

Introduction to Scallop Aquaculture

Part 1



Educator Guide

Written and distributed by Hurricane Island Center for Science and Leadership

Table of Contents

[Aquaculture Timeline](#)

[Tides](#)

[Plankton 101](#)

[Extension: Build a Plankton](#)

[Go Farm Card Game](#)

[Extension: Complete a mock Application](#)

[Scallop Anatomy](#)

Aquaculture Timeline

Essential questions:

- What is aquaculture?
- How long has aquaculture existed? Who utilizes aquaculture?
- Is aquaculture an important global food system?

Objectives:

- Students will understand that aquaculture (AQ) has existed for millennia across various cultures and that aquaculture technology continues to evolve.
- Students will be able to list different species of organisms which are commercially grown in aquaculture.

Duration: 30 minutes

Subjects: History

Materials: [Aquaculture Timeline Materials](#) (print and cut ahead of time)

Background info: AQ has been practiced for millennia, primarily for food (mostly protein), but now the majority is for other uses: fertilizer, animal (terrestrial + aquatic), feed, food additives, industrial chemicals, pharmaceuticals, cosmetics, fuels, and pets

- Humans commonly populated the world by choosing locations with fresh/saltwater access for aquatic food
- Global context of Aquaculture
 - AQ provides about 1/6 of of the world's consumed protein (mariculture provides about 1/2 of this 1/6); wild-capture fisheries another 1/6; the remaining 2/3 from agriculture
 - Most world AQ is:
 - Land-based fresh water (mostly human-made inland ponds)
 - Fish (54m tons total in 2020: mostly carp, then tilapia)
 - ...vs. 60m tons from wild-capture fisheries
 - ...vs. 600m tons from agriculture
 - In Asia (China produces 60% of global AQ; also India, Indonesia, Vietnam, Bangladesh, Myanmar). Also Egypt, Chile, Norway, Scotland
- But the US (and Maine) are relatively late to diversely scaled AQ production

- US AQ is low volume (16 of top 20 global producers)
- US AQ is limited species (catfish, shrimp, other freshwater species; shellfish, seaweed; salmon)
- US AQ imports 85% of its seafood
- Maine has access to the biologically rich Gulf of Maine (nutrients and flushing from numerous rivers, Gulf Stream, and Bay Fundy) and a particular seafood/aquaculture brand: “cold, clear waters of the Gulf of Maine”

Activity:

- Lay out years in chronological order to create a physical timeline.
- Have students work together to put events next to what they believe is the corresponding year.
 - Throughout the process encourage discussion about what species can be cultured, why they are cultured, and aquaculture technology. What similarities do aquaculture and agriculture have?
- Review the aquaculture timeline, starting from the earliest date. Pull out incorrect answers (many connections will be incorrect). Continue pulling out incorrect AQ events until you are half-way through the timeline, then allow the group to reassess and move around events to new connection points.
- Review the timeline again, connecting all events to the corresponding point in time.
- Closing discussion
 - Which country has shown the greatest (landings and/or value) recent growth with aquaculture? Who has been doing it the longest? Any thoughts why that is?
 - What is the role of aquaculture in meeting global seafood demand? Is it likely to keep up with a growing population? What might need to change?
 - What event surprised you the most to learn when it occurred?
 - How have general aquaculture practices changed over time due to pressures of market and environmental regulation?

- What environmental regulations would the students impose on the industry? To what extent do you think there needs to be any changes to regulations and what might that look like?
- What might this industry look like in 2050 or 2100? What would you want to see happen?

1600s

3500 BCE

Early 1800s

Mid 1800s

1930s

Late 1800s

1960s

1970s

1990s

Early 2000s



Maine's first fish hatchery, the Craig Brook Fish Hatchery was founded.



Maine began their first finfish grow-out efforts



Maine begins commercial seaweed
aquaculture



Cooke Aquaculture purchases all of the
commercial salmon operations in Maine.



First aquaculture lease granted in Maine



First outbreak of sea lice in Maine



Cultivation of carp begins in China using
freshwater ponds and rice paddies



The French place strings of tiles in the water for
oyster larvae to settle on and then transplant
them to protected beds



Seaweed farming begins in Japan



An Ohio trout farm is the first in the US to
artificially fertilize its fish eggs

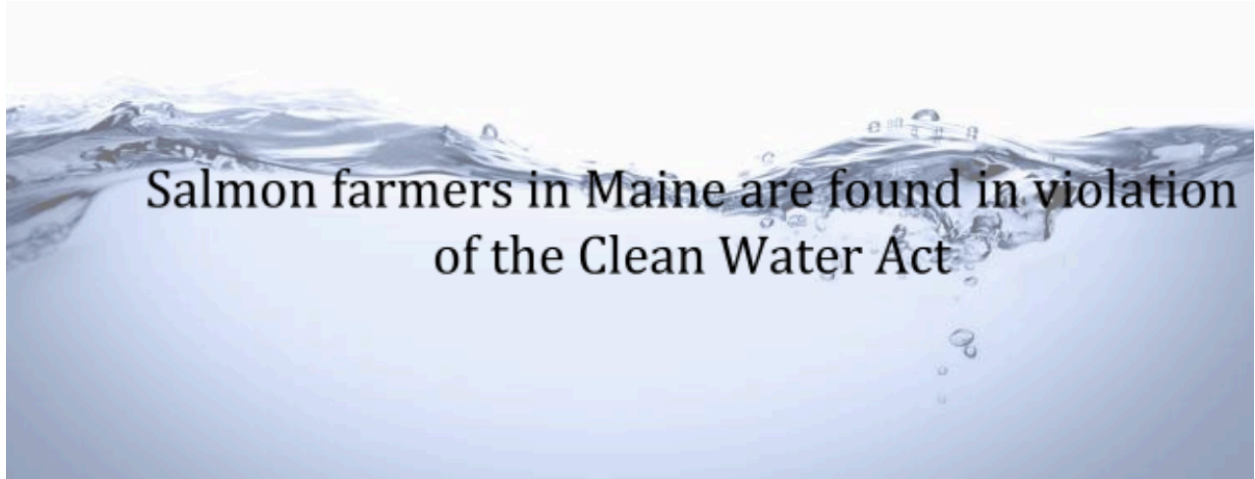
Salmon



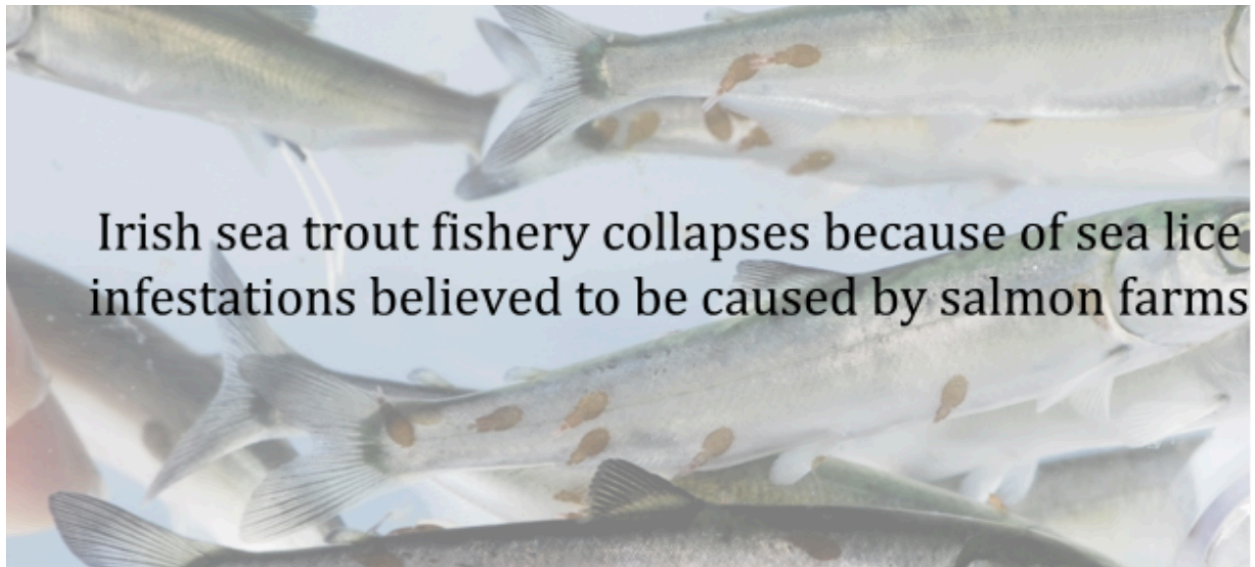
First commercial salmon farms are established
in Norway and Scotland



Raft culture of scallops developed in Japan



Salmon farmers in Maine are found in violation
of the Clean Water Act



Irish sea trout fishery collapses because of sea lice
infestations believed to be caused by salmon farms



Experiments in lobster aquaculture begin in New England

Answer Key

3500 BC

Cultivation of carp begins in China using freshwater ponds and rice paddies.

