Sustainable Aquaculture Pilot Program: TEACHERS GUIDE

Contacts: Dominique Richardson and Zoe Allen, Cabrillo Marine Aquarium

Objective: Immerse students in the growing sustainable aquaculture industry beginning with an overview of aquaculture science and economics, and continuing to explore sustainability, engineering, genomics, cryogenics, water quality and food security.

Classes are designed for 2 to 2.5 hour blocks.

Class 1: Introduction to Aquaculture

Pre-Class Preparations:

- Activity 1: Print Assessment for students
- Activity 2: One or two large pieces of poster paper taped to the wall
- Activity 3: pre count out 6 cups of 20 mms per each group A, and one cup of 50 mms and 1 cups cups of 50 ms for each group B
- Activity 4: Upload video(s) onto computer and set up video system at school.

Grouping: Whole class, small groups and individuals

Purpose:

- Assess students current knowledge of and attitudes towards aquaculture
- Introduce the concepts of Aquaculture and Sustainability
- Explain the importance of aquaculture to conservation
- Students will evaluate the importance of aquaculture to future food security
- Students will explore the economics of unsustainable fishing vs sustainable aquaculture
- Explore the economics of unsustainable fishing vs sustainable aquaculture

Science Standards:
HS-ETS1

HSESS3-3 The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.

HSESS3-4 Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.

MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Materials:

- Activity 1:
  - Assessment
- Activity 2: What is aquaculture brainstorm
  - One or two pieces of large poster paper per class
  - Post-it Notes for each student
  - Poster markers
  - Pen for each student
- Activity 3: Fishing vs. aquaculture game

Per 2 groups

    - ~200 MMs or Skittles divided in paper cups per prep instructions
    - 2 trays
    - Plastic tweezers per student
    - Small paper cup per student
    - Worksheet 1A

  - Activity 4:
    - Videos listed in procedures

<u>Procedure:</u>

Activity 1 (time: 5 minutes)

Over the next 6 weeks we are going to learn about Aquaculture. Has anyone heard of aquaculture before? We'd like to get an idea of what you already know.

Students will answer, to the best of their knowledge, the short pre-assessment questions. This activity is for the teachers to better understand the students' knowledge prior to the class.

Activity 2 (time: 10 minutes)

After students are done filling in your short assessment, let's brainstorm as a group! Students can work as a group to brainstorm their ideas on the post-it notes and come up to one of the poster boards and add their ideas about what they think aquaculture is.Then as a class, talk about some of the words that stand out the most.

TEACHER NOTE: After class, enter the words the students wrote into Word Cloud. Print out the document and use it on the last class to show students what they have learned.

Activity 3 (time: 40 minutes)

Small Groups of about 4-5

Fish is an important source of food, particularly protein, for the world. But there are many different ways we can get fish. Instruct the students that we will be playing a game about different fishery methods. They should wait for all instructions before doing anything. At the end, if their worksheets are complete and they've shared their data with the class, they may eat the mms, but not before!

1. Divide class up into an equal number of groups. Designate groups either an "A" group or "B" group without revealing any more information to the students about what their group label represents. Teacher's note: "A" will represent an "open ocean" group and B will denote an "aquaculture farm."
2. Place a tray or large sheet of butcher paper in the middle of each group. Give each student a small paper cup and a pair of tweezers.

3. Scatter 1 cup of 20 mms onto the tray for group B. Scatter 1 cup of 50 mms onto the tray for group A. Students should not touch any mms until instructed to do so.
4. When teacher calls “Start” students will have 30 seconds to collect as many mms as possible. They must use the tweezers only, no hands, and get the mms into their paper cup. When the teacher calls “Stop” students must stop collecting. This constitutes one “round.”
5. After a round, students will record how many mms they collected. Each mm counts for $100 dollars.
6. After each round, have the students count how many mms remain on the tray.
7. For group A, replace 1 mm for each mm left on the tray from their pot. For group B, add in an additional 20 mms. For group A, not all mms may be used or if their pot is empty, no more will be added.
8. Repeat steps 4-7 for 5 rounds. Students should record their count, dollar amount and remaining mms after each round.
9. After finishing their rounds, have the students add up their totals for themselves and their group.
10. As a class review the total mms picked up and $ amount for each group

    What happened in Group A?
    What happened in group B?
    Who had the most mms and $ after the first round?
    Who had the most in the long run?
    What do you think would happen if we continued to play for 5 more rounds? 100 more rounds?
    What do they think the two different groups represent?

As a class, briefly explain the current state of the world's fisheries. There are 2 main ways we get our fish, either by capturing wild fish out in the open ocean, like group A or cultivating and harvesting using aquaculture techniques liek group B.
Currently about 90% of global fish stocks in the open ocean are fully fished or overfished, meaning more fish are taken than can reproduce. Like we saw in the game, this might have meant a lot of fish at first, but quickly there was not enough left to allow us to keep fishing. Another method of getting fish is aquaculture or like group B. Although it did not have the massive yields at first, like group A did, it kept producing over time.
According to the FAO, fish is 6 times more efficient to raise than cattle and 4 times more than pork. With earth’s growing population, farming fish is a good option for ensuring we have enough food for the future, or good for food security.

