**Monitoring Rockfish using Remotely Operated Vehicles (ROVs)**

***Focus***

Scientific surveys of rockfishes using remotely operated vehicle

**Grade Level**

6-8 (Life Sciences)

9-12 (Life Sciences)

**Focus Question**

How are remotely operated vehicles (ROVs) used to assess the population status of rockfishes in Puget Sound?

***Learning Objectives***

1. Students will understand why it is important to know the size of fish populations.
2. Students will learn how remotely operated vehicles are used to observe rockfishes.
3. Students will identify rockfishes based on visible traits.
4. Students will analyze rockfish counts and habitat characteristics from ROV videos to estimate Puget Sound rockfish population.
5. Students will apply knowledge of habitat use by rockfishes to plan an ROV survey.

**Teaching Time**

One 45-minute class period

**Seating Arrangement**

Groups of four students

**Maximum Number of Students**

40

**Materials**

Data Collection Forms for each student

Puget Sound Rockfish Worksheet for each student

Tablet computer for each group

microSD card for each group

USB drive loaded with slide show, worksheets, and lesson plan

Rockfish model

Laminated map for each group

**Audio/Visual Equipment**

Projector attached to a computer capable of displaying a Powerpoint or PDF presentation and video in mp4 format.

**Key Words**

Bottom trawling

Conservation

Fisheries management

Habitat

Overfishing

Remotely operated vehicle

Scientific surveys

**Background Information**

***Why we care about healthy fish populations***

Fish populations support recreational and commercial fisheries that make up a large sector within the US economy. Within the United States, these industries generate $205 billion dollars in annual revenue and support 1.62 million jobs. In Washington State alone, there are approximately 60,000 fishing related jobs. The commercial fishing industry continues to be a large employer and food source, making it important to maintain into the future. In the recreational fishing industry, large quantities of money are spent on fishing gear, fishing destinations and the privilege to fish for a specific species. In 2015, there were approximately 9 million saltwater anglers that took 61 million fishing trips. This generated $63 billion in sales and $22 billion in income impacts. Recreational fishing also supports nearly 439,000 U.S. jobs. In addition to the economic benefits, fishing also has important cultural value to humanity.

Fishes also play a key role in marine food webs as predators and prey of other fishes, invertebrates, birds, and marine mammals. Consequently, the loss of fish populations can have a ripple-effect on the function of marine ecosystems. Therefore, maintaining healthy fish populations is also vital to sustaining healthy marine ecosystems.

***Ensuring healthy fish populations through conservation and management***

Scientific surveys play a critical role in estimating fish population size and monitoring whether fish populations are managed sustainably to ensure the continuation of valuable benefits to society. Different surveys use different sampling methods, depending on which species are targeted and the habitat in which the survey is conducted. Some common methods are bottom trawling, scuba diving, hook and line, and more recently, remotely operated vehicles (ROVs).

The choice of sampling method is often selected based on where fishes live. For example, trawl nets can sample fishes living on sandy or muddy substrate, but cannot sample rocky or high relief areas because the net gets snagged. Scuba diving surveys can non-lethally survey fish and are not limited by habitat type, however they restricted by how deep a human can safely dive. Hook and line surveys offer another alternative for surveying fish in rocky habitat, however hooks can still snag on rocks and this survey also requires sacrificing fish.

A more recent method of surveying fish populations is by ROVs. Using underwater cameras, fish can be non-lethally counted in a given area that the ROV surveys. This makes ROV surveying an ideal method for threatened or endangered fish species. This type of survey can also survey more rocky underwater terrain which trawling cannot. ROVs are currently used to survey Rockfish populations in the Puget Sound, two species of which have been declared threatened and endangered by the Endangered Species Act. These surveys can be interpreted to provide an estimate of fish abundance. Students will learn how this is done in more detail in this lesson.

***More on ROVs:*** Remotely operated vehicles (ROVs) are a recent technological advancement that allows scientists to view underwater habitat without actually having to go underwater. Most ROVs are equipped with cameras, GPS, electronic instruments that measure conductivity, temperature and depth (CTD stands for the grouping of the instruments that measure those properties), and some have robotic arms for collecting specimen or water samples. Another tool often found on ROVs are laser beams which help scientists with measuring the width of objects and to provide a reference scale.