1600s

Seaweed farming begins in Japan.

Early 1800s

Oyster farming is further developed by the French by placing strings of tiles in water for oyster larvae to settle on and then transplanting the larvae to protected beds.

1853

An Ohio trout farm becomes the first in the U.S. to artificially fertilize its fish eggs.

1871

Maine's first fish hatchery, the Craig Brook Fish Hatchery was founded. Craig Brook National Fish Hatchery has a long history, beginning in 1871 when Charles Grandison Atkins began fish culturing operations in an old mill at the mouth of Craig Brook, on the shore of Alamoosook Lake.

1880s

Aquaculturists experiment with lobster and winter flounder aquaculture in New England.

1934

Raft culture of scallop developed in Japan.

Late 1960s

First commercial salmon farms are established in Norway and Scotland.

1970

Maine began their first finfish grow-out efforts by Maine Salmon Farms, Wiscasset.

1975

First aquaculture lease granted in Maine to Abandoned Farm, Inc., Clark's Cove, South Bristol.

Early 1990s

The Irish sea trout fishery collapses because of sea lice infestations believed to be caused by salmon farms.

1994

Maine begins commercial seaweed aquaculture.

First outbreak of sea lice in Maine

2003

Salmon farmers in Maine are found in violation of the Clean Water Act and ordered to fallow their sites for two to three years and cease the use of European strains of fish at their farms. Commercially farmed cod available in the US for the first time.

2004

Cooke Aquaculture purchases all of the commercial salmon operations in Maine. These purchases leave Cooke Aquaculture as the sole commercial salmon grower in Maine.

Additional resources:

Maine Aquaculture Innovation Center: [Recent Timeline of Aquaculture in Maine](#)

Food and Agriculture Organization of the United Nations: [2018 State of the World's Fisheries and Aquaculture](#)

Alabama Cooperative Extension Service: [Timeline of U.S. and World Aquaculture List](#)

Tides

Essential questions:

- What controls the tides?
- How does tidal heights fluctuate in the Gulf of Maine? What causes these changes?
- Why are tides important?

Overview: The gravitational forces of the moon, Earth, and sun all pull on the water on Earth to form tidal bulges. In coastal areas of the Gulf of Maine, we experience semidiurnal tides (twice daily high and low tides) that vary in time and extremity based on the phase of the moon (alignment of the moon, Earth, and sun). On average the tidal variation in the Gulf of Maine is between 9 and 11 feet. These extreme tides are constantly moving nutrients around this ecosystem, which allows for a very productive marine environment.

Understanding the tides is a crucial part of working within fisheries and aquaculture. You must consider tidal variation when choosing an aquaculture site, selecting gear types, deploying gear, etc. High tidal variance, like that of the Gulf of Maine, has many implications to the gear that is used and how it is set up. For example, you might want gear suspended in the water column, but at low tide it could be sitting on the sea floor. While the extreme tides may make some aspects of aquaculture difficult, it is also essential for cycling nutrients and plankton throughout the Gulf of Maine, which in turn provides a healthy supply of food for aquaculture species.

Objectives:

- Students will explain how the forces of the moon, sun, and earth interact with each other causing the tides to rise and fall each day, vary throughout the month, and why some tides are stronger than others.

Duration: 60 minutes

Subjects: Physics, Earth Science, Chemistry, Math

Materials:

- Globe
- Tide data sheets
- Tide tracking charts
- Moon phase charts

- Pencils
- Rulers

Background info: The Earth, moon, and sun all have their own gravitational forces which affect the tides. These gravitational forces fluctuate depending on their positions to one another. One complete lunar cycle takes approximately 29.5 days to be completed, which includes one full and one new moon. A full moon is observed when the Earth is directly between the sun and moon, and a new moon is observed when the moon is directly between the sun and Earth. The occurrence of these two moon phases creates the greatest gravitational pull on Earth's tides.

Activity:

These two activities (Exploring tidal patterns & Gravity model) are meant to be done back to back

EXPLORING TIDAL PATTERNS

- Instruct students to find a partner to work with
- Provide each student pair with one week of tide data from Hurricane Island (or location of your choice)
 - Each pair should have a **different** week of tide data, with all weeks provided spanning a consecutive time span (ex. Sept-October 2023).
- Discuss what they notice about the data and best methods for plotting data
 - *Are these charts easy to read?*
 - *How can we display this data in a way that is easier to digest?*
- Hand out the blank tide charts for plotting
- Instruct students to work in pairs to plot the tide data onto the charts. Once all data points have been plotted, connect the dots.
- Line up all of the student's finished tide charts in chronological order
 - *What patterns do you notice?*
 - *How many high/low tides are there per day?*
 - *When during the month are the tides the most extreme? (highest highs, lowest lows)*
 - *When during the month are the tides the least extreme?*
- Now, provide the students with corresponding moon phase data
 - *How does the moon phase align with the patterns you noticed in the tide charts?*
- Instruct the students to discuss what might cause extreme tides to align with full and new moons

- Really emphasize how much water is being moved in and out of coastal areas every day, twice a day! That is a LOT of water!
 - *Why is this tidal flushing so important? What does this do for nutrient cycling?*

GRAVITY MODEL

- Bring your students outside or to a big, open room.
- Assign one person to represent the Earth. This person's nose represents where we are on Earth.
- Ask 4-6 students to represent the ocean and hold hands in a circle around the Earth. Without a moon, the ocean should be equally distributed around the Earth.
- Assign another student to represent the moon. The addition of the moon to this system will cause our ocean to move due to the moon's gravitational pull.
- The part of the "ocean" closest to the moon takes 2 steps toward the moon (Ocean students are still holding hands!) - *This represents the gravitational force of the moon pulling the water on earth - high tide!* The oceans on the side of this high tide bulge need to adjust, moving closer to the Earth – *low tide!*
- Due to inertia, there is a high tide bulge on the side of Earth opposite the moon as well. The ocean should have two high tide bulges on opposite sides of "Earth" and in line with the "moon" (see image below)
- Instruct the students representing the ocean to show the tide so that the high tide bulge closest to the moon is slightly larger (less extreme high tide is the bulge cause by inertia)
 - *What is the tide where we are (on the "Earth's" nose)?*
 - *What is missing from this model? The sun!*
- Add one student to represent the sun. Ask them to stand in a line with the Earth and moon.
- Explain that the sun also has a slight gravitational pull, but it is less than the moon because it is further away.
 - *How should the ocean closest to the sun move?*
- The ocean closest to the sun should take one step towards the sun
- Have the students determine the time of day and tide on the "Earth's" nose
 - Repeat this, having the earth turn slowly and pausing every 90°
- Reinforce that in 24 hours (the Earth rotating once) there are two high tides and two low tides

- Ask how this model would change throughout the month? Ask the moon to revolve around the Earth, pausing every 90° so the students can determine the moon phase. The ocean should adjust accordingly.
- Ask what time high tide is? The Earth should rotate to face the tidal bulge to determine the time of day (focus on relation to the sun)
 - During new and full moons high tides will be around noon and midnight
- Introduce spring tides and neap tides to the students.
 - Spring tide – highest highs, lowest lows – largest tidal height difference between high and low
 - Neap tide – lowest highs, highest lows - smallest tidal height difference between high and low
- Ask students in the model to demonstrate a spring tide and then a neap tide

WRAP UP

What controls the tides?