Activity 4 (time: 20 minutes)

Watch a video to get an introduction to Aquaculture.
NOAA Into- https://www.youtube.com/watch?v=3Oi9GARr-Xc
NOAA Steelhead example: https://www.youtube.com/watch?v=e_C3eZDfWqc
Aquaculture by numbers: https://www.youtube.com/watch?v=6QhF0MK_3oM

Extra Videos:
Aquaculture for species recovery https://www.youtube.com/watch?v=nAu2ssRQS_Q
Aquaculture for restoring native species https://www.youtube.com/watch?v=fEZfhftzUNw
Cultivating and harvesting seaweeds https://www.youtube.com/watch?v=fEZfhftzUNw
Food for farming fish
https://www.scientificamerican.com/video/soldier-flies-the-new-food-for-farm-fish/
Open ocean farming https://www.youtube.com/watch?v=BBbB27698Ug
Innovations in aquaculture https://vimeo.com/220729565

To show numbers in aquaculture in the U.S.
http://noaa.maps.arcgis.com/apps/Cascade/index.html?appid=77637819eeb742c3a512313006a1cdec
Talking points for during and/or after the videos:

- Humans love to eat seafood. It is both delicious and healthy. In 2015, the average American ate 15.5 lbs of seafood. With 7.3 billion people on Earth and increasing, do you think it is possible to eat the amount of seafood we eat and never run out? Definitely not. Currently about 90% of fish stocks in the open ocean are fully fished or overfished. This means that fish are being harvested faster than they can reproduce.
- Fish is an important source of proteins and healthy fats, as well as a source of essential nutrients including omega-3 fatty acids, iodine, vitamin D, and calcium.
- Seafood production is important to the U.S. economy. In 2015 it was valued at $5.3 billion. Aquaculture accounted for 21% of that value. According to the FAO, fish is 6 times more efficient to raise than cattle and 4 times more than pork. With earth's growing population, farming fish is a good option for ensuring we have enough food for the future, or good for food security.

After the video, answer questions.

Discuss as a class or in small groups:

What is Aquaculture?
How is it beneficial to us?
What are some local aquaculture operations happening in our area?
What are some jobs you saw in the video that may interest you?
What kind of science and technology did you see in the video that may interest you?

Discuss how over the next several weeks, students will be learning about the science of aquaculture and jobs in aquaculture. Students will get the chance to evaluate current farms, design their own pens, test their skills at maintaining tanks, feed animals and visit a real aquaculture farm and more.

Class 2: Sustainability [Case Studies and Genomics]

Pre-Class Preparations:

- Activity 1: Print and laminate enough case studies for each group to have a complete set
- Activity 2: Pre-make buffer solution for each group: 1 teaspoon salt to ⅓ cup water to 1 tablespoon dish soap. Pre-measure and set supplies out on trays for each group. Chill isopropyl alcohol in the freezer. Write procedure on whiteboard.
  For Reference: http://www.gs.washington.edu/outreach/dhillon_dnaprocedure.pdf

Grouping: Small groups (about 4-5 students each)

Purpose:

- Allow students to analyze current aquaculture farms and evaluate their sustainability
- Students will develop their own ideal farm using examples
- Students will isolate DNA
- Students will understand the importance of genomics in aquaculture

Science Standards:
MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms

MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

MS-LS4-5 Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.

MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Materials:

- Activity 1: Aquaculture Case Studies

Per group
- One or two large pieces of poster paper
- Markers/pens
- File folder containing 4-6 case studies
- Worksheet 2A

- Activity 2: DNA Extraction

Per group

- Zip lock bag
- Salt
- Dish soap
- 2 Small cups or beakers
- Coffee filter
- Test tube
- Stir stick or pipette
- Refrigerated Isopropyl alcohol
- Strawberries
- Skewer
- “Test results” on Worksheet 2B

<u>Procedure:</u>

Activity 1: Aquaculture case studies (time: 1 hours)

Introduction

As the human population continues to grow and as we continue to drain the resources from the ocean, aquaculture will become essential. Humans, as well as the environment, can benefit greatly from the outcome of aquaculture. However, whether or not the aquaculture is sustainable can have a large impact on the effectiveness. The word sustainable means the capability of being maintained at a steady level without exhausting natural resources or causing severe ecological damage. In terms of aquaculture, sustainability can be influenced by many different factors such as what type of energy is used to power the tanks. If the farm runs on oil or coal, then it is most likely unsustainable. There are some farms that do not rely on any source of outside energy, so those would be the most sustainable choice. Other factors such habitat destruction and pollution, gene flow, integration, and economics can all play a role in determining if a aquaculture is sustainable or unsustainable.

Before the case study activity, as a whole class have students write on a large piece poster paper one or two words about what they think sustainable means. Talk with the class about the words they wrote on the paper. Those words will then be entered into word cloud and analyzed.

In groups of 4-5, students have the opportunity to evaluate several real aquaculture situations. Students will read the case studies in the file folders and determine which are sustainable and which are unsustainable by using worksheet 2A to write the pros and cons of each study (if there are no cons or no pros, just leave it blank). Depending on the class, you may choose to do one case study all together. Once each group has had sufficient time to work on the activity, talk about each case study as a class and show video clips of actual aquaculture practices that are currently happening.

The reasoning behind each study can be found below:

- Case #1: Open ocean mussel farm- Sustainable, mussel farming is one of the most sustainable forms of aquaculture. Mussels are filter feeders, filtering out plankton from the ocean, so farmers do not need to feed their crop. Along with filtering for food, mussels filter the ocean of pollutants. Other organisms can grow on the ropes and amongst the mussels, creating a habitat. Mussels produce thousands of offspring, which grow quickly. Gametes spread through the water, creating genetic diversity.
- Case #2: Enclosed open ocean salmon pen- Unsustainable. In this scenario more than one species is being fished because the salmon food is made of other fish. This food is then processed by machines and shipped to wherever the buyer is. A monoculture means that only one species is being farmed. A monoculture can be unsustainable because there is usually no other species to clean up the fish waste. Fish waste that is left in pens can flow into the surrounding environment and cause disease that can spread to the wild fish outside the pens. When there is little genetic variation amongst the fish, one disease can kill the entire yield.
- Case #3: Aquaponics- Sustainable. Aquaponics includes the raising of two species, some kind of aquatic species and a vegetable. Polycultures are usually a sustainable choice because there is more than one species being raised and depending on the design, one of those species may either feed on or use the waste to grow. In the case of aquaponics, the waste from the tilapia is used as fertilizer for the plants. It is necessary to purchase fish food, but the plants get their energy from the sun. Small scale aquaponics can be done in your backyard or classroom and large scale aquaponics can be done indoors.
- Case #4: Shrimp ponds- Unsustainable because habitat was destroyed to create the farm and when the conditions in the pond are unsuitable for life, a new pond is created. The shrimp live in their own waste, this makes them prone to disease. To prevent disease, shrimp are injected with antibiotics, pesticides, and hormones all of which are then consumed by the people eating the shrimp. This species of shrimp is not native to this part of Thailand. Due to overcrowding, it is likely that individuals may escape into the surrounding habitat and outcompete the native species, becoming an invasive species.