***History of rockfish harvest in Puget Sound, current population status and management goals***

Unsustainable harvest during the 1970s–1980s caused steep declines in Puget Sound rockfish populations. In the last forty years, the rockfish population in Puget Sound declined by 70%. In an effort to rebuild rockfish populations, commercial fishing for rockfish was banned in Puget Sound in 1992, and restrictions were placed on recreational fishing in 2010. Despite these efforts, rockfish populations in Puget Sound have yet to recover. As of 2019, distinct population segment of Boccaccio rockfish in Puget Sound is listed as endangered, and the distinct population segment of Yelloweye rockfish is listed as threatened under the Endangered Species Act (ESA).

The history of rockfish fishing had a slow start but rapidly increased until some of the species crashed due to overfishing. Prior to the 1970s, there was little recreational and commercial fishing for rockfish in the Puget Sound. After the 1970s, recreational and commercial fishing pressure on rockfish increased. Populations still declined and in 1992 a commercial fishing ban was put in place. In 2010 the recreational rockfishing closed and a 120 feet depth limit was implemented. These bans and closures did not prevent rockfish populations from crashing.

Habitat degradation may have exacerbated population declines of rockfish in Puget Sound. The Puget Sound region is strongly impacted by human development. Human activities have led to the pollution of Puget Sound with chemical contaminants, and changes in the regional climate have contributed to increasing temperature and hypoxia (low oxygen) conditions which may be detrimental to rockfish.

Today, rockfish conservation efforts are underway in Puget Sound. ROV surveys are being done by the National Oceanic and Atmospheric Administration (NOAA) and Washington Department of Fish and Wildlife (WDFW). They are also working with Northwest Indian Fisheries Commission and the University of Washington to create an adaptive management recovery plan for rockfish in Puget Sound. These organizations aim to protect and ensure healthy populations for sustainable fishing for years to come.

Rockfish in Puget Sound are subject to multiple stressors. Puget Sound waters have been polluted from sewage, stormwater runoff and loss of habitat from activities such as dredging. Along with these habitat quality changes, rockfish are often unintentionally caught by fishermen.

***Rockfish biology***

Rockfish are a diverse group of fishes that increase the local marine biodiversity and link in the food web in marine ecosystems. They differ in life span ranges, come in a rainbow of colors, and are located from anywhere in shallow waters to 300 meters deep. Despite these differences, all rockfishes are slow-growing, long-lived, and late-maturing. Some rockfish can live up to 200 years, and reach reproductive maturity at 5-25 years. The combination of slow-growth and late maturity make rockfish especially vulnerable to fishing pressure. On the West Coast of North America, there are seventy species of rockfish, twenty-eight of which occur in Puget Sound.

***Bathymetry and habitat types in Puget Sound***

The Puget Sound estuary was formed from the scouring of glaciers ranging from two million years ago to the last ice deposit from around 15,000 years ago. These ice sheets carved out the surrounding landscape and gave rise to what is the Puget Sound today. On average, Puget Sound is 140 meters deep. The deepest part is approximately 280 meters off of Point Jefferson.

Throughout Puget Sound, there is a mix of both high and low relief habitat. Higher relief habitat is defined as more complex with different layers of features that rockfish like to inhabit. Low relief is typically less complex underwater landscapes and tend to be more flat and desolate. Rockfish are a benthic species of fish and prefer high relief habitat with lots of crevices to hide from predators.

***Lesson Summary***

Introduce students to Puget Sound rockfishes and new technologies used to assess the health of fish populations. Students get a hands on experience with ROVs and learn how they are used to count rockfishes in Puget Sound.

***Audience and Duration***

*Audience:* This lesson is geared towards Middle Schoolers and High Schoolers who should have some background knowledge on properties of water.

