position) – upturned and found in fishes that feed on prey above them

Terminal (mouth position) – straight forward and found in fishes that feed on prey in front of them

Inferior (mouth position) – bottom facing and found in fishes that feed on prey on or near the bottom

Trophic level – a position in a food chain that is occupied by organisms, ex. producer, herbivore (primary consumer), carnivore (secondary/tertiary consumer)
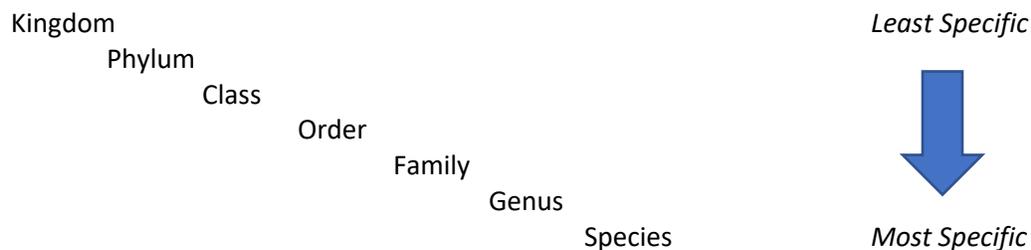
Food chain – a network of links in a food web that begins with producers and lead to higher consumers.

Chesapeake Bay – the largest estuary in the United Stateslocated on the mid-Atlantic coast; home to over 3,600 species of plants and animals

Background information:

Before scientists can study an animal, they need to know what kind of animal it is. Marine biologists who study fishes must know the identities of the fish they catch to determine: the number of **species** in an area; or if it is a fish that they want to bring back to the lab for experiments. When pulling nets for fish surveys, scientists must be able to identify many different species in a single catch. The same goes for recreational fishers, who need to know what kind of fish they have caught so they can decide if it will be kept or released. One way of identifying fishes is by using a **dichotomous key**. These keys use a series of paired (two) choices based on the physical characteristics of an organism to narrow down possible options leading to its identity.

Since the days of Aristotle, humans have been classifying organisms into groups. Biologists **classify** and sort animals into groups based on their **taxonomy** from broad groupings (Kingdom) down to very specific kinds (Species). See below:

Kingdom   *Least Specific*
     Phylum
        Class
           Order
              Family
                 Genus
                    Species   *Most Specific*

Carl Linnaeus founded the **binomial nomenclature** (two names) system of naming distinct kinds of organisms by the genus and species. Humans, for example, are called *Homo sapiens*. This system of classifying and naming organisms has been based mostly on features of the anatomy (body) of an organism. Today, we can also use DNA analysis to identify and name organisms. However, for quick field identification, using features of anatomy is the fastest.

The **Chesapeake Bay** is home to over 3,600 species of plants and animals. More than 350 species of fish can be found in the Bay, which is the largest estuary in the United States. Some of these fishes look very distinct, making their identification relatively straightforward. Other times, two species may look alike. One way to identify these similar-looking species is by looking closely at their **morphology**.

In this lesson, we will be using dichotomous keys to identify various fishes that are commonly found in the Chesapeake Bay. By using a diagram of a fish and its external anatomy, we will identify physical landmarks on the fish and positions of structures (fins) to aid in their identification. The back or upper surface of a fish is the **dorsal** side and the bottom or under surface of the fish is the **ventral** side. If a structure comes before, or is in front of, another structure, it is **anterior**. Conversely, if it comes after, or is behind, it is **posterior**. We will also look at common mouth positions found in fishes. The **superior** mouth position is upturned and found in fishes that ambush the prey above them, they can also feed near the water surface. The **terminal** mouth position is commonly found in fishes that eat other fishes, catching prey that are in front of them. The **inferior or sub-terminal** mouth position faces downward and is commonly found in fishes that feed on the bottom.

For fishes, it truly is a fish-eat-fish world. Some species have very specific diets and others eat just about anything. At the end of the identification activity, students will identify the **trophic level** that their fish belongs to and the whole class will discuss **food chains**. Fishes that occupy lower trophic levels are usually small in size, lack sharp teeth, and eat zooplankton and phytoplankton. They are usually abundant (present in large numbers). Some medium trophic level fishes have sharp teeth and large mouths. They usually feed on organisms in the lower trophic level and eat a variety of prey items, including other fishes and crustaceans. Higher/top trophic level fishes are large bodied, with large mouths and many sharp teeth. Top trophic level fishes are usually less numerous or abundant than either low ormedium trophic level fishes. They feed on low, medium, and even other high trophic level fishes and are usually top level predators. It should be noted, however, that fishes that feed on similar prey or occupy the same trophic level might have different mouth types from one another. Mouth position, tooth type, and body size, are just some of the adaptations found in fishes that allow them to succeed in their trophic roles.

Student handouts and other materials needed (worksheet, data tables, diagrams, websites, etc. PLUS, answer keys for all questions, worksheets, graphing activities):

Student worksheets #1-9
Dichotomous key
Answer keys for the the fish identities (part 1), trophic level assignments (part 2), questions (part 3), and take-away questions

Materials & Supplies, A/V/Tech Support:
Computer and projector for accompanying PowerPoint
Printer for key and worksheets

Classroom/Lab/Field Study Setup:
Students should work in teams of two

Procedure:
Advance preparation of materials – 15 minutes:
- If possible, laminate dichotomous keys (can be reused) and print out worksheets in advance (2 pages each, preferably front/back). Each group should have a copy of one worksheet and one dichotomous key. There are nine different worksheets total, restart from number one if more than nine are needed to supply all student teams.