What causes changes in the strength of the tides?

Why are tides important?

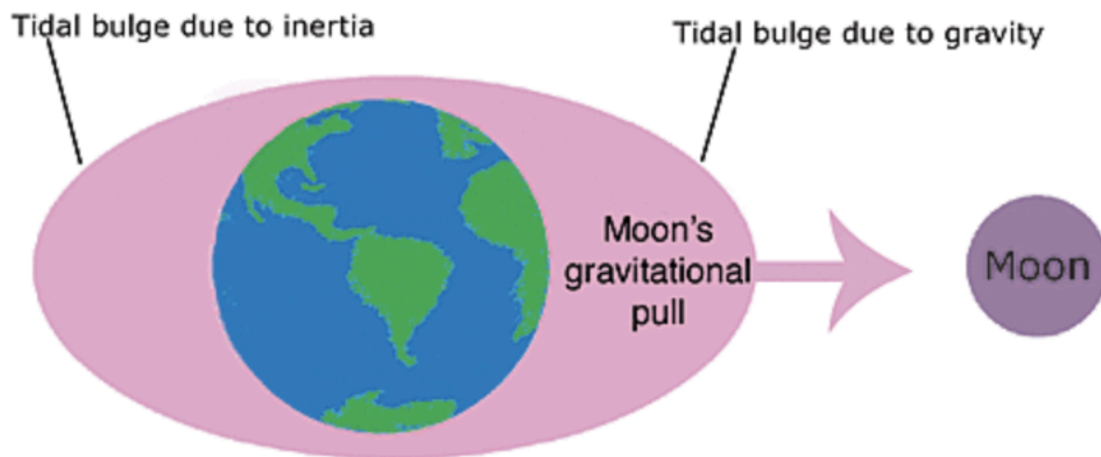
Why is it important to track the tides?

What can or should we do to prepare for increased tidal impact for the future?

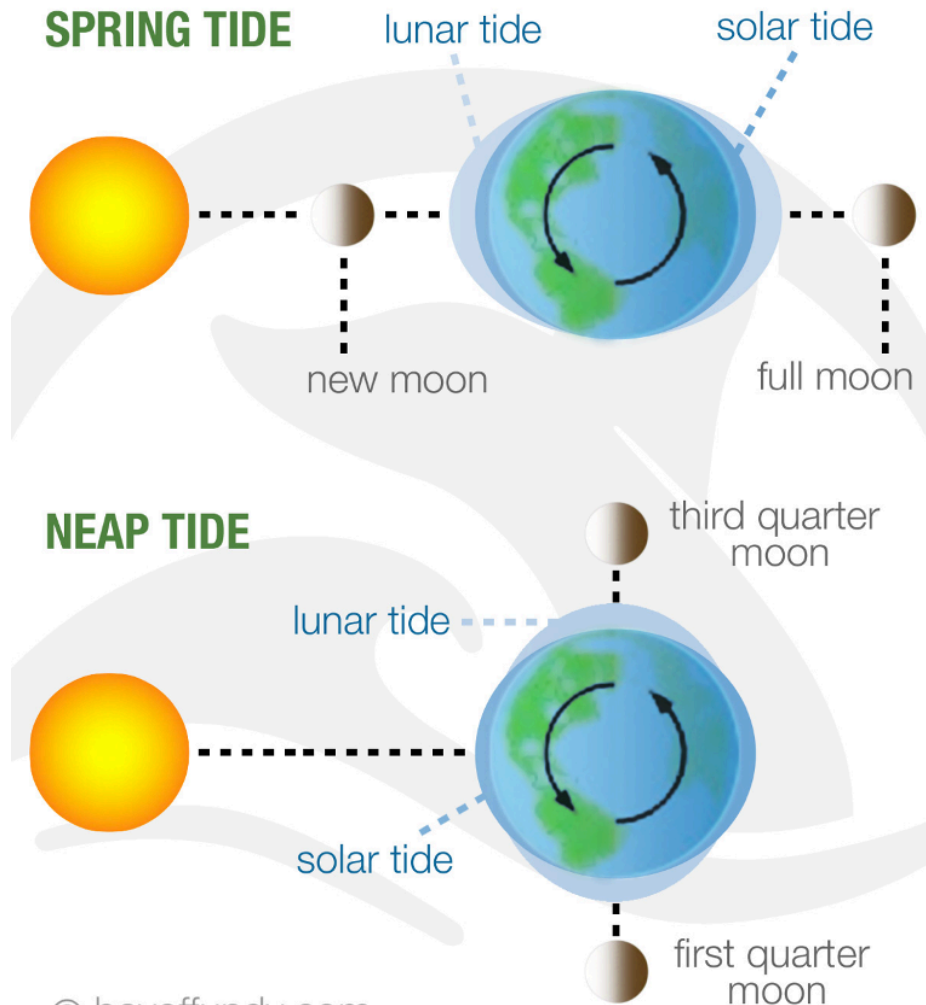
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Feet		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High		
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NAME _____

Additional resources:



Gravity and inertia act in opposition on the Earth's oceans, creating tidal bulges on opposite sides of the planet. On the "near" side of the Earth (the side facing the moon), the gravitational force of the moon pulls the ocean's waters toward it, creating one bulge. On the far side of the Earth, inertia dominates, creating a second bulge. **From** <https://oceanservice.noaa.gov/>



Plankton 101

Essential questions:

- What is plankton?
- Why are plankton important?
- How do we define the different types of plankton?

Overview: Understanding plankton is essential to understanding the marine ecosystem. Plankton are ocean drifters which make up the bottom of the food web. There are two main groups of plankton; phytoplankton (micro-algae) and zooplankton (animals). These two types of plankton can be broken down into many sub-categories which define their life cycles, shape, toxicity, etc.

Phytoplankton are primary producers undergoing photosynthesis. Some species of phytoplankton are toxic and can cause health issues for humans. Understanding these harmful algal blooms (HAB's) caused by phytoplankton is important for the human consumption of seafood. In the Gulf of Maine and around the world there is a lot of research being done on toxic phytoplankton.

Zooplankton are low-level consumers, feeding on phytoplankton and other zooplankton. Some zooplankton are planktonic their entire lives. These zooplankton are referred to as holoplankton. Other zooplankton begin their lives in a planktonic, larval, stage and then continue developing into larger animals. These are called meroplankton.

Understanding plankton is a critical part of scallop aquaculture. Scallops begin their lives with a 40-day planktonic larval stage. Most scallop aquaculture farms get their scallops from the wild scallop population by collecting scallops at the end of the larval stage in spat bags. We will dive into what spat bags are and how they work later in this guide.

Objectives:

- Understand the differences between phytoplankton and zooplankton, where they live in the ocean, and what they require to survive.
- Understand the differences between meroplankton and holoplankton.
- Develop skills to identify different types of plankton
- Understand the importance of plankton and why we monitor plankton blooms

Duration: 60 minutes

Subjects: Ecology, Biology,

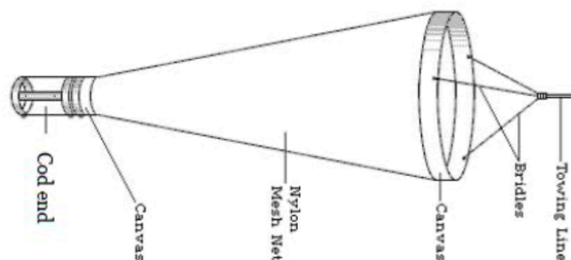
Materials:

- Plankton tow
- Microscopes (Stereo or Compound)
- Petri dishes
- Depression microscope slides
- Pipettes
- Plankton ID sheets
- Paper
- Colored pencils

Background info: Primary producers are organisms that produce energy (autotrophs) through the process of photosynthesis (or chemosynthesis). Photosynthesis creates sugar and oxygen by taking in carbon dioxide, water, and light. This is the photosynthesis equation: $\text{CO}_2 + \text{H}_2\text{O} + \text{light} \rightarrow \text{CH}_2\text{O} + \text{O}_2$. Primary producers are the base of all food webs. Consumers are organisms that cannot produce their own energy (heterotrophs), but instead eat primary producers to gain energy.