*Duration:* 45 minutes

***Lesson Outline***

Introduction by Visiting Scientists – Brief (2-3 minute) introduction about:

* Who you are
* What you do
* How you got to where you are (degrees, school, where you’re from)

**Skip starred (\*\*) slides lessons < 1 hour.**

|  |  |
| --- | --- |
| **Section 1** | **Why should we care about how many fish are in the ocean?** |
| **Slide 1** |  |
|  | Ask students to brainstorm 2-3 reasons why we care about how many fish are in the sea. [allow several minutes to talk in groups and ask students to share with the class]  Expected answers:   * Food/sustenance for humans * Fish are part of the food chain * Recreation/sport fishing * Jobs and money * Culture and cultural subsistence * Protecting biodiversity * Conservation   \*tie into following slides |
| **Slide 2** |  |
|  | *How many of you have seen a food chain or web?* Fish are part of the food chain. Fish provide food for humans and aquatic animals, such as Orca whales (killer whales). *We need to make sure that there is enough fish for everyone to eat.*  **High school:** Fish provide a bountiful source of protein for human society. Fishing has a smaller carbon footprint than many terrestrial forms of protein production, such as farming cattle. Maintaining abundant fish populations is essential for ensuring food security. |
| **Slide 3** |  |
|  | *Raise your hand if you have ever been to Pike Place Market?* *Or maybe you have seen fishing boats coming into the Port of Seattle/ terminal.* We care about how many fish are in the ocean because fish populations provide a valuable renewable resource that supports an entire industry. Fishers, grocery stores, restaurants, our country.  Fisheries contribute $205 billion to the US economy per year. Examples of jobs shown on the slide:   * Pike Place Market in Seattle, Washington * Commercial purse seiner fishing for salmon |
| **Slide 4** |  |
|  | *How many people here fish?* *(if students fish, ask them what do they fish?)* Many people fish for fun! Making sure there are plenty of fish is important for recreation. |
| **Slide 5** |  |
|  | Fish are important to many cultures. The cultural significance of fish in the Puget Sound region is exemplified by the prevalence of fish-related art in Seattle. Fish welcome travelers at SeaTac airport as soon as they land and lead them into Seattle. *Fish is important to PNW culture before European colonization.*  Tie up this section: Many reasons fish are important to us, therefore important to make sure we do not catch too many and that populations are big enough to continue providing benefits in the future. |
| **Section 2** | **What methods are used to assess the size of fish populations?** |
| **Slide 6** |  |
|  | *So we learned why fish are important to humans, but now we need to how many fish are there so that we can maintain those reasons.* A main focus for fisheries scientists is to figure out how big fish populations are and how many we can catch. However, the way scientists count fish depends on the fish species and where it lives. This picture is an example of fish you can see from the surface, but other species of fish live deep in the ocean. |
| **Slide 7-8\*\*** |  |
|  | *By show of hands, how many have gone to the ballard locks?* This is a map of Seattle, Puget Sound is on the left and then Lake Washington on the right. Salmon swim through the saltwater, through the Ballard Locks and then through Lake Washington. This picture shows the Ballard Locks in Seattle up close. Adult salmon swim past a viewing window at a fish ladder at the Ballard Locks as they return from spending several years at sea. To assess the size of the population, a scientist sits at the viewing window and counts fish as they swim by. |
| **Slide 9** |  |
|  | *Most fish don’t swim through the ballard locks or some are not located at the surface water so how do we count them?* Most fish live in places where they are a lot more difficult to count, such as deep in the ocean. There are many different methods for assessing the size of the populations that are not visible. |
| **Slide 10\*\*** |  |
|  | Trawling is a survey method where a boat tows a net to catch fish. Fish are brought back to the surface and counted, providing information about the size of fish populations. Trawling is often lethal for fishes and trawls cannot sample rocky bottom because the trawl snags and gets destroyed. |
| **Slide 11\*\*** |  |
|  | *How many of you have gone snorkeling in the pool or maybe even scuba diving?* Scuba diving is a survey method where scientists go underwater to count fish in their natural habitat. Unlike trawling, scuba diving does not harm fish. However, scuba divers are limited by the maximum depth a human can safely dive and how much oxygen they can carry on a dive. |
| **Slide 12** |  |