Engagement – Begin PowerPoint
- Ask students if there are fishes they like to see or eat, are there any that look similar?
- Do you know what any of these fishes are? Do you know what these fishes eat?
- Have you seen or caught a fish that you didn't know the name of?
- What about these fishes looks similar? Different?

Activity – Split class into teams of 2 and hand out one key and worksheet to each group. Explain that the identification step is to be completed before the trophic level step.
- Have each group check their identification with you before proceeding to the next step. Additionally, after the trophic level step, have each group check their answer with you before moving on to the questions.

Assessment:
Once all groups have successfully identified their species, its trophic level, and have answered the questions, have everyone stand up and form groups in different parts of the classroom according to their trophic levels. Display images of each fish from the internet so that students can see their assigned fish in greater detail. Work through the Major Points slide in the PowerPoint and ask them the Take-Away Questions (below). Within their respective trophic groups, students can discuss their fishes and how the trophic levels interact. Additionally, a test or quiz can be made from the worksheet questions and/or the Take-Away questions.

1. Do other fishes in your trophic level have the same mouth position?
2. What would happen if the fishes in the high trophic level disappeared?
3. Could fishes occupy different trophic levels during different stages of their life (juvenile vs. adult)?

This lesson plan can be completed before or after a field trip to an aquarium. For fish size reference, paper cutouts or drawings on the board in the size range for each trophic level can be made.

Extension Activities:

Fish Morphology
http://njseagrant.org/wp-content/uploads/2014/03/fish_morphology.pdf

Build A Fish
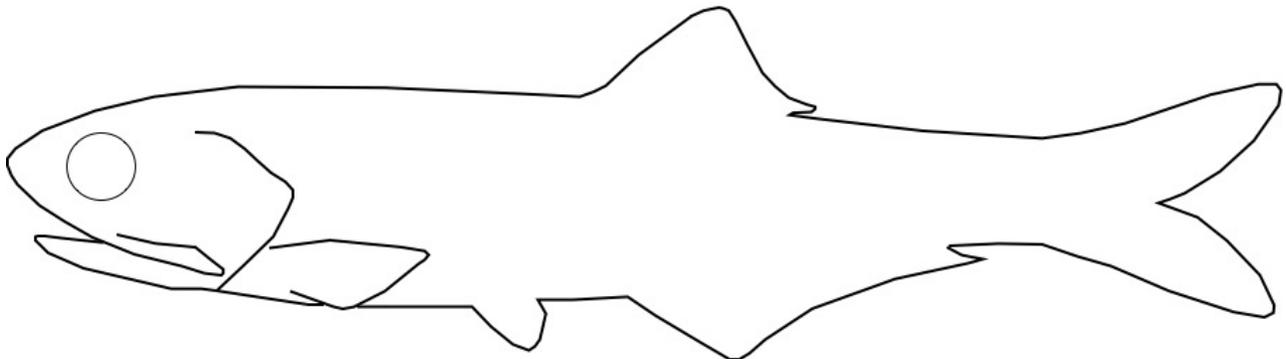http://njseagrant.org/wp-content/uploads/2014/03/build_a_fish.pdf

References:

Murdy, E. O., Musick, J. A., Kells, V. A. (2013). Field guide to fishes of the Chesapeake Bay. Baltimore, MD. JHU Press.

Vocabulary definitions: Definitions: https://biologydictionary.net/species/

Step 1. Use the dichotomous key and the fish diagram to identify your unknown fish below. Once you have identified your fish, write your answer in the box below:

Who am I?
_____

Step 2. Using the image of your identified fish above and the information regarding its trophic level given below, choose the trophic level you think your fish belongs to:

Description: Fishes in this trophic level are small in size, large in numbers, form large schools, and are a common and abundant prey item in the Chesapeake Bay.

Size Range: 10 cm (3.9 in.) – 55 cm (1.8 ft.)

Prey types: Zooplankton;, phytoplankton; detritus (dead plant and animal material); small invertebrates.

Mouth and Feeding: Small mouth; filter feed or select small prey items.

Trophic Level: Low/Medium/High
_____

Worksheet 1.