Activity:

- Before beginning this lesson, set up microscopes to make sure they are working. If the students are unfamiliar with microscopes, it is helpful to pre-focus them, or be prepared to explain how to use the microscopes at the beginning of the lesson.
- Walk the students to the water (dock or pier) where you will be collecting a plankton sample.
 - **If you are not close to the water:** collect a plankton sample ahead of time for your students to observe.
- Go over the parts of the plankton tow and how it works. Show the students the plankton tow and ask if anyone can explain how it works.
 - It is basically a really fine mesh net!
 - Review parts: towing line, bridle, mouth, mesh net, cod end



- Collect the sample by having the students pull the plankton tow through the water along the dock or pier. Pull the tow the length of the dock or pier multiple times. (The more you do it, the denser the plankton sample will be).
- Return to the classroom. Pass around the sample in the cod end for students to look at with their naked eye. *What do you notice?* As they are passing the sample around, encourage them to discuss with their neighbors what they know about plankton.
- Ask students to share what they know about plankton. Write everything that is said on a white board.
- On a board at the front of the class, teach students about plankton by starting with what they know and asking exploratory questions. **See additional resources.**
 - *Phytoplankton vs. Zooplankton*
 - *Do you think phytoplankton or zooplankton are bigger?*
 - *Do you think we will see more phytoplankton or zooplankton in our sample? Why?*
 - *Where in the ocean do they live? Why?*
- After the lesson, instruct students to find a microscope with a partner.
- Using a pipette, put some of the plankton sample on the petri dishes and microscope slides
- Instruct students to observe the plankton under the microscopes for 10-15 minutes. Encourage them to move around the room, using different microscopes and looking at different samples.
- While they are observing, pass out plankton identification guides (**See additional resources**). Ask students to notice the toxic algae highlighted on the sheets
 - *Do you see any toxic phytoplankton in your sample?*
- Instruct the students find and draw two phytoplankton species and two zooplankton species that they find in their sample. Try to identify them.
- As a wrap up, review why plankton are important
 - Playing a role in reducing atmospheric CO₂
 - Producing oxygen
 - Base of the marine food web
 - Fossil fuels
 - Indicators of environmental change

Additional resources:

Phytoplankton vs. Zooplankton

Phytoplankton:

- Phytoplankton are plants – primary **producers**. Like all plants, they require sunlight, water, and nutrients (specifically nitrates and phosphates in the marine environment).
 - *If they require sunlight, where must they live?* Surface waters
 - *Where do the nutrients they require come from? Have you ever applied fertilizer to your yard or garden?* Runoff is a major source of nutrient input in the marine environment. Coastal waters tend to be more nutrient rich.
 - Photosynthesis $6\text{CO}_2 + 6\text{H}_2\text{O} + (\text{energy}) \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ Phytoplankton provide approximately 50% of the oxygen that we breathe
 - Diatoms and dinoflagellates – common types of phytoplankton found in the Gulf of Maine
 - Diatoms can be centric (circular) or pennate (long and narrow).
 - Some species produce neurotoxins, which can cause harmful algal blooms (HAB's) – This is one reason why we monitor plankton!
 - Ex. Pseudo-nitzschia (diatom) causes amnesic shellfish poisoning.
 - Ex. Alexandrium sp. (dinoflagellate) causes paralytic shellfish poisoning
 - Ex. Dinophysis sp. (dinoflagellate) causes diarrhetic shellfish poisoning

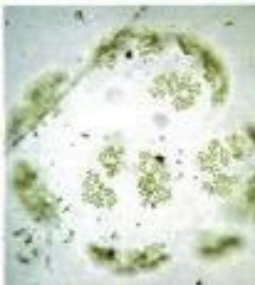
Zooplankton:

- Zooplankton are animals – **consumers**. There are two types of zooplankton, holoplankton and meroplankton.
 - **Holoplankton** – animals that are plankton for their entire lives.
 - Ex. Copepods, krill, jellies
 - Fun fact: Copepods are one of the most abundant animals in the ocean.
 - **Meroplankton** – animals that are only planktonic for the early stages of their lives.
 - Ex. Crabs, lobsters, scallops, fish, etc.

Plankton ID resources:

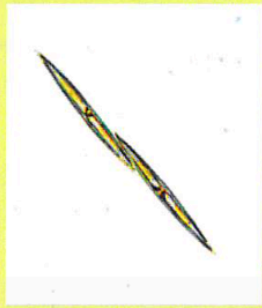
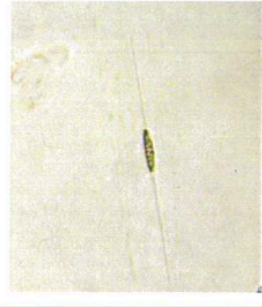
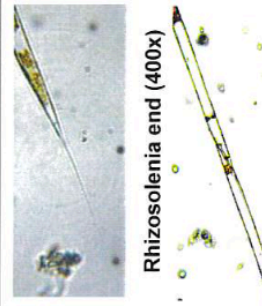
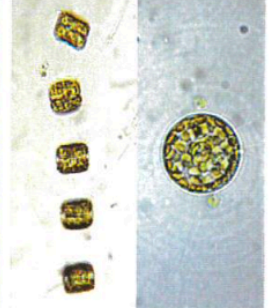
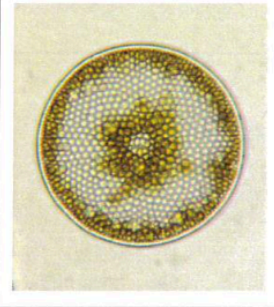
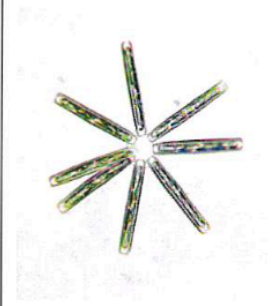
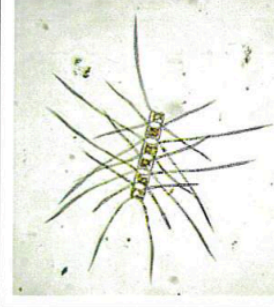
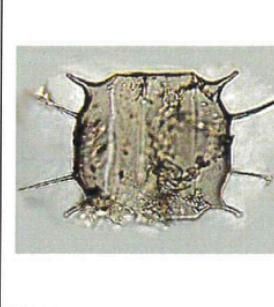
[Common Gulf of Maine Phytoplankton](#)

Common Gulf of Maine Phytoplankton

	Alexandrium sp (AL) (400x)		Gymnodinium sanguineum (GY) (400x)		Gonyaulax spinifera (GS) (400x)		Protoperdinium sp (PT) (400x)		Scrippsiella sp (SC) (400x)
	Dinophysis norvegica (DN) (400x)		Dinophysis acuminata (DA) (400x)		Dinophysis tripos (DT)(400x)		Prorocentrum lima (PL) (400x)		Prorocentrum micans (PM) (400x)
	Ceratium fusus (CF) (100x)		Ceratium lineatum (CL) (100x)		Ceratium longipes (CP) (100x)		Phaeocystis sp (PC) (100x)		Chaetoceros socialis (CS) (100x)