|  | *Has anyone ever seen an ROV?* Similar to scuba diving, remotely operated vehicles (ROVs) can record underwater video to count fish and assess the size of fish populations. ROVs can dive to deeper depths than scuba divers and are not limited by the oxygen they can carry. However, ROVs are more expensive and difficult to maintain than scuba equipment.  Picture: ROV used by the Washington Department of Fish and Wildlife to assess rockfish populations in Puget Sound. |
| **Section 3** | **All about Puget Sound rockfish** |
| **Slide 13** |  |
|  | *Has anyone seen this type of fish? Maybe at the aquarium?* Ask if students know what the fish in the picture are. *[Display Rocky, the yelloweye rockfish mount]*  Answer: rockfish |
| **Slide 14** |  |
|  | Largely due to overfishing, rockfish populations in Puget Sound steeply declined during the early-to-mid 1900’s. Because their populations declined so much, two species, yelloweye rockfish and boccaccio, have been listed as threatened and endangered under the Endangered Species Act.  To promote the recovery of rockfishes, all fishing for rockfish has been banned in Puget Sound since 2010.  To determine whether or not rockfishes are recovering, we need to estimate the size of rockfish populations in Puget Sound. |
| **Section 4** | **In class exercise: Estimating Rockfish Population in Puget Sound** |
| **Slide 15** |  |
|  | *So this is where you come in! We just learned why fish are important to folks (for jobs, cultural value, or for funsies) and how we count fish. We are going to help WDFW and NOAA count the number of rockfish in Puget Sound.*  Students will analyze video collected by ROVs to assess the size of the rockfish population in Puget Sound.  The Washington Department of Fish and Wildlife and the National Oceanic and Atmospheric Administration want to know:   1. How big is the rockfish population in Puget Sound? 2. What type of habitat do rockfish use? |
| **Slide 16** |  |
|  | *So you spent many warm, sunny days on your research boat on the Puget Sound using your ROV to collect data. Now we are back in the lab to analyze these videos*! Students will count rockfishes in video collected by NOAA and WDFW using remotely operated vehicles. Their goal will be to estimate how many rockfish live in Puget Sound. \*\*The nautical charts (maps) show locations where ROV footage was collected in Puget Sound.\*\* *Nautical charts can be left out of lesson to save time.* |
| **Slide 17** |  |
|  | There are 28 species of rockfish in Puget Sound. They come in many different colors. Some species of rockfish can live to be over 150 years old! |
| **Slide 18** |  |
|  | [*Display yelloweye rockfish mount*]  *Say hello to my little friend, Rocky. He’s got some large spikes on his dorsal fin (fancy word for top fin) and really large pectoral (aka side fins).*  Use Rocky, the yelloweye rockfish mount, to show two distinguishing features of a rockfish: (1) a spiny dorsal fin (top fin) in front of a rounded dorsal fin, (2) large, rounded pectoral fins (side fin). Rockfish often hold their pectoral fins out to the side. |
| **Slide 19** |  |
|  | *But before we let the hounds loose, you gotta know what a rockfish is and how to identify it*. Before looking at ROV video, students will need to learn how to identify rockfishes.  Fish pictured on this slide belong to two different families. In this context, family means the fish are closely related and look similar.  Have students work in groups to sort fish into two families based on what the fish look like. Ask which characteristics led to their decision. |
| **Slide 20** |  |
|  | Top left, top right, and bottom middle are rockfish.  Top middle is a sixgill shark.  Bottom left is a salmon.  Bottom right is a ratfish.  Rockfish are colorful, have a spiny dorsal fin (top fin), pointed snout, squat body shape, and large and rounded pectoral fins (side fins). |
| **Slide 21** |  |
|  | Show an ROV video of a rockfish to prepare students for identifying rockfish in the activity.  The rockfish is hovering in place then darts away when the ROV gets close. |
| **Slide 22** |  |
|  | *Ratfish are not a rockfish!! They have longer bodies and have a long tail. They have side fins that are parallel to the ocean floor (like space ships) and glow in the dark.* Ratfish are another fish that students may see in the ROV videos. Prepare students to differentiate between ratfish and rockfish to prevent students misidentifying them when watching the videos.  Ratfish have three dorsal fins and a pointy tail. Ratfish are closely related to sharks, and are very common in Puget Sound. |
| **Slide 23** |  |
|  | Ask students whether the fish pictured on this slide is a rockfish or ratfish.  Answer: ratfish |
| **Slide 24** |  |
|  | Introduce the two habitat types that students will be asked to identify in the activity. Low relief (like the desert) is fairly flat and simple. A high relief habitat has complex, vertical features (like the mountain). |
| **Slide 25** |  |
|  | Still images from ROV videos showing low relief and high relief habitat types.  *Low relief underwater is similar to desert habitats (super flat and muddy). High relief is vertical and looks more complex (like our mountains).* |
| **Slide 26-28** |  |