Step 3: Questions

<u>Short Answer</u>

1. Based on the dichotomous key, what is the main identifying structure(s) of your fish that led you to its identity?

_____

2. Why did you assign your fish to the chosen trophic level?

_____

<u>Circle Best Answer(s):</u>

3. Based on your fishes' trophic level, fishes in (low, medium, high) trophic level(s) may prey on your fish
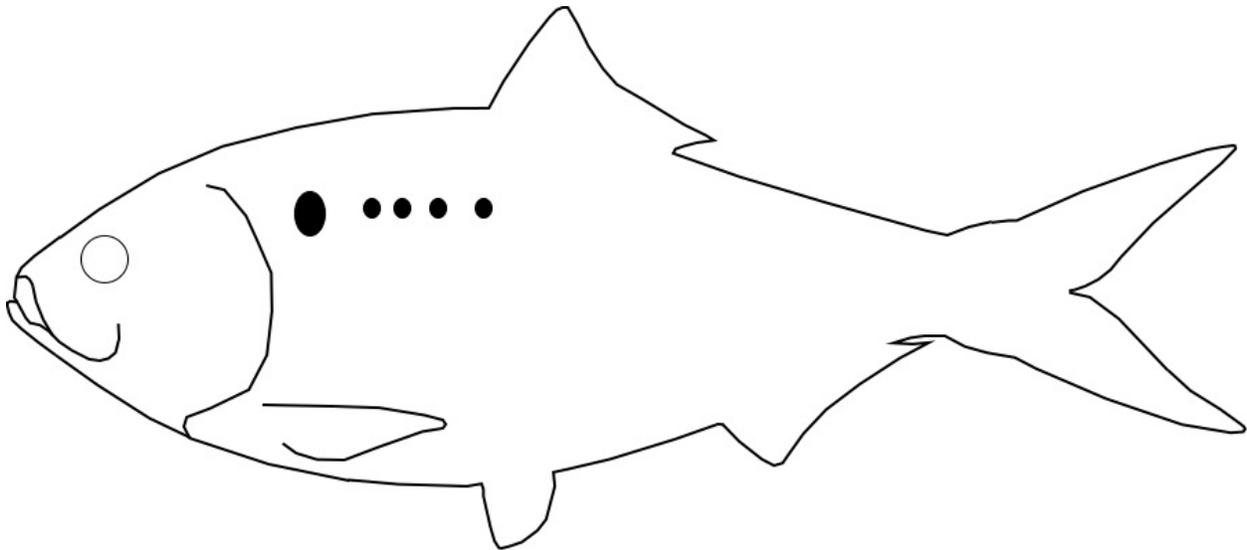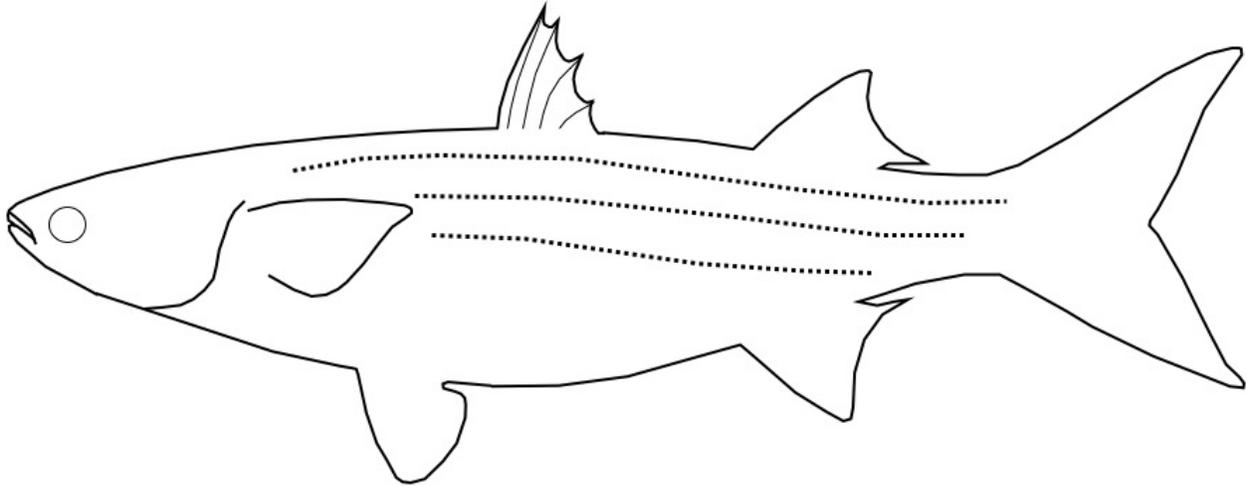
4. Based on the trophic level of your fish, your fish may prey on fishes in (low, medium, high) trophic level(s)

5. Based on the image of your fish, its mouth position is: Superior   Terminal   Inferior

Worksheet 2.   **Names:** _____

Step 1. Use the dichotomous key and the fish diagram to identify your unknown fish below. Once you have identified your fish, write your answer in the box below:

Who am I?
_____

Step 2. Using the image of your identified fish above and the information regarding its trophic level given below, choose the trophic level you think your fish belongs to:

Description: Fishes in this trophic level are small in size, large in numbers, form large schools, and are a common and abundant prey item in the Chesapeake Bay.

Size Range: 10 cm (3.9 in.) – 55 cm (1.8 ft.).

Prey types: Zooplankton; phytoplankton; detritus (dead plant and animal material); small invertebrates.

Mouth and Feeding: Small mouth; filter feed or select small prey items.

Trophic Level: Low/Medium/High
_____

Worksheet 2.

Step 3: Questions

<u>Short Answer</u>

1. Based on the dichotomous key, what is the main identifying structure(s) of your fish that led you to its identity?

_____

2. Why did you assign your fish to the chosen trophic level?

_____

<u>Circle Best Answer(s):</u>

3. Based on your fishes' trophic level, fishes in (low, medium, high) trophic level(s) may prey on your fish
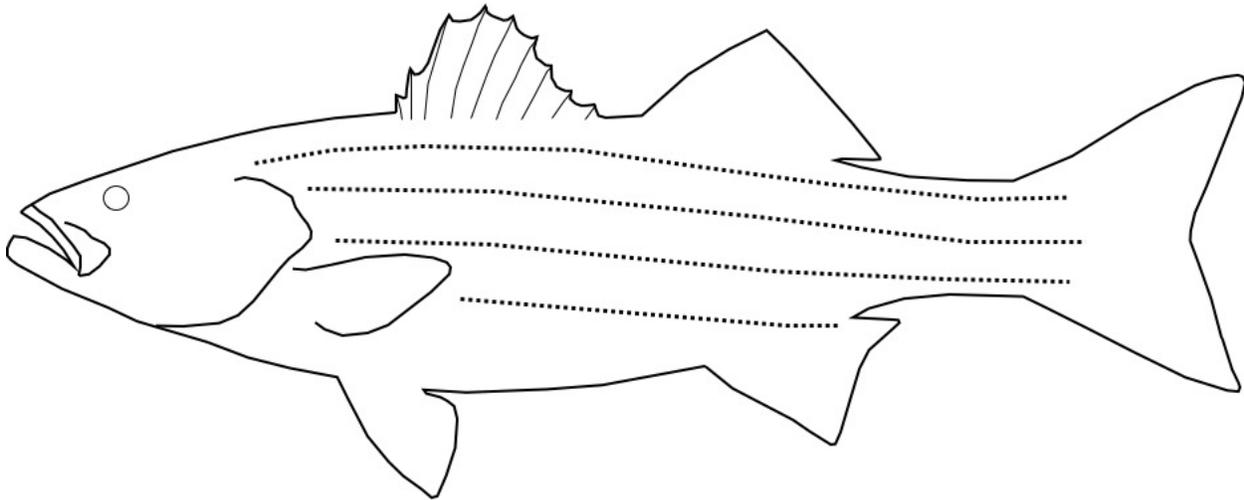
4. Based on the trophic level of your fish, your fish may prey on fishes in (low, medium, high) trophic level(s)