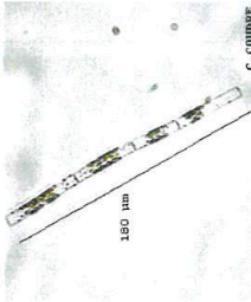
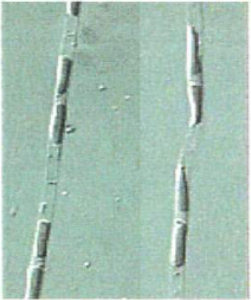
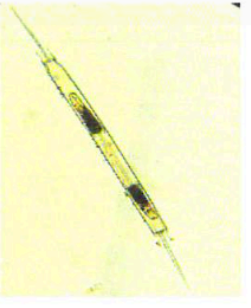
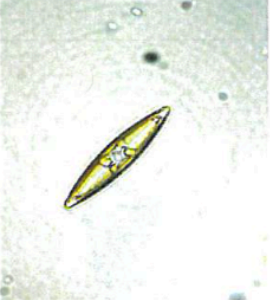
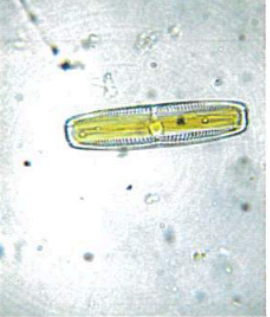
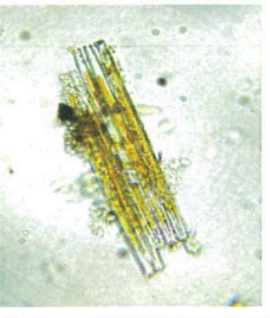
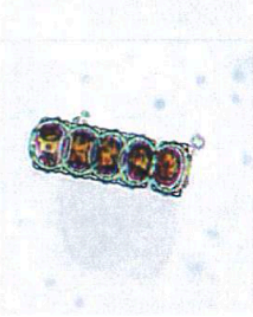
Note: Species pictured in yellow boxes may produce harmful toxins.

Common Gulf of Maine Phytoplankton

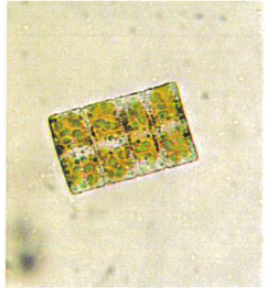
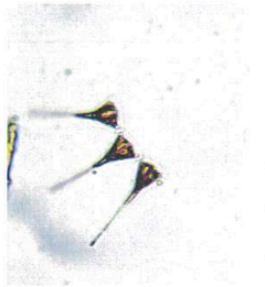
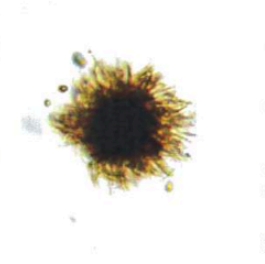
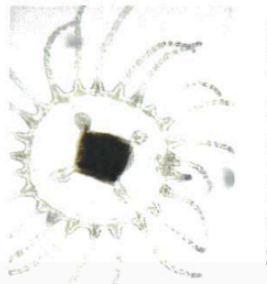
	Pseudonitzschia sp (PS) (100x)		Pseudonitzschia delicatissima (PS) (400x)		Cylindrotheca closterium (NZ) (400x)		Rhizosolenia sp (RH) (100x)		Rhizosolenia end (400x) Rhizosolenia junction (400x)
	Rhizosolenia sp (RH) (100x)		Thalassiosira sp (TL) (400x) girdle view(tp)/valve view(btm)		Coscinodiscus sp (CO) (400x) valve view		Skeletonema costatum (SK) (400x)		Thalassionema nitzschoides (TA) (400x)
	Chaetoceros sp (CH) (100x)		Chaetoceros sp (CH) (100x)		Chaetoceros sp (CH) (100x)		Biddulphia sp (BD) (400x)		Odontella sp (OD) (400x)

Note: Species pictured in yellow boxes may produce harmful toxins.

Common Gulf of Maine Phytoplankton

Common Gulf of Maine Phytoplankton

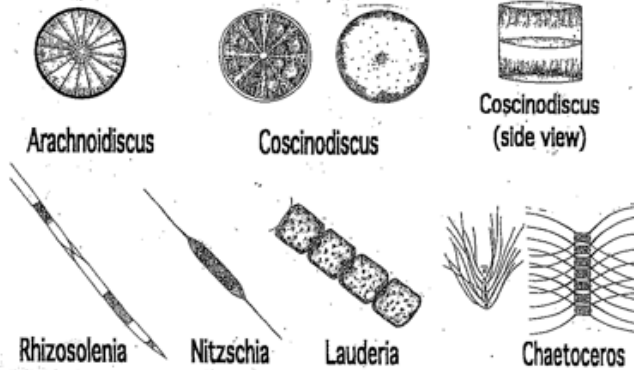
				
Dactyliosolen sp (DS) (400x)	Detonula sp (DL) (400x)	Fragilariopsis sp (FR) (400x)	Asterionellopsis sp (AS) (400x)	Licmophora sp (LC) (400x)
				
Fragilariopsis sp (FR) (400x)	Mesodinium rubrum (MR) (400x)	Dictyocha sp (DY) (400x)	Pollen (not plankton) (PO) (100x)	Tintinid (zooplankton) (ZT) (100x)
				
Obelia (zooplankton) (OB) (100x)	Copepod nauplius (zooplankton) (ZN) (100x)	Bivalve larva (zooplankton) (ZC) (100x)	Trichome (not plankton) (TC) (100x)	Copepod sp - top view (zooplankton) (CO) (100x)

Photos by S. Cooper except: C. Coudre (LP1), C. Dolan (OB, TC, ZC, RH3), A. Godhe (GS), S. Hedrick (GY), Rebecca Jones (CO), B. Karlson (DT, LP2), L. Maranda (PL), J. Parmentier (CS), A. Smith (SC), B. Trow (MR), M. Webber (LC), Unknown (BD, CR, EU, ML, PM)