Using the information they just gathered about which practices are sustainable, have students write a detailed paragraph, or bullet points, (on worksheet 2A) about how *they* would make a sustainable aquaculture farm. Make sure students are using the case studies as examples of what they know are sustainable and unsustainable practices. Once each group has had enough time, each group will present to the rest of the class about their sustainable aquaculture farm.

Activity 2: DNA Extraction (time: 1 hour)

How do you know fish is what people really say it is? Sometimes an unsustainable fish is labeled as a fish that is sustainable before it is sold, like whelk being called abalone or toothfish being called chilean sea bass. There are actual fish detectives out there sampling fish that is sold or fish from restaurants to see if it really is a sustainable fish and the sellers claim or if it is an endangered species that must be protected. One way to do this is through DNA testing. DNA is present in all living organisms and our genetic code or the instructions our bodies use to make us us. It can be found in all cells of the body and using the right equipment it can be extracted, duplicated and "read" to determine what organism it contains instructions for.

We are going to extract DNA from a sample and "send it to the lab" to be analyzed to see if the organisms we have is really sustainable species the seller claims it to be!

While working in small groups, follow the teachers instructions and you'll all be guided through as a class.
Small groups of 2-3

1. Place the sample into a plastic sandwich bag. Squeeze out all of the air and seal tightly.
2. Mash the sample with your fingers until completely pulverized (about 2 minutes). In this step you are breaking down the cell walls and connective tissues, which increases the surface area.
3. Add 3 tablespoons of lysis buffer or extraction liquid. Push out all air and reseal bag.
4. Mix the sample and lysis buffer for 1 minute. The lysis buffer is breaking down the cell membranes and freeing the DNA.
5. Fold the coffee filter into a funnel shape and place in the paper cup. Carefully pour the liquid from the bag through the filter into the cup. This may take time, be patient. You can gently squeeze the filter to speed things up, but DO NOT RIP THE FILTER. Only pulp should remain in the filter. You are removing the solid material, the DNA should be in the solution in the cup.
6. Carefully pour the solution from the cup to the test tube.
7. Carefully pipette out about 5mL of cold rubbing alcohol at a time. Tilt the test tube to a 45 degree angle and slowly drip the alcohol down the side of the tube until it layers onto the sample solution. Do this until you have a layer of alcohol about 1 inch deep. DO NOT ALLOW THE TWO SOLUTIONS TO MIX.
8. Observe the solution. You should start to see a gooey clear/white stringy material form at the surface between the two layers. This is the DNA.
9. Use a skewer to twirl and pull out the sample. Place the sample in a microcentrifuge tube to "mail to the lab."

A process similar to this can be used to extract DNA and a machine called a PCR can be used to increase the amount of DNA extracted for testing. The DNA can be tested to identify specific gene markers present to determine what or who the DNA belongs to.

Using the worksheet, explain to the students that the "lab results" from a previous test are available. The samples were identified as being sold "Sustainable Red Abalone". You extracted

DNA and sent them to the lab and they ran them along with some other species the sample could possibly be.

Compare the results on your worksheet.

Which match your sample?

Is this what the sample was claimed to be?

Why do you think people might mislabel seafood?

According to the results on the worksheet, the food being sold was called “Sustainable Red Abalone” but was actually “Whelk.” Sometimes food is mislabeled in order to sell more food, or sell undesirable food labeled as a desirable product, or to sell endangered food that would otherwise not be allowed to sell.

Have the students discuss as a group:

What can be done to prevent this?

How can you be sure your seafood is actually sustainable?

Consumer pressure, regulation and people checking to food (either at random or checking suspicious or reported food, like we did in the example worksheet) can help prevent mislabeling. Individuals can help support sustainable seafood by buying from reputable sources, and using rating programs like Monterey Bay’s Seafood Watch or Aquarium of the Pacific’s Seafood for the Future.

Class 3: Animal Care and Larval Stages [Field Trip to Cabrillo Marine Aquarium]

Pre-Class Preparations:

- Aquatic Nursery: Prepare animal food for students, set up demonstration tank
- Classroom:
    - Set up compound and dissecting microscopes.
    - Prepare the slides.
    - Set up cryogenics equipment.
    - Start a sea urchin spawning.