5. Based on the image of your fish, its mouth position is: Superior   Terminal   Inferior

Step 1. Use the dichotomous key and the fish diagram to identify your unknown fish below. Once you have identified your fish, write your answer in the box below:

Who am I?
_____

Step 2. Using the image of your identified fish above and the information regarding its trophic level given below, choose the trophic level you think your fish belongs to:

Description: Fishes in this trophic level are small in size, large in numbers, form large schools, and are a common and abundant prey item in the Chesapeake Bay.

Size Range: 10 cm (3.9 in.) – 55 cm (1.8 ft.).

Prey types: Zooplankton; phytoplankton; detritus (dead plant and animal material); small invertebrates.

Mouth and Feeding: Small mouth; filter feed or select small prey items.

Trophic Level: Low/Medium/High
_____

Worksheet 3.

Step 3: Questions

<u>Short Answer</u>

1. Based on the dichotomous key, what is the main identifying structure(s) of your fish that led you to its identity?

_____

2. Why did you assign your fish to the chosen trophic level?

_____

<u>Circle Best Answer(s):</u>

3. Based on your fishes' trophic level, fishes in (low, medium, high) trophic level(s) may prey on your fish
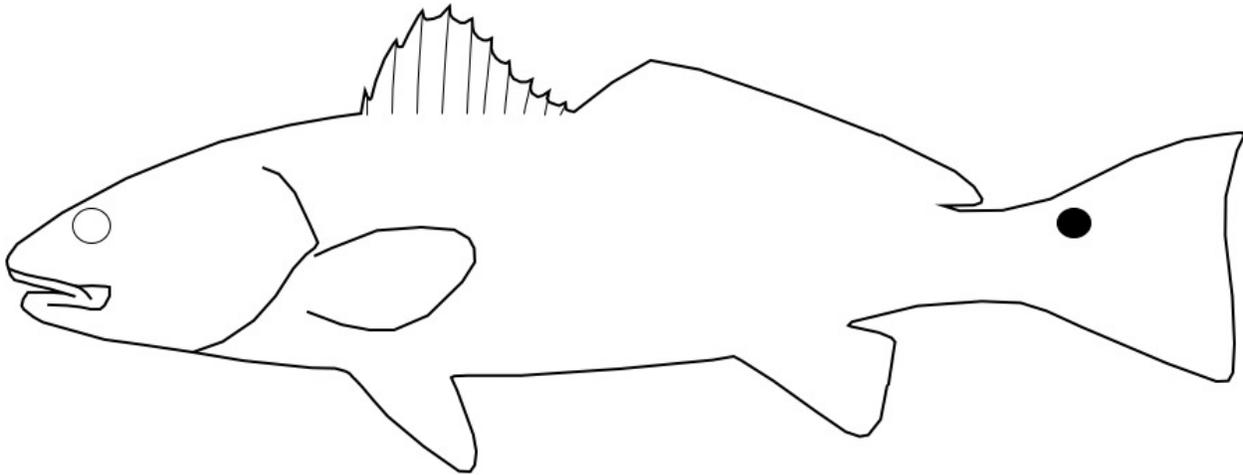
4. Based on the trophic level of your fish, your fish may prey on fishes in (low, medium, high) trophic level(s)

5. Based on the image of your fish, its mouth position is: Superior   Terminal   Inferior

Worksheet 4.   **Names:** _____

Step 1. Use the dichotomous key and the fish diagram to identify your unknown fish below. Once you have identified your fish, write your answer in the box below:

Who am I?
_____

Step 2. Using the image of your identified fish above and the information regarding its trophic level given below, choose the trophic level you think your fish belongs to:

Description: Fishes in this trophic level are medium in size, some are important commercially and recreationally in the Chesapeake Bay. They are powerful swimmers that can chase prey items.

Size: Reach maximum size around 1.8 m (6 ft.)

Prey types: Small to medium size crustaceans (crabs, shrimp); squids; and fishes (eels).

Mouth and Feeding: Large extendable mouth; some with sharp teeth.

Trophic Level: Low/Medium/High
_____

Worksheet 4.