|  | Quiz students with videos of different habitat types to prepare for activity:   * Next three slides have 10 second clips and ask students what type of habitat these are   + Slide 26: high relief   + Slide 27: low relief   + Slide 28: low relief and note the fish swimming in the background     - *Is that a rockfish? No! It’s a ratfish! These fish are quick swimming, a pointy long tail and are shiny in the dark.* |
| **Slide 29** |  |
|  | Guide students through the activity and leave this slide up during the activity. The slide shows where students can find the information they will need to complete their data collection sheets. |
| **Activity** |  |
|  | Students will use the **Data Collection Form** and **Puget Sound Rockfish Worksheet** to complete the activity.   1. Instruct students to take out their Data Collection Form and Puget Sound Rockfish Worksheet. 2. Remind students of the two study questions, which are listed on the Puget Sound Rockfish Worksheet. 3. Have students fill in their hypothesis about which habitat type will have more rockfish based on what they learned about rockfish in the presentation. 4. Remind students of the study methods. Each group will watch two 90 second videos. For each video, students will use the data collection form to document information about the video (shown on the slide), the habitat type in the video, and a count of all of the rockfish they see in the videos. 5. Instruct students to find videos and guide them through opening videos to watch underwater ROV footage. Instruct students to fill in their data collection sheets as they watch the videos noting the habitat and counting the number of fish seen. 6. Students complete the activity by following the **Puget Sound Rockfish Worksheet**. After watching the video, students will fill out the “Analyze your data” section. 7. Have groups report the number of fish they saw in each habitat type, write each group’s results on the board. 8. **\*\*High School\*\* If there is time:** After groups have finished recording data, explain the area swept method. Give students several minutes to use the area swept method to estimate the size of the rockfish population in Puget Sound on the back of the Puget Sound Rockfish Worksheet and answer the survey planning question. |
| **Wrap-up** |  |
| **Slide 30** |  |
|  | Ask students in what habitat type rockfish were most abundant.  Expected answer:   * High relief   Ask students therefore where they would focus their survey effort in the future to review question from their rockfish worksheet. |
| **Slide 31** |  |
|  | Ask students to share what challenges there were counting rockfish using the ROV video footage.  Expected answers:   * Poor visibility * Low video quality * Hard to tell if fish were rockfish or ratfish * Rockfish were hidden in rocks and hard to see   All real challenges scientists face everyday. |
| **Slide 32** |  |
|  | Ask students if groups counted the same number of rockfish. Estimates will be written up on the board.  Can discuss reasons why:   * Could be because of the challenges they identified in the last question that caused them to get different counts. * Different numbers of rockfish in different videos/ areas.   Scientists have to think about these things when trying to make population estimates as accurate as possible. |
| **Slide 33** |  |
|  | Walk through area swept methods on the board and total population estimates.  Use a few different counts from videos to show how population estimates can vary. Explain why watching more videos ends up in a better estimate. |
| **Slide 34** |  |
|  | Summarize main takeaways:   * We care about the size of fish populations for many reasons, including:   + Food chain   + Jobs/money   + Recreation   + Culture * We can identify rockfish based on appearance, such as spines and pectoral fins. * We use ROVs to survey rockfish in Puget Sound * We can figure out how large the rockfish population is based on ROV video * Rockfish prefer high relief habitat to low relief habitat |
| **Slide 35** |  |
|  | Thank all students for their contribution to science and rockfish recovery in Puget Sound! Next time they are at the aquarium, say ‘hi’ to the rockfish! |

Extend the Discussion [Optional]

1. Demonstration: to know reality, or true population size, we would have to count fish in the entire Puget Sound. We can’t do this because it’s too big and we have limited time and money. But the more area we cover, the better our estimate will get. If we do area swept method with all groups counts combined, we can show that the more area you cover, the closer you get to what the actual population is. “Splitting the difference” between each individual estimates.
   1. There is a tradeoff with the amount of resources available, so what locations would you go to look at if can only survey 10 sites (or number of groups in the class)?
2. Danger of grouping all 28 species together is that we might miss some species that have really low population numbers like Bocaccio and Yelloweye.