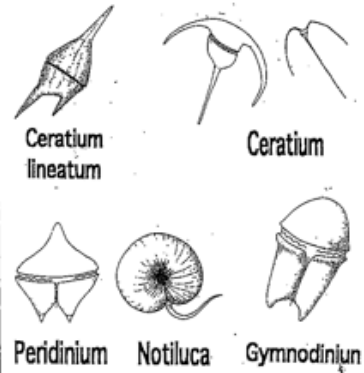
Plankton Identification

PHYTOPLANKTON

DIATOMS

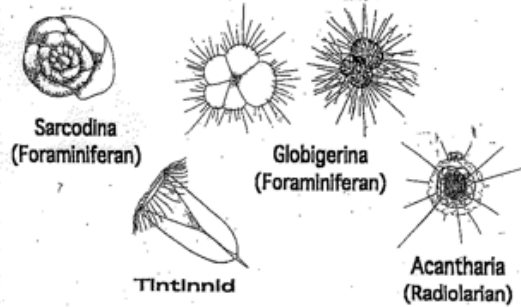


DINOFLAGELLATES

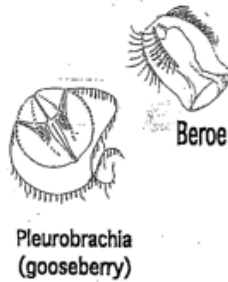


ZOOPLANKTON

PROTOZOANS



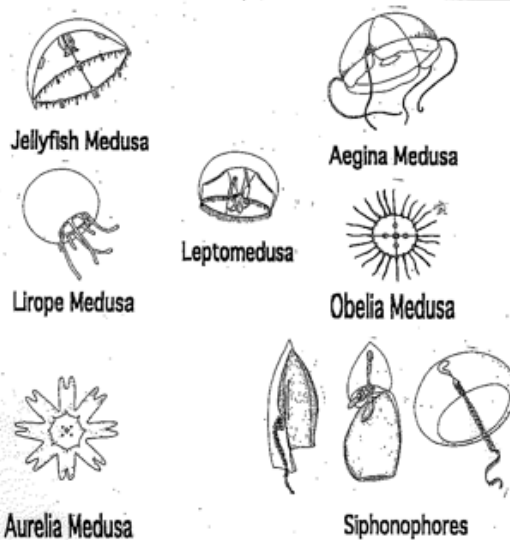
CTENOPHORES



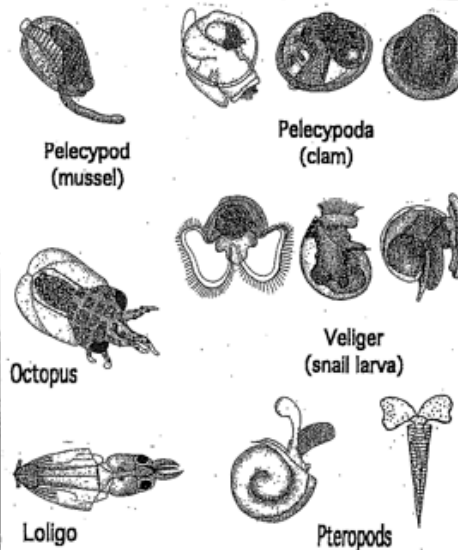
BRYOZOANS



Cnidarians

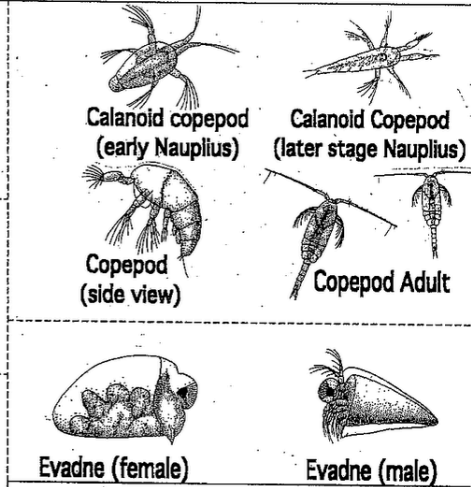
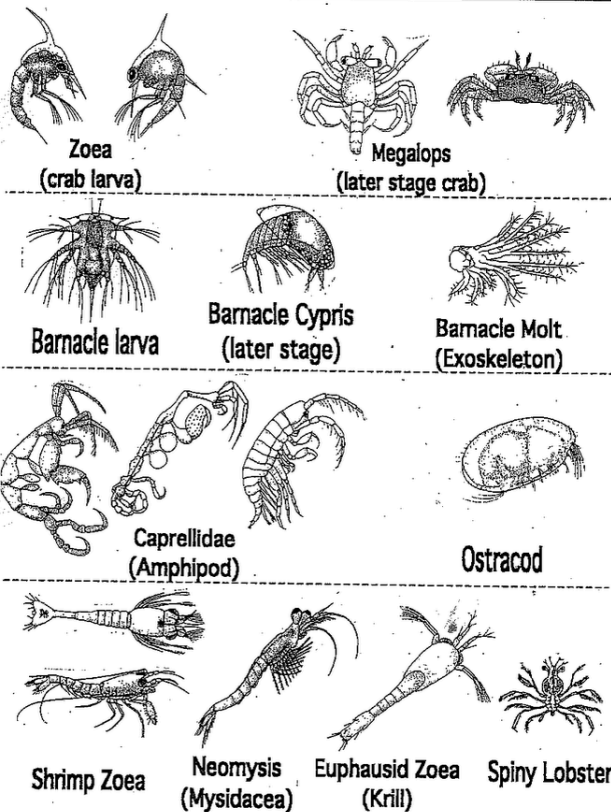


Molluscs



ZOOPLANKTON

ARTHROPODS

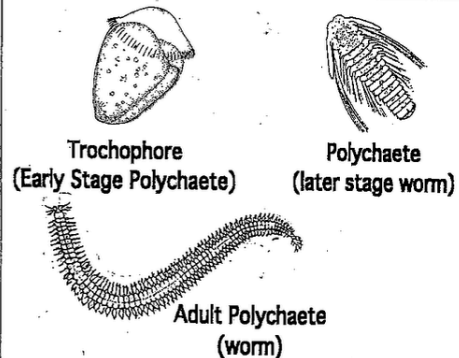


CHAETOGNATHS

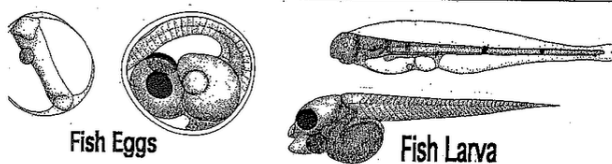


Arrow Worm

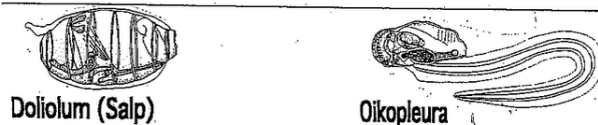
ANNELIDS



CHORDATES



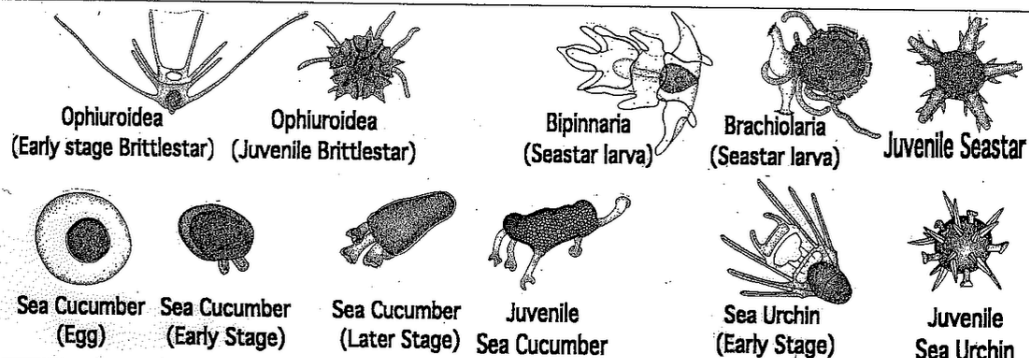
UROCHORDATES



PLATYHELMINTHES



ECHINODERMS



Extension: Build a Plankton

Essential Question:

- How do plankton keep themselves in the photic zone and avoid sinking?
- How does the ratio of surface area to volume play a role in buoyancy?

Objectives:

- Learn about buoyancy, surface area, and density
- Understand how the ratio of surface area to volume plays a role in buoyancy
- Learn about how the unique structures, appendages, and functional adaptations plankton have help them survive in their environment

Overview: While plankton cannot swim against currents, they can move through the water column locally to seek sunlight, prey, and hide from predators. These organisms have physiological adaptations that help them do these things in order to survive. For example, many plankton have transparent bodies to be less easily detected by predators, or long appendages that increase their surface area to reduce sinking. Plankton are neutrally buoyant in the ocean, using gas exchange and lipid concentrations to control their placement in the water column.

Duration: 30 minutes

Subject: Physics, biology, physiology

Materials:

- Craft supplies (feathers, pipe cleaners, tooth picks, beads, paper clips, straws, rubber bands, tin foil, pompoms, felt, coins, tape, etc.)
- A fish tank or large transparent container
- Water
- Timer
- Solid cooking oil or Vaseline

Activity:

- Provide students with a small bag of assorted craft materials
- Instruct them to build a neutrally buoyant “plankton” with the provided materials. They may use as much or as little of the provided materials.
- While they are building, fill the tank or container with water
- Use a timer to record the length of time it took for each student's “plankton” to sink to the bottom of the tank. Record the times.

- Allow the students to go back and adapt their plankton to sink slower. Repeat this 2-3 times.
- Allow a final timed plankton run and record the times. The student whose plankton sank the slowest wins!
- Debrief how the experiment went
 - *Was it easy to achieve neutral buoyancy? Was anyone able to?*
 - *What were your techniques?*
 - *What materials sank the fastest or slowest? Why?*
- Review with students how plankton can control their lipid and gas storage to control their position in the water column.
 - *What would happen if you added oil to your plankton?*
- Add some of your oil or Vaseline to the “plankton.” Time them in the water again and see if this affected their buoyancy.