Step 3: Questions

<u>Short Answer</u>

1. Based on the dichotomous key, what is the main identifying structure(s) of your fish that led you to its identity?

_____

2. Why did you assign your fish to the chosen trophic level?

_____

<u>Circle Best Answer(s):</u>

3. Based on your fishes' trophic level, fishes in (low, medium, high) trophic level(s) may prey on your fish
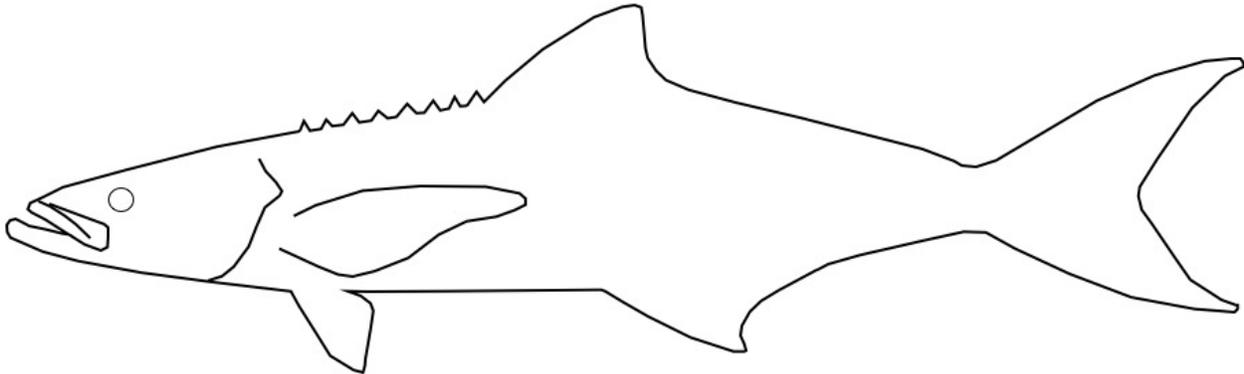
4. Based on the trophic level of your fish, your fish may prey on fishes in (low, medium, high) trophic level(s)

5. Based on the image of your fish, its mouth position is: Superior   Terminal   Inferior

Names: _____

Step 1. Use the dichotomous key and the fish diagram to identify your unknown fish below. Once you have identified your fish, write your answer in the box below:

Who am I?

_____

Step 2. Using the image of your identified fish above and the information regarding its trophic level given below, choose the trophic level you think your fish belongs to:

Description: Fishes in this trophic level are medium in size, some are important commercially and recreationally in the Chesapeake Bay. They are powerful swimmers that can chase prey items.

Size: Reach maximum size around 1.8 m (6 ft.)

Prey types: Small to medium size crustaceans (crabs, shrimp); squids; and fishes (eels).

Mouth and Feeding: Large, extendable mouth; some with sharp teeth.

Trophic Level: Low/Medium/High

_____

Worksheet 5.

Step 3: Questions

<u>Short Answer</u>

1. Based on the dichotomous key, what is the main identifying structure(s) of your fish that led you to its identity?

_____

2. Why did you assign your fish to the chosen trophic level?

_____

<u>Circle Best Answer(s):</u>

3. Based on your fishes' trophic level, fishes in (low, medium, high) trophic level(s) may prey on your fish
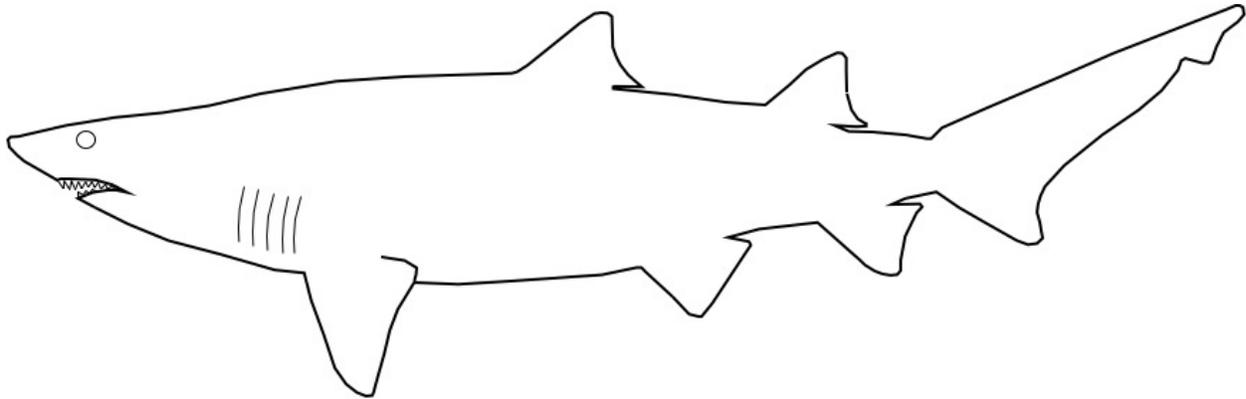
4. Based on the trophic level of your fish, your fish may prey on fishes in (low, medium, high) trophic level(s)

5. Based on the image of your fish, its mouth position is: Superior   Terminal   Inferior

Step 1. Use the dichotomous key and the fish diagram to identify your unknown fish below. Once you have identified your fish, write your answer in the box below:

Who am I?

_____

Step 2. Using the image of your identified fish above and the information regarding its trophic level given below, choose the trophic level you think your fish belongs to:

Description: Fishes in this trophic level are medium in size, some are important commercially and recreationally in the Chesapeake Bay. They are powerful swimmers that can chase prey items.

Size: Reach maximum size around 1.8 m (6 ft.)

Prey types: Small to medium size crustaceans (crabs, shrimp); squids; and fishes (eels).

Mouth and Feeding: Large, extendable mouth; some with sharp teeth.

Trophic Level: Low/Medium/High

_____

Worksheet 6.