Grouping: Whole class, small groups and individuals

Purpose:

- Students will observe an aquaculture lab
- Students will observe different lab raised animals and evaluate the different needs of different species
- Students will feed and interact with aquacultured and local marine animals
- Students will observe different animal life stages under a microscope
- Students will assess the different parts of an aquaculture system
- Students will participate in a spawning
- Students will learn the importance of cryogenics in aquaculture

Science Standards:
MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem

Materials:

- Activity 1: Animal feeding
    - Kelp for abalone
    - Mysid Shrimp for seahorses
    - Brine Shrimp for jellies and microscope
    - Rotifers for microscope
    - Pitchers
    - Feeding basters
    - Example tank set-up, can use kit from next class (tank, sump, drain, water pump, filter)
- Activity 2: Larval fish viewing
- Activity 3: Sea urchin spawning/cryogenics demonstration
    - 5-8 Purple sea urchins (*Strongylocentrotus purpuratus*)

        - 0.5M Potassium chloride solution (3.73g of KCl in 100mL of distilled water
        - Filtered seawater
        - Small syringes
        - Plastic pipettes
        - Petri dishes
        - 100mL glass beakers
        - 500mL glass beakers
        - 250mL glass beakers
        - Depression slides
        - Glass slides with coverslips
        - Slide putty
        - 10mL test tubes
        - Test tube racks
        - Worksheet 3A
        - Cryotank
        - Cryogenics gloves, goggles, and lab coats
        - Dry ice
    - Activity 4: Larval stage observation
        - Compound microscope
        - Dissection microscope
        - Samples of:
            - Fertilized sea urchin eggs (from urchin spawning in activity 3)
            - Larval fish
            - Eggs
            - Jellyfish ephyrae
            - Brine shrimp
            - Rotifers
            - Other specimens as available
        - Worksheet 3A
    - Activity 5: Life support tour
    - Activity 6: Touch tank
    - Activity 7: Free exploration in exhibit hall/tank parts scavenger hunt
        - Phones/tablets for taking pictures
        - Checklist (worksheet 3B)

Procedure:

Note: if this activity is not done at the aquarium watch the videos of animal feeding, compare larval stages with adult stages to comparing differing needs at life stages, cryogenics example and aquarium tank life support systems.

Rotation 1 (Aquatic nursery)- (time: 30 minutes)

Activity 1: Introduction to aquaculture in an aquarium - Location: Kitchen

- Students will learn how animals are grown in aquariums for exhibits, food, research and conservation.
- Students will be be introduced to the tank scavenger hunt and what to look for.
- Students will view a variety of animals and the tank requirements those animals have

Activity 2: Feeding animals and larval fish viewing - Location: Rotation Stations

- Students will feed abalone and view feedings of seahorses, sea jellies, and larval fish comparing the different care methods needed for different types of lab raised animals.
- Students can compare the live viewings to the close up preserved specimens seen in the classroom.

Rotation 2 (Classroom)- (time: 30 minutes)

Activity 3: Sea urchin spawning and cryogenics demonstration (time: 20 minutes)

- Students will observe and participate in a sea urchin spawning and observe the fertilized sea urchin eggs under microscopes.
- Students will learn about the role cryogenics plays in aquaculture by observing cryogenics equipment.
- Students will observe different life stages of animals under microscopes and hypothesize as to care needs for each stage.

Activity 4: Life stage observations (time: 10 minutes)

- Students will observe the larval stages or eggs of various marine animals under microscopes and can draw and/ or describe what they are seeing on worksheet 3A.
- They can also observe adult specimens and compare the different needs at different life stages. Students can compare these to the live animals seen in the Aquatic Nursery
- Make sure they label what they are drawing and/or describing.

Rotation 3 (Life support and Touch tank)- (time: 30 minutes)

Activity 5: Tour of life support systems (time: 20 minutes)

- Students will observe and make notes on various components of life support systems required to keep aquaculture animals alive at different stages.
- Water flow, physical filtration, chemical filtration, biological filtration, sumps, pumps
And different tank designs for different species: larval rearing tanks, raceway troughs, kriesels, standard tanks, etc

Activity 6: Touch tank (time: 10 minutes)

All together: Free exploration in exhibit hall/tank parts scavenger hunt (time: 30 minutes or remaining time)

Activity 7: Tank parts scavenger hunt

- Students will free explore the exhibit hall, focusing on the different tank requirements different organisms have. They can look for different tank components based on the overall introduction they saw in the Aquatic Nursery.
- Encourage students to take pictures with their phones or tablets, so they have something to reference while building their own system in the next class. They should also be encouraged allowed to look at tank design while in the classroom and aquatic nursery. Keep in mind the type of animals that live in each type of tank. *This should also be done throughout all rotations.

Class 4: Building an Aquaculture System

Pre-Class Preparations:

Activity 1:

- Place photos of Aquaculture farms up on the board
- Separate equipment out for each group
- Set up water tank in the front of the room

Optional Activity 2:

- Ensure tank kits have all pieces

Grouping: Small Groups

Purpose:

- Students will review aquaculture systems
- Students will engineer and test an open aquaculture system
- Students will build and test a closed aquaculture system
- Students will compare multiple systems

Science Standards:

MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Materials:

Per Class:

- Power Outlet
- Extension cord
- 10 gallon tank
- Water pump
- Water
- Floating beads
- Food dye

Per Group:

- Closed system:

        - Tank kit (Includes: bottom draining tank, sump, drain pipe, pipe cover, water pump, tubing, fitraltion [carbon filter, mesh filter or filter bag, bioballs], power cord)
    - Pen/Open System:
        - Paper
        - Pipettes
        - Rope
        - Plastic Netting
        - Tape
        - String
        - Paper clips
        - Scissors
        - Plastic bin
        - Other construction materials as available (ie straws, plastic utensils, paper cups, et al)

<u>Procedure:</u>

Activity 1: (time: 1.5 hours)

Small groups 4-5

Keeping in mind what constitutes successful and sustainable aquaculture from their past lessons, students will design their own pens or tanks for an open system. Pictures of previously viewed designs will be up for students to consult.

Design criteria include:

Students will be given 10-15 minutes to plan and sketch their design. They must describe:

- What species will be raised
- Approximately how many of that species will be held per pen they're designing
- What type of structure will be used
- Where this structure would best be placed (ocean, pond, river, etc)

Students will be given supplies and given 45 minutes to work on building a scale model of their design.

The last 30 minutes, students will bring their designs to the instructor to test and see if it meets the design criteria.