Go Farm Card Game

Steps to getting an Aquaculture Lease

Essential questions:

- How do you obtain a commercial aquaculture lease?
- What are the steps to get an aquaculture lease and who is involved?

Objectives:

- Understand the process of applying for and obtaining a standard aquaculture lease in Maine

Duration: 30 minutes

Materials:

- Aquaculture Lease Application Go-Fish cards
 - 4 copies of the cards for a group of 4-6 students
 - Print and cut out cards to make playing decks

Background info:

Activity:

- This game is an adapted version of Go Fish
- Students should play in groups of 4-6
- How to play
 - Deal seven cards to each player
 - One at a time, ask another player if they have a specific card
 - If the other player has it, they must give it to you
 - If you get the card you asked for, you can go again
 - If the player you asked says “Go Farm” (meaning they don’t have the card), you draw a card from the remaining deck
 - Collect pairs and put them down in front of you
- The game ends when the deck has run out of cards. The player with the most pairs of cards laid out in front of them wins.
- At the end of the game, ask the students to organize the cards into 3 piles -
 - (1) I understand what this means
 - (2) I kind of understand what this means, but I need some explanation
 - (3) I totally do not understand what this means and will need a full explanation

Pre-Application Meeting

with the Maine DMR and Harbormaster

Draft Application

Submitted to DMR

Vicinity Map

With Required items shown

(Submitted with application)

Draft Application Fee

\$500

Boundary Drawing

With Required items shown

(Submitted with application)

Tax Map

(Submitted with application)

Gear Drawing

For each type of gear proposed

(Submitted with application)

Overhead View Drawing

Depicting layout of gear from overhead

(Submitted with application)

Cross Section View Drawing

Depicting gear and moorings from the side

(Submitted with application)

**Draft
Application
Accepted**

**Scoping
Session**

Schedule & Notify the
Public

**Final
Application**

**Final
Application
Fee**

\$1000

**DMR
Accepts
Application**

Site Visit

With the DMR

Site Report

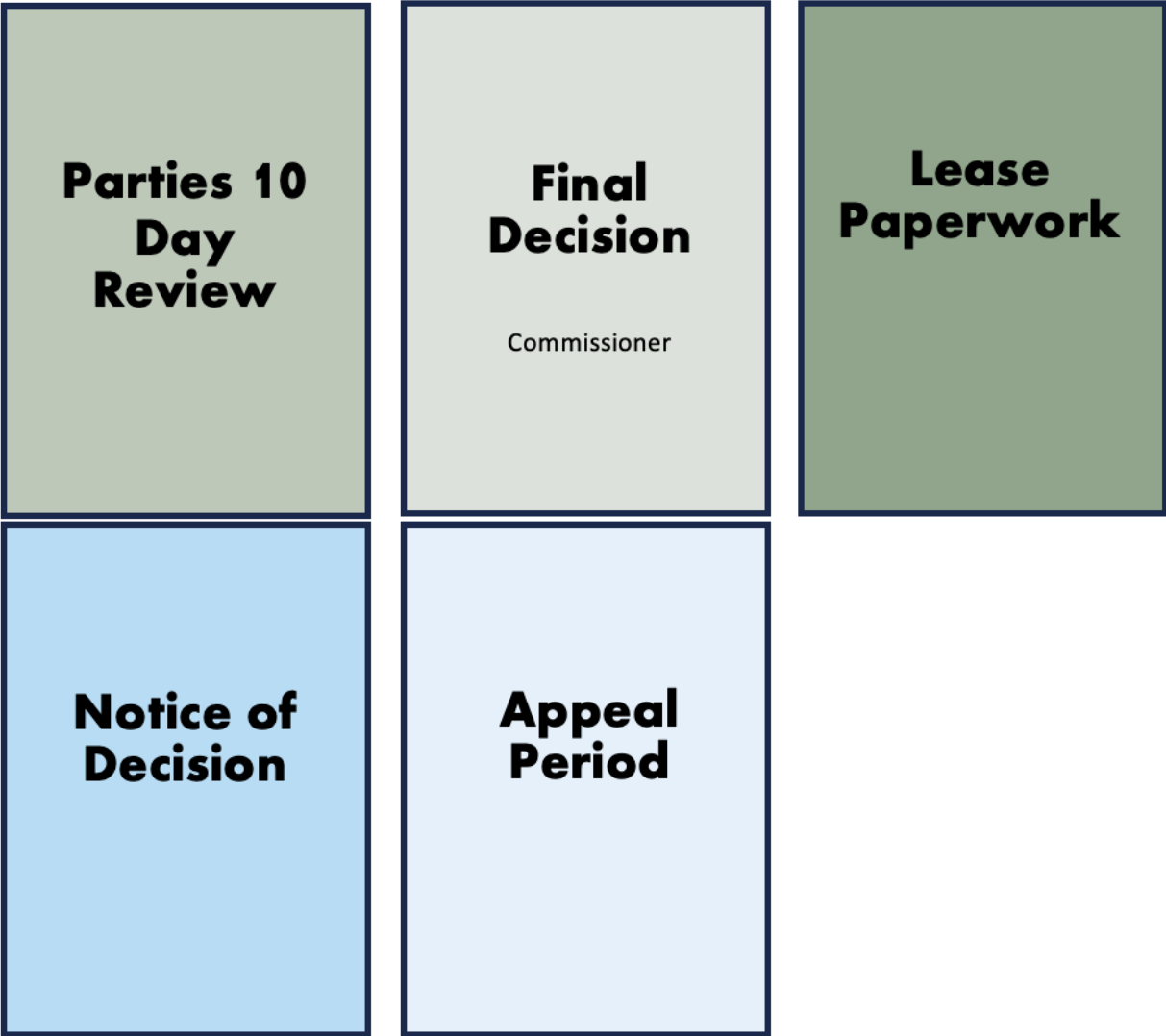
DMR Posts on Website

**Public
Hearing**

DMR Notifies Public

**Draft
Decision**

With DMR & Assistant
Attorney General



Extension: Complete a mock Application

Essential questions:

- How do individuals apply for a standard aquaculture lease?
- What materials are required to apply for an aquaculture lease?

Objectives:

- To understand how to apply for a standard aquaculture lease in Maine
- Develop the skills and knowledge needed to adequately apply for a lease
- Demonstrate their understanding of Gulf of Maine aquaculture species and what they need to survive

Duration: 2-3 hours

Materials:

- Paper
- Colored pencils
- [Standard: Non-discharge Aquaculture Lease Application](#)
- Internet access (for research)
- NOAA chart of desired area

Activity:

- Print out the [Standard: Non-discharge Aquaculture Lease Application](#) for each student group (groups of 2)
- Using their work from the previous lesson (Choosing an Aquaculture site) they should complete an application to the best of their ability
- The students will have to get creative with their maps and gear drawings, and do some research online about how they will stock their farms
 - *Are you testing multiple types of gear?*
 - *How do you have your gear positioned on your site?*
 - *How will you get the organisms for your farm?*
- Instruct the students to draw a Site Map, Boundary Drawing, Gear Drawing, Overhead View Drawing, and Cross section View Drawing. These drawings will require some thought/research into how they want to set up their farm, what gear they will use, and how they will suspend the gear within the site.
- Instruct students to complete all written parts of the application. (Species Information and Gear Information tables, Production activities, Noise & light, Lease Site Info, etc.)

- Once finished, the students can present their application packets to the class, describing what they are growing, how, where, etc. and explain their many site drawings.

Additional resources:

[DMR Aquaculture](#)

[Maine DMR Aquaculture Map](#)

[Scoping Session Applicant Guidance](#)

[Maine DMR Standard Lease Application Process](#)

Scallop Anatomy

Essential questions:

- What are the different organs of a scallop?
- What function does each organ serve?