Step 3: Questions

<u>Short Answer</u>

1. Based on the dichotomous key, what is the main identifying structure(s) of your fish that led you to its identity?

_____

2. Why did you assign your fish to the chosen trophic level?

_____

<u>Circle Best Answer(s):</u>

3. Based on your fishes' trophic level, fishes in (low, medium, high) trophic level(s) may prey on your fish
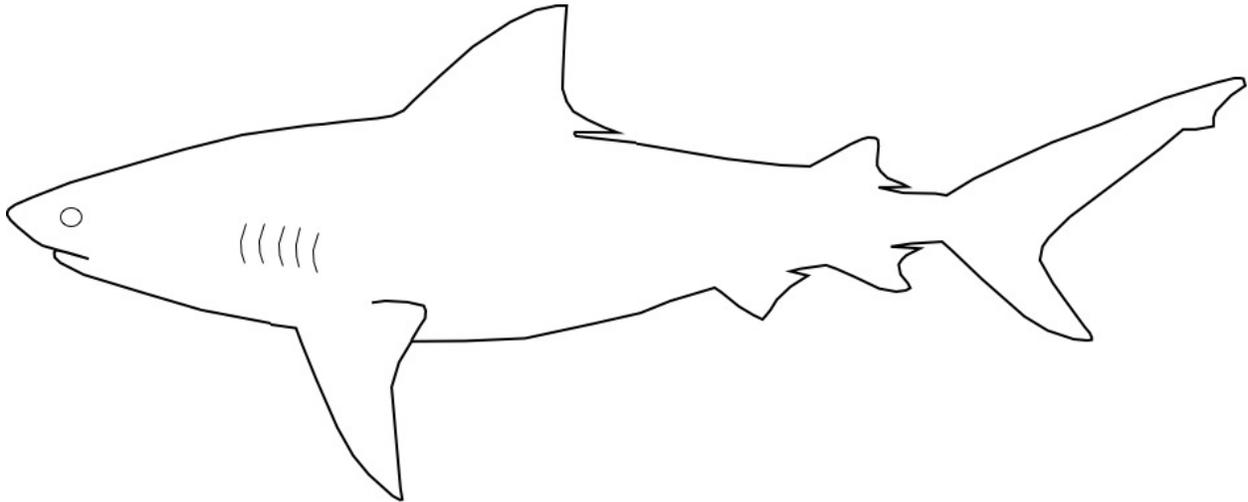
4. Based on the trophic level of your fish, your fish may prey on fishes in (low, medium, high) trophic level(s)

5. Based on the image of your fish, its mouth position is: Superior   Terminal   Inferior

Worksheet 7.   **Names:** _____

Step 1. Use the dichotomous key and the fish diagram to identify your unknown fish below. Once you have identified your fish, write your answer in the box below:

Who am I?

_____

Step 2. Using the image of your identified fish above and the information regarding its trophic level given below, choose the trophic level you think your fish belongs to:

Description: Fishes in this trophic level are large in size, and are known to regulate ecosystem health. They are low in numbers and are powerful swimmers.

Size: Reach maximum size around 3.3 m (10 ft.)

Prey types: Feed on medium to large size crustaceans, squid, and fishes, including small sharks.

Mouth and Feeding: Large mouth filled with multiple rows of sharp teeth.

Trophic Level: Low/Medium/High

_____

Worksheet 7.

Step 3: Questions

<u>Short Answer</u>

1. Based on the dichotomous key, what is the main identifying structure(s) of your fish that led you to its identity?

_____

2. Why did you assign your fish to the chosen trophic level?

_____

<u>Circle Best Answer(s):</u>

3. Based on your fishes' trophic level, fishes in (low, medium, high) trophic level(s) may prey on your fish
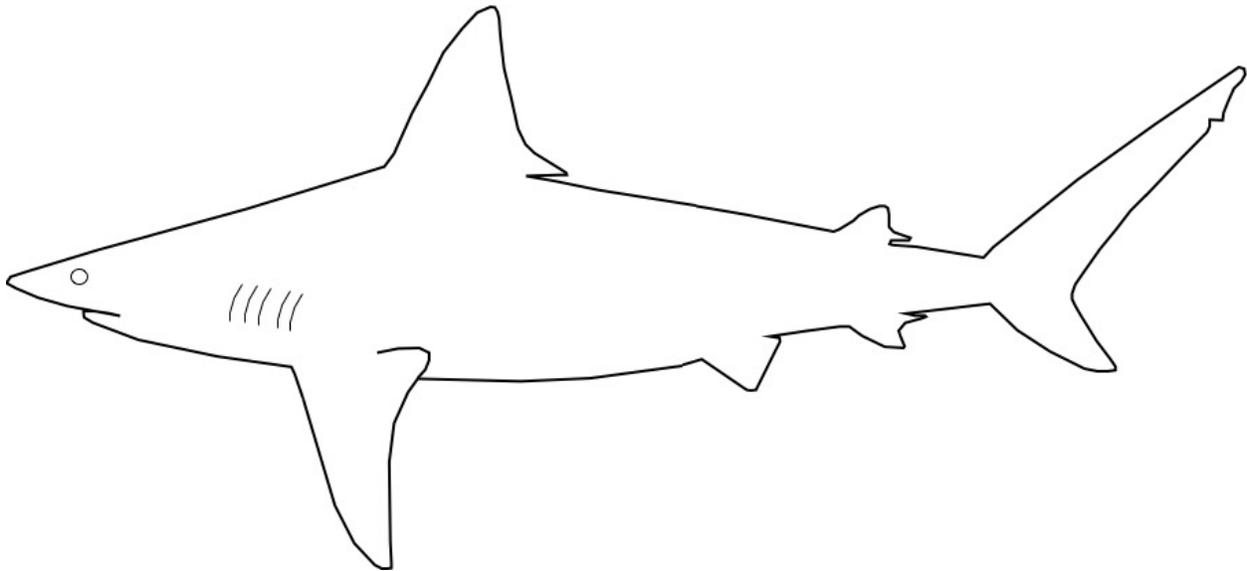
4. Based on the trophic level of your fish, your fish may prey on fishes in (low, medium, high) trophic level(s)

5. Based on the image of your fish, its mouth position is: Superior   Terminal   Inferior

Step 1. Use the dichotomous key and the fish diagram to identify your unknown fish below. Once you have identified your fish, write your answer in the box below:

Who am I?