Students can present their design to the class if time allows

Optional Activity 2: (time: 30 mintues or if time allows)

Using their photos, scavenger hunt list and memory of the tanks in the aquatic nursery, students will help guide the instructor through drawing a diagram of a closed aquaculture system on the board.

Students will highlight what fish need to survive: food, oxygen, water flow; and what the tank needs to be successful. Discuss how this differs from open systems like the ones they designed earlier.

If time allows, students will use their diagram to help them assemble a tank kit, with all of the working parts of a closed system.

Class 5: Aquaculture System maintenance [Water Quality]

Pre-Class Preparations:

- Activity 1:Prepare water samples according to directions below. Put each in a separate container labeled “A”, “B”, “C” and “D”. Each batch should contain enough water for all groups to test (at least 1 cup of each sample per group).
    - Sample A: Fresh water
    - Sample B: Clean Ocean water or aquarium salt water
    - Sample C: Dirty ocean/aquarium tank water or salt water with added fish waste or ammonia
    - Sample D: Clean ocean/aquarium salt water with added vinegar

Grouping: Whole Class, small groups

Purpose:

- Students will test the water quality of several different samples
- Students will evaluate and assess the needs of ongoing system
- Students will learn about the variety of aquaculture jobs available
- Students will assess their knowledge and attitudes of aquaculture

Science Standards:
MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Materials:

- Activity 1:

Per group

- Refractometer
- 4 cups
- Pipette
- Water quality pH kit, like API Saltwater pH Test Kit or Master Test Kit
- Water quality ammonia kit or Nitrate Kit, like API Saltwater Ammonia test kit or Master Test Kit
- 4 Water samples
- Worksheet 5A

- Activity 2:
    - Videos listed in procedures

Procedure:
Activity 1: Water quality testing (time: 1.5 hours)
Introduction:
Maintaining a healthy environment is very important for the animals you are raising. It is important to test their water daily to ensure that the conditions are suitable for them. As we discussed in the last class, ammonia is a product from animal waste. Having too much of it in the water can be make the animals sick. The pH, or acidity of the water, will affect how well the fish can survive in the water, and the salinity is important to their health too. Your group will be given samples of water from several different pens at your aquaculture facility. Your groups job is to test each of the samples and evaluate the health of each of the tanks. Be sure to note if any actions need to be taken to improve the conditions in a particular pen.

Write the “Healthy” or “Acceptable” conditions on the board and go over these natural parameters for an ocean water system. Note that these are specific to marine animals and these parameters will differ if freshwater fish are being grown in a facility.

Salinity: 32 to 35ppt, pH: 7 to 8.2, Ammonia: 0 to 0.5 mg/L

Demonstrate how to use all of the equipment first. Then groups can complete the following tests on each of their 3 water samples.

Salinity Testing
1. Using a pipette, take 1mL of your sample water.
2. Slowly drop your sample water onto the slide until the slide is covered.
3. Close the lid on the slide.
4. Hold the refractometer up to the light and look through it.
5. Record the level of salinity in ppt of your sample.
6. Does this salinity fall within acceptable limits?
7.

pH testing
1. Fill a clean test tube with 5 mL of your sample water.
2. Add 8 drops of solution #1, holding the dropper bottle upside down in a completely vertical position to assure uniform drop.
3. Add 8 drops from solution #2 using the same method as in step 2.
4. Cap the test tube and shake vigorously for five seconds.
5. Wait 5 minutes for color to develop.

6. Compare color of sample to color key to identify ammonia/ammonium concentration. (NOTE: there is a different key for salt water than freshwater – make sure you use the appropriate key).
7. Record the pH of your sample. Does this fall within healthy limits?

Ammonia Testing

8. Fill a clean test tube with 5 mL of your sample water.
9. Add 8 drops of solution #1, holding the dropper bottle upside down in a completely vertical position to assure uniform drop.
10. Add 8 drops from solution #2 using the same method as in step 2.
11. Cap the test tube and shake vigorously for five seconds.
12. Wait 5 minutes for color to develop.
13. Compare color of sample to color key to identify ammonia/ammonium concentration. (NOTE: there is a different key for salt water than freshwater – make sure you use the appropriate key).
14. Record what the ammonia concentration is. Does this fall within healthy limits?

OR Nitrate Procedure:

1. Fill a clean test tube with 5 mL of your sample water.
2. Add 10 drops of nitrate test solution #1, holding the dropper bottle upside down in a completely vertical position to assure uniform drop.
3. Cap the test tube and invert tube several times to mix solution.
4. Vigorously shake the Nitrate Test Solution Bottle #2 for at least 30 seconds *This step is extremely important to insure accuracy of test results.
5. Add 10 drops from Nitrate Test Solution Bottle #2, using the same method as in step 2.
6. Cap the test tube and shake vigorously for one minute. *This step is extremely important to insure accuracy of test results.
7. Wait 5 minutes for color to develop.
8. Compare color of sample to nitrate color key to identify nitrate concentration (NOTE: there is a different key for salt water than freshwater – make sure you use the appropriate key).
9. Record the Nitrate concentration. Does this fall within healthy limits?

After groups have tested all water samples, go over the results as a class.
What adjustments will need to be made to each tank to ensure the fish have healthy living conditions?

Tank A: Salinity was too low, increase salinity by adding sea salt mixture or new water

Tank B: Fall within acceptable parameters, maintain current conditions

Tank C: Ammonia (or Nitrate) levels are too high, clean tank or do a water change to remove waste

Tank D: pH is too low, clean tank with a water change and add buffer to mantain pH

Activity 2:
Video of Aquaculture Jobs

Example: https://www.youtube.com/watch?v=RUgjvXneWSk
And Alta Sea Video to introduce Catalina Sea Ranch: https://altasea.org/videos/
Catalina Sea Ranch Videos:
https://www.youtube.com/watch?v=ba6UGDa2irY
https://www.youtube.com/watch?v=0zNoIZI-wmE
https://www.youtube.com/watch?v=LQCfbxrCBoc
https://www.youtube.com/watch?v=KE8mKB4c5oA
https://www.youtube.com/watch?v=nbBfBmpGSY0
https://www.youtube.com/watch?v=VITsPX7ZE60

After watching the videos, ask the students as a group which jobs they saw. Write a list on the board. Add in additional jobs that are present in the aquaculture field or additional aquaculture jobs the students brainstorm.