Overview:

Atlantic Sea Scallops belong to the phylum Mollusca, under the class Bivalvia. Like all bivalves, they have two shells that open and close. As adults, scallops live on the seafloor. They are subtidal organisms, meaning they are always submerged by water and can live in depths of up to 300 feet. Understanding the anatomy of a scallop is essential to understanding their physiological adaptations and the niche that they fill in their ecosystem.

While most bivalves are relatively stationary, scallops can swim along the seafloor by opening and closing their shells and propelling themselves by pushing the water out either forward or backwards. This is a unique adaptation for scallops and is due to their large adductor muscle, which is the organ that controls the opening and closing of the shells. The adductor muscle is also the only part of scallops that we traditionally eat. All bivalves have adductor muscles, but most are very small.

Like all bivalves, scallops are filter feeders. They filter plankton out of the water using their gills, which also allow them to breathe by taking in dissolved oxygen.

Scallops are broadcast spawners, meaning they release their gametes into the water column to mix and fertilize. Scallop gonads can be very large, making up about $\frac{1}{3}$ of their bodies when they are close to spawning. The color of the gonad indicated the sex of a scallop. Male gonads are white, and female gonads are a redish-pink color.

For this activity, students will learn about the organs of a scallop and where they are located within the animal. They will learn and record definitions for each organ describing its function. The students will then build a scallop puzzle. The puzzle is made up of unlabeled organs, which the students will identify and place in the correct location on the shell. They can then label the organs and glue their scallop together. At the end of this activity, there is an optional matching game for students to test their scallop organ function knowledge.

Objectives:

- Learn about the anatomy of a scallop and be able to identify different organs
- Understand the function of each organ

Duration: 60 minutes

Subjects: Science, Physiology, Anatomy

Materials:

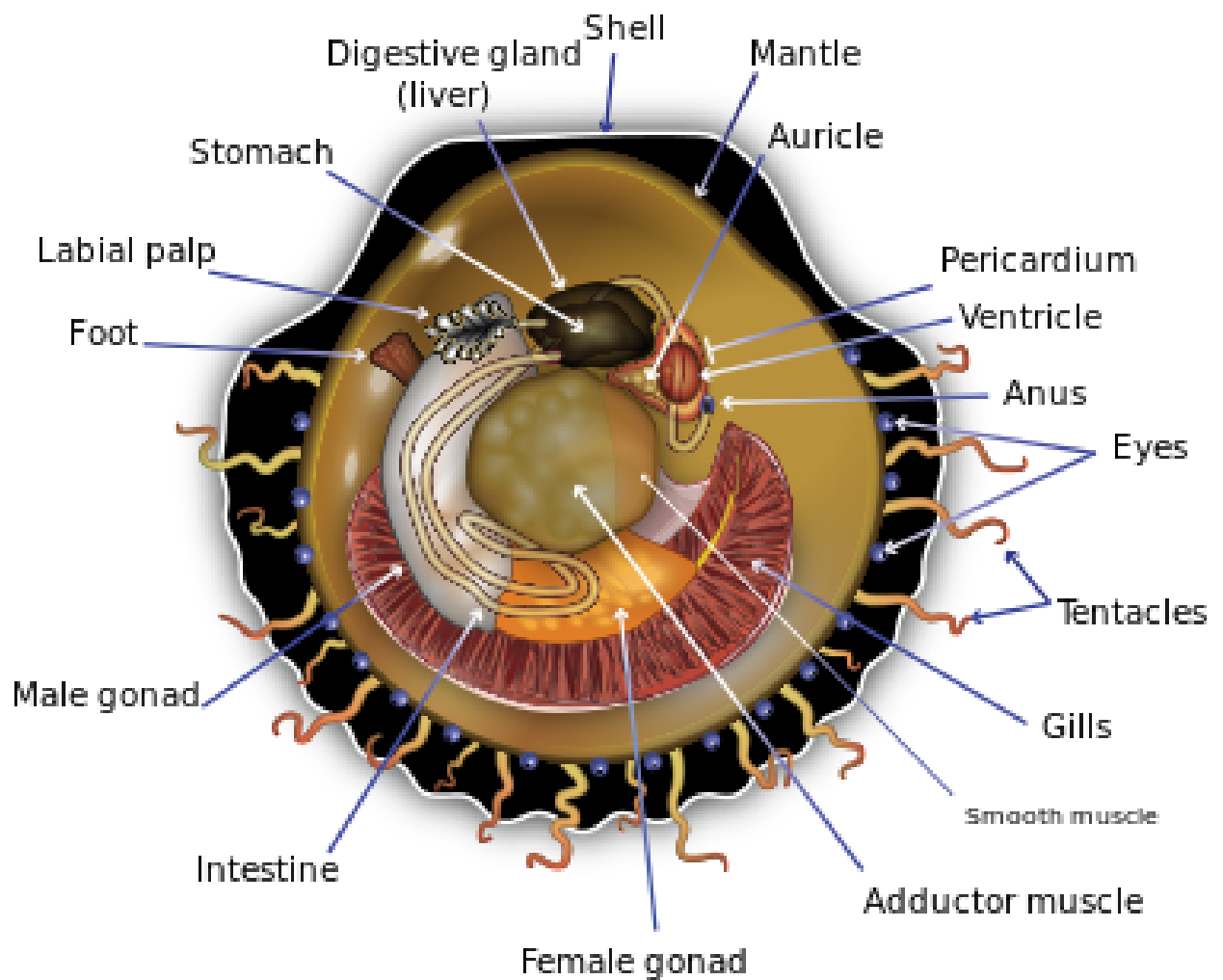
- Parts of a scallop print out
- Scallop puzzle print out
- Scallop puzzle labels and definitions
- Scallop anatomy worksheet
- Scallop anatomy matching game
- Scissors
- Glue
- Pencils

Activity:

- Pass out the Parts of a Scallop diagram to students. Ask them to make observations
 - *What do you notice? What surprises you?*
 - *Have you ever eaten scallops? What part did you eat?*
- Start with an overview of scallops
 - *What are they?*
 - *Where do they live?*
 - *What do they eat?*
 - *How do they reproduce?*
- Hand out the Scallop Anatomy Worksheet. Have the students identify the organs on the Parts of a Scallop diagram and write down definitions for the organs as you go over them as a class. Prompt the students to guess what the organs do, and then elaborate using the provided definitions.
- Hand out the Scallop Puzzle and instruct students to cut out each organ and write the organ's corresponding number on the back of each piece.
- Ask the students to identify the organs that make up the puzzle. They can write the corresponding number next to the term on the Scallop Anatomy Worksheet.
- Challenge the students to build the scallop puzzle. Once they feel good about their puzzle, they can glue the pieces in place.
 - *Is your scallop a male or female?*
- Optional: Hand out the Scallop Anatomy Matching Game for students to test their knowledge.

Additional resources:

Parts of a Scallop - from <https://atlanticseascallopfishery.weebly.com/biology.html>



Scallop Puzzle



Scallop puzzle labels and definitions

1. Shell
2. Mantle
3. Gills
4. Gonad (female)
5. Gonad (male)
6. Adductor muscle
7. Resilium
8. Pericardium
9. Foot
10. Digestive gland
11. Stomach
12. Labial palp

1. Scallops are bivalves, meaning they have two of these, hinged and made of calcium carbonate.
2. This organ secretes the material which forms their shell (calcium carbonate) and is lined with up to 200 eyes and sensory tentacles.
3. This organ takes in dissolved oxygen and removes food from the water.
4. Female reproductive organ – develops and releases gametes
5. Male reproductive organ – develops and releases gametes.
6. Big, round, central organ that is responsible for opening and closing the shell - the delicious and commercially important organ.
7. The small ligament attached to the shells that holds them together.
8. Organ protecting and isolating the heart.
9. This organ provides little function to adult scallops but is used for locomotion in juveniles.
10. Where the food is digested
11. This organ is imbedded in the digestive gland, or liver
12. This organ directs food to the mouth and can reject and discard food.

Scallop Anatomy Worksheet

Shell -

Mantle –

Gills –