_____

Step 2. Using the image of your identified fish above and the information regarding its trophic level given below, choose the trophic level you think your fish belongs to:

Description: Fishes in this trophic level are large in size, and are known to regulate ecosystem health. They are low in numbers and are powerful swimmers.

Size: Reach maximum size around 3.3 m (10 ft.)

Prey types: Feed on medium to large size crustaceans, squid, and fishes, including small sharks.
Mouth and Feeding: Large mouth filled with multiple rows of sharp teeth.

Trophic Level: Low/Medium/High

_____

Worksheet 8.

Step 3: Questions

<u>Short Answer</u>

1. Based on the dichotomous key, what is the main identifying structure(s) of your fish that led you to its identity?

_____

2. Why did you assign your fish to the chosen trophic level?

_____

<u>Circle Best Answer(s):</u>

3. Based on your fishes' trophic level, fishes in (low, medium, high) trophic level(s) may prey on your fish

4. Based on the trophic level of your fish, your fish may prey on fishes in (low, medium, high) trophic level(s)

5. Based on the image of your fish, its mouth position is: Superior   Terminal   Inferior

Worksheet 9.   **Names:** _____

Step 1. Use the dichotomous key and the fish diagram to identify your unknown fish below. Once you have identified your fish, write your answer in the box below:

Who am I?
_____

Step 2. Using the image of your identified fish above and the information regarding its trophic level given below, choose the trophic level you think your fish belongs to:

Description: Fishes in this trophic level are large in size, and are known to regulate ecosystem health. They are low in numbers and are powerful swimmers.

Size: Reach maximum size around 3.3 m (10 ft.)

Prey types: Feed on medium to large size crustaceans, squid, and fishes, including small sharks.

Mouth and Feeding: Large mouth filled with multiple rows of sharp teeth.

Trophic Level: Low/Medium/High
_____

Worksheet 9.

Step 3: Questions

<u>Short Answer</u>

1. Based on the dichotomous key, what is the main identifying structure(s) of your fish that led you to its identity?

_____

2. Why did you assign your fish to the chosen trophic level?

_____

<u>Circle Best Answer(s):</u>

3. Based on your fishes' trophic level, fishes in (low, medium, high) trophic level(s) may prey on your fish

4. Based on the trophic level of your fish, your fish may prey on fishes in (low, medium, high) trophic level(s)

5. Based on the image of your fish, its mouth position is: Superior   Terminal   Inferior

Dichotomous Key

Use the dichotomous key and the fish diagram below as a guide to identify the fish on your worksheet. Start with options 1a and 1b then work your way through the key based on the morphological features of your fish. Once you have identified your unknown fish, write its name in the "Who am I?" box on your worksheet.
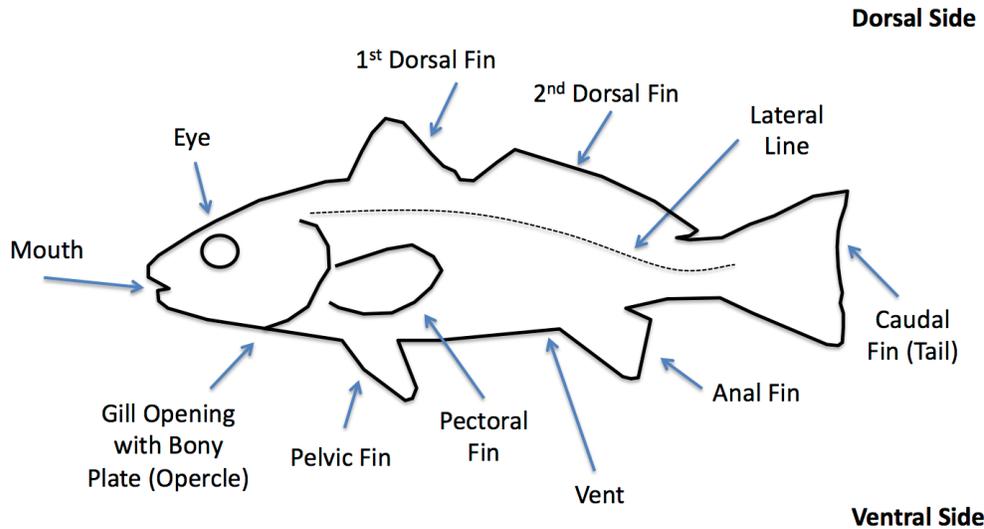
1a. Single gill opening covered with opercle (go to 2)
1b. 5 gill openings without opercle (go to 8)

2a. Single dorsal fin (go to 3)
2b. Two dorsal fins (go to 4)

3a. Rounded snout, slender body, no spots behind gill opening ……………. **Bay Anchovy**
3b. Large head, dark spots behind gill opening ……………. **Atlantic Menhaden**

4a. Dorsal fins separated (go to 5)
4b. Dorsal fins not separated (go to 6)