We are going to get a chance to meet people that work in this field at Catalina Sea Ranch next week. Break into small groups and have each group brainstorm 3 questions they would want to ask people who work in aquaculture.

Come back together as a class and have each group share their questions. Filter questions and help the students word them clearly for interviews next week. Write up a list of “suggested questions” and “staff to look for” that students can use during the field trip.

<u>Class 6:</u> Jobs in aquaculture/Wrap-up [Field Trip to Catalina Sea Ranch]

<u>Pre-Lab Preparations:</u>

- Activity 1: Havel long line available (or 600m rope)
- Activity 2: Prepare worksheet questions
- Activity 3: Select game show prizes

<u>Grouping:</u> Whole Class, small groups

<u>Purpose:</u>

- Students will interview different workers at an aquaculture farm
- Students will learn more about current jobs in aquaculture
- Students will tour an active aquaculture facility
- Students will get a sense of scale for current aquaculture projects

<u>Materials:</u>

- Activity 1:
  - Worksheet
  - De-commissioned long line
- Activity 2:
  - Catalina Sea Ranch Staff (minimum 3-4)
  - Worksheet
- Activity 3:
  - Large poster paper
  - Markers
  - Prizes
  - List of questions
- Actiity 4:
  - One or two pieces of large poster paper
  - Post-it Notes
  - Markers/pens

<u>Procedure:</u>

Activity 1: Introduction and longline (time: 30 minutes)

Receive welcome and tour from Catalina Sea Ranch staff. On the tour, connect what students learned about DNA, tanks and water systems, cryogenics, etc to the locations at CSR.

Raising organisms can be done in the tanks, or out in the ocean like we saw in example farms. CSR has many long lines out in the ocean.
Ask the students how long the long lines really are. To get a sense of scale, use a broken or out of commission long line to unfurl. Take the students and rope to one end of the warehouse or outside where there is a lot of space. Have a few students grab the end of the rope and instruct them to (safely) begin walking. Stop when they reach the end of the warehouse. Students will be able to get a sense of length (600ft). Allow students to touch the rope and explore the length and special texture used for bivalve attachment. Describe how a typical farm is 4 to 17 long lines, usually about 120m long, suspended from buoys and marked with special buoys.

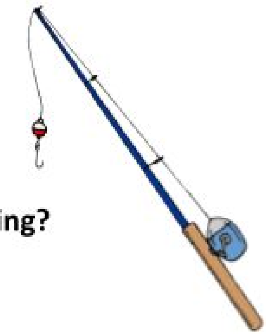
Activity 2: Job interviews (time: 1 hour)
In small groups, students will rotate to different areas at Catalina Sea Ranch to speak to various staff members. Students will ask the staff questions from their pre-made list (worksheet 6A) as well as their own questions to learn more about prospective jobs.

Activity 3: Game show (20 minutes)
Split the class into two teams. Flip a coin to determine which team will go first. Ask the team going first the first question from the list. Give the team 30 seconds talk about what the answer is. If they answer it right, they get the point. If they answer wrong, the other team has 30 seconds to talk it over and answer the question and earn the point. The team to get the most amount of points gets the first pick of prizes.

Activity 4: Review Word Cloud (10 minutes)
Following the activity in the first class, students can work as a group to brainstorm their ideas on the post-it notes and come up to one of the poster boards and add their ideas about what they think aquaculture is.Then as a class, talk about some of the words that stand out the most. Compare their responses with the word cloud generated after the first class to show the students how much they've learned.

Appendix A: Worksheets

Worksheet 1A



Goin' Fishing?

Directions:

1. Your teacher will assign you a group letter, write that on page 2 of this handout.

2. On your tray, scatter 20 M&M's for group B and 50 M&M's for group A. DO NOT EAT M&M's until all rounds have been completed.

3. When your teacher says "start", you have 15 seconds to collect as many M&M's you can with only the tweezers. DO NOT USE YOUR HANDS. Place collected M&M's into the paper cup. Keep collecting until teacher says "stop".

4. Record how many M&M's you collected and how much money you earned. 1 M&M's is $100. If you earned $500, you may continue to the next round. If you did not, you did not earn enough money to go fishing and must sit out the next round.

5. Count and record how many M&M's remain.

6. Group A: for every one M&M remaining, add one M&M to the tray from your replacement pot until the pot is empty. Group B: Add 20 M&M's to the tray.

7. Repeat steps 1-6 for the remaining 4 rounds. Your teacher will continue to call out the start and stop of each round

8. After finishing all 5 rounds, total the amount you earned and the amount your entire group earned.

9. Eat your M&Ms and enjoy!

Worksheet 1A

Goin' Fishing?

Group ______	Round 1	Round 2	Round 3	Round 4	Round 5
Starting amount					
Amount collected in this round					
Remaining amount					
Amount added					
Money earned*					

Total Money Earned: You _______ Your Whole Group ________

*1 M&M= $100

1. What happened in to the number of M&Ms in Group A? Group B?

2. Which group had the most M&M's and money after the first round?

3. Which group had the most M&M's and money after 5 rounds?

4. What do you think would happen if we played for 5 more rounds? 100 more rounds?

5. What do the two different groups represent?

Worksheet 2A

Aquaculture Case Studies

In a group, assess each of the aquaculture farms in the case studies given to you. For each case study write at least one pro and one con of this farm.

	Pro: What is good about this farm? What makes it sustainable?	Con: What is bad about this farm? What makes it unsustainable?
#1		
#2		
#3		
#4		
#5		
#6		

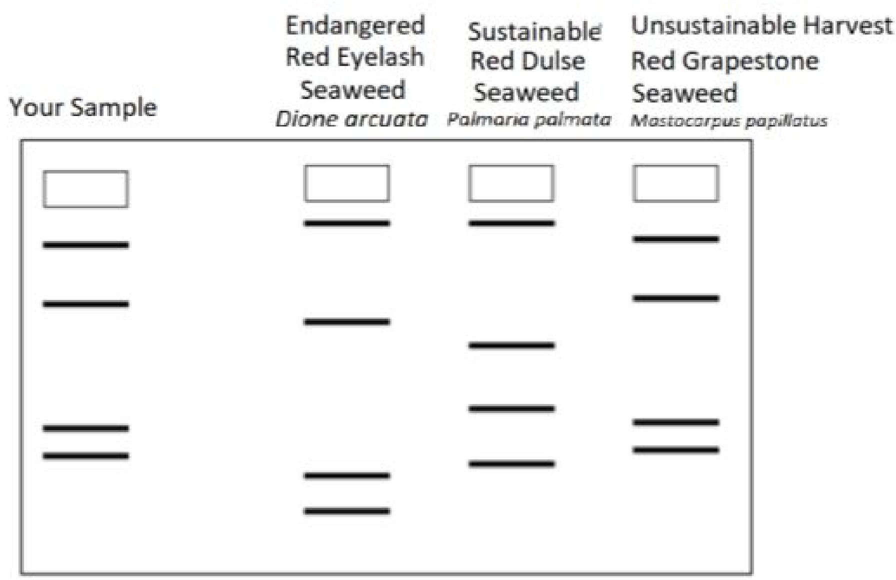
Using the case studies as examples of what to do and what not to do, design your own aquaculture farm. What will you raise, how will you raise it and why? In a **short,** descriptive paragraph describe your group's sustainable aquaculture farm.

Worksheet 2B

Sustainable Seafood Genomics

You collected a DNA sample from a batch of seaweed that was being sold as "sustainable red algae" and sent it off to the lab to see if it is really what it's being sold as. The lab sends you back the DNA profile below.

Compare the DNA sample you collected with the profiles of of organisms the seafood could possibly be. What species is your sample actually from?



Why might companies mislabeled food, calling it something things not?

What can you do to ensure the seafood you eat comes from a sustainable source?

Worksheet 3A

Animal Life Stage Observations

Observe different animals' life stages, from larva to adult, underneath the microscopes. Draw and/or describe what you see. Be sure to label what you are observing. How do their needs in each life stage differ?

Worksheet 3B

Aquaculture Tank Scavenger Hunt

On your field trip through the Aquarium, look for the following items that are necessary for raising sea animals. Draw the items or take a picture with your phone. Note: You may see many different versions of these items! We'll piece the items together into a diagram of a functioning tank, just like the ones you saw.

- Rectangular Tank
- Trough or Raceway Tank
- Circular Tank
- Water pipe (inflow)
- Water pipe (transport)
- Water drain (outflow)
- Sump (water holding)
- Water pump
- Biological Filter
- Physical Filter
- Chemical FIlter
- Rocks
- Plants or Fake Plants
- Animals

Worksheet 4A

Aquaculture Farm Design

Using what you've learned about sustainable aquaculture over the past several weeks, you and your group will design a sustainable aquaculture enclosure.

Will you design an "open" or "closed" system?

What specie(s) will you raise? How will this impact your design?

Will your enclosure be placed in the ocean? River? Pond? Tank?

How will you keep your enclosures clean and fed?

What other things will you need to consider?

Draw a sketch of your design below. When you are ready, get the parts you need from your insructor and begin building. At the end of the class you will get to test your enclosure in the water! Good luck!

Worksheet 5A

Water Quality Testing

Complete the following chart for each sample of water you test. Use the thermometer to measure temperature in degrees Celsius, refractometer to measure salinity in parts per thousand, and test kit to measure pH and ammonia.

	Describe how the sample looks	Temperature (°C)	pH	Salinity (ppt)	Ammonia	Where do you think this sample was taken from?
Sample 1						
Sample 2						
Sample 3						

Which sample of water would be a healthy condition for a <u>marine</u> aquaculture species? ____

For the other samples, what could be done to make them healthier?

Worksheet 5B

Jobs in Aquaculture

What jobs did you see in the video that interest you? List at least 3, but feel free to list more if you'd like.

What would you like to learn about these jobs? Or what would you want to ask people that work in these jobs? Try to come up with at least 3 questions.

1.

2.

3.

4.

5.

Worksheet 6A

Jobs in Aquaculture

Find at least 3 people to interview about their jobs. You can use the questions we brainstormed last class or add a few of your own! Take notes and we'll share what we've learned as a group.

- What is your job title and responsibilities?
- How did you get involved in this job?
- What are your favorite parts and least favorite parts of this job?
- What kind of schooling and training was required?
- How much does a job like this pay?
- What is your advice for someone looking to do something similar?

Interview 1
Name: Job:
Notes:

Interview 2

Name: Job:

Notes:

Interview 3

Name: Job:

Notes:

Appendix B: Class 2 Sustainability Case Studies

Case #1: An open ocean mussel farm in Southern California

- Mussels grow on ropes that hang from rafts 7 miles offshore.
- Mussels are filter feeders, filtering plankton from the water to eat, as well as filtering out pollutants in the ocean. Farmers do not need to buy food for the mussels because they get it naturally from the ocean.
- The ropes can create a habitat, becoming a home for other organisms such as barnacles, sponges, and algae.
- Mussels produce thousands of offspring per year and grow relatively fast.