5a. Small head, dark spots on side of body form horizontal stripes ……………. **Striped Mullet**
5b. Anal fin posterior to second dorsal fin, dark stripes along side of body ……………. **Striped Bass**

6a. One or more large dark spots near caudal fin ……………. **Red Drum**
6b. No large dark spots near caudal fin (go to 7)

7a. Seven to nine short, stout spines in place of first dorsal fin ……………. **Cobia**
7b. No short, stout spines in place of first dorsal fin (go to 8)

8a. First dorsal fin short and far behind head ……………. **Sand Tiger Shark**
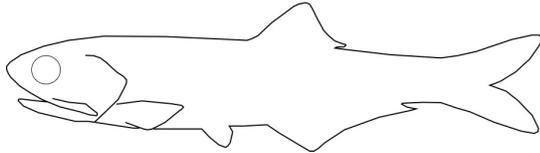8b. First dorsal fin not short and far behind head (go to 9)

9a. Snout short, rounded, and broad, dorsal fin not tall and triangular ……………. **Bull Shark**
9b. Snout pointed (go to 10)

10a. Pointed snout, first dorsal fin pointed, tall, and triangular ……………. **Sandbar Shark**
10b. Snout not pointed, first dorsal fin not pointed, tall, and triangular
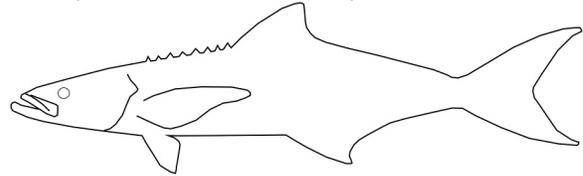
Answer Key (Steps 1 and 2)
Worksheet number, dichotomous key position, common name, scientific name, mouth position, and trophic level position are provided for each species
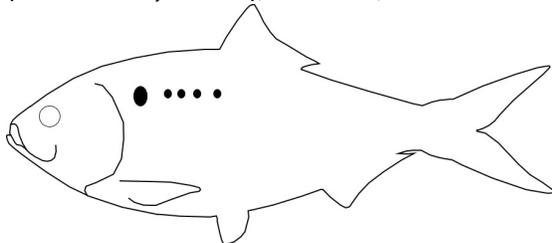
Worksheet 1. 3a. Bay Anchovy
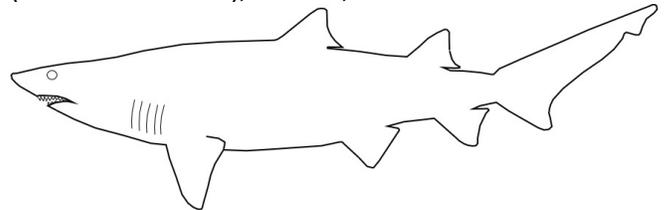(*Anchoa mitchilli*), Terminal, Low

Worksheet 2. 3b. Atlantic Menhaden
(*Brevoortia tyrannus*), Terminal, Low

Worksheet 3. 5a. Striped Mullet
(*Mugil cephalus*), Superior, Low

Worksheet 4. 5b. Striped Bass
(*Morone saxatilis*), Superior, Middle

Worksheet 5. 6a. Red Drum
(*Sciaenops ocellatus*), Inferior, Middle

Worksheet 6. 7a. Cobia
(*Rachycentron canadum*), Superior, Middle

Worksheet 7. 8a. Sand Tiger Shark
(*Carcharias Taurus*), Inferior, Hi

Worksheet 8. 9a. Bull Shark
(*Carcharhinus leucas*), Inferior, Hi

Worksheet 9. 10a. Sandbar Shark
(*Carcharhinus plumbeus*), Inferior, Hi
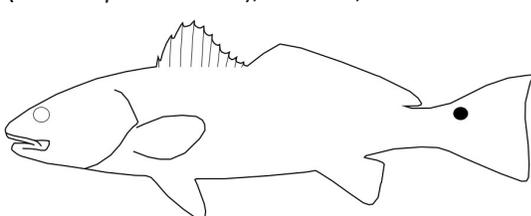
Answer Key (Step 3)

1. Any of the descriptors given in the dichotomous key position of the particular fish

2. Any of the descriptors given in the worksheet (step 2) for the trophic level of the particular fish

3. Low: Medium, High
   Medium: Medium, High
   High: Medium*, High
   > *(Note: adult fishes in the medium trophic level may consume the early/juvenile stages of even high trophic level fishes)

4. Low: None – low trophic level fishes do not eat other fishes, they consume zooplankton, phytoplankton, detritus (dead plant and animal material), and small invertebrates
   Medium: Low, Medium, High*
   > *(Note: adult fishes in the medium trophic level may consume the early/juvenile stages of even high trophic level species)
   High: Low, Medium, High

5. Mouth positions for each species are given in the answer key for parts 1 and 2

Answers to Take-Away Questions:

1. Not always. Even though members of a specific trophic level feed on similar prey items, they do not necessarily have the same mouth positions.

2. If high trophic level fishes (sharks) declined due to overfishing or unfavorable climate impacts (climate change), the number of fishes in the middle trophic level may increase and they may be left unchecked to overeat fishes in the low trophic level. In this case, the high trophic level fishes regulate the balance of the ecosystem.

3. Yes. For example, an adult fish in the middle trophic level that preys on fishes is capable of feeding on juvenile fishes that belong in the high trophic level. Another example is that when middle and high trophic level fishes are juveniles, they may feed on zooplankton, small crustaceans, and small fishes before shifting their prey preferences to larger fishes as they grow.