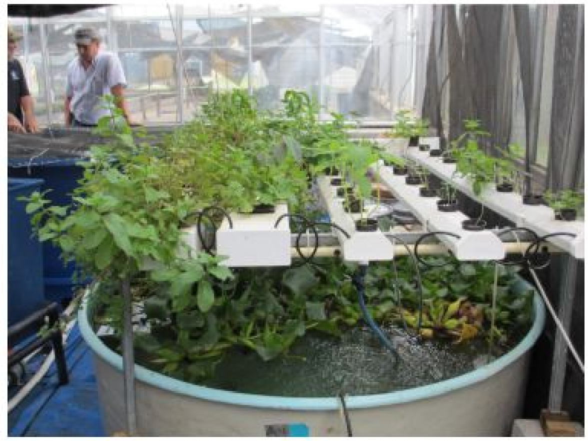
 

Case #2: An enclosed open ocean Atlantic salmon pen in Scotland

- Salmon are enclosed in a pen that sits in the ocean
- Salmon are fed food pellets that are made of other ground up fish species and vitamins. The salmon farmers buy the pellets from a different part of Europe.
- This farm is a monoculture, meaning there is only one species grown.
- Since it is a monoculture, there are no detritovores to clean up the fish waste. The fish swim in their own waste and sometimes it flows out of the pen and into the environment.
- There is little genetic variation amongst the salmon (they all have similar DNA), so one disease could kill all the fish.
- Those diseases from the farmed fish could spread to the wild fish.

Case #3: A coastal seaweed farm in Japan

- Seaweed grows from ropes that are suspended in the ocean, close to shore.
- Seedlings are transplanted onto the ropes and grow relatively quickly after that.
- A large, open space is required for seaweed farming. Farmers had to cut down a mangrove forest to make room for the farm.
- The growing seaweed creates a habitat for smaller animals to live.
- Just like plants on land, seaweed gets its energy from the sun. Farmers do not have to buy food or feed the seaweed.
- The process of photosynthesis, which is how seaweed gets its energy from the sun, creates oxygen.



Case #4: An aquaponics system in your own backyard

- A tank of tilapia fish sit underneath a tray that has lettuce growing in it. You are growing more than one species, which is a polyculture or integrated farm.
- The tilapia produce waste that is pumped up, along with water, into the lettuce tray, fertilizing the lettuce.
- Lettuce gets its energy from the sun, via photosynthesis. You do not have to provide any additional food.
- You must purchase fish food to feed the tilapia, but it is inexpensive.
- Small scale aquaponics systems take up very little room and can go in your backyard, classroom, or house. You just need a light source.

Case #5: Man-made trout ponds in Washington State

- Trout live in man made ponds lined with plants that grow naturally in the area
- The water from the ponds is treated thoroughly to remove waste and pollutants before leaving the ponds
- The trout are fed responsibly sourced feed ingredients with no antibiotics or hormones
- Fish are regularly checked by a veterinarian to ensure their health

Case #6 Shrimp ponds in Thailand

- Valuable mangrove forest land, that protects coastlines and sustains young sealife, is clear-cut to make room for shrimp pens
- This species of shrimp is not native to this part of Thailand. If some escape, they could outcompete native species in the area and become an invasive species.
- Shrimp are densely packed into pens and when the water in an area becomes too polluted for life, then pens are moved to a new area, leaving the waste behind
- Shrimp are treated with antibiotics, hormones and pesticides to ensure they survive in the cramped, polluted conditions
- Batches of shrimp are regularly rejected for sale at market due to salmonella and other contamination

Appendix C: Pre/Post Assessment Questions and Gameshow Questions

Pre/Post Assessment Questions:

Answer the following questions to the best of your abilities.

1. Do you eat seafood? If so, how often?
2. Where do you and/or your family get seafood (i.e. grocery store, restaurant, fishing)? What kind of fish do you eat?
3. What is Aquaculture?
4. Name 3 different jobs in the fishery industry.
5. What does “sustainable” mean?

Possible Gameshow Questions:
-What is aquaculture?
-Name two reasons why people do aquaculture
-Name two aquaculture species
-What does “sustainable” mean?
-From our first class, which method was more sustainable in the long term: fishing or aquaculture?
- In our second class, we looked at actual aquaculture farms. What was one practice you learned about that was sustainable?
- In our second class, we looked at actual aquaculture farms. What was one practice you learned about that was NOT sustainable?
- Name a species that is farmed using aquaculture.
-Other than raising animals for food, what else is one thing aquaculture used for?
- What is a monoculture?
- What is a polyculture?
- What is DNA?
- Why might someone try to sell seafood as “sustainable” even if it’s not?
- What is something you can do to support sustainable seafood?
- Name one animal grown at Cabrillo Marine Aquarium.
- What is an “ephyra”?
-Name the fish that we hatched at the Aquarium.
-Why does the fish you hatched at the aquarium lay its eggs out of the water?
-What shape is the tank that jellyfish have to live in? Extra points if they know the name of the tank.
-Name the snail that you fed at the aquarium.
-How did the seahorses you fed at the Aquarium eat?
-Name one part of life support for a tank.
-In which type of system (open or closed) involves a pen that is exposed to the ocean?

-What is one benefit to an open system (having the pen exposed to the ocean)?
-What is a “closed” system?
-What is “cryogenics”?
- What is “ammonia”?
-Where does the ammonia in the water come from?
- How do we measure salinity?
- What is “pH”?
- What can you do for a tank if the ammonia is too high?
- Name two jobs in aquaculture.
-What is farmed at the Catalina Sea Ranch?
-What do the animals grown at Catalina Sea Ranch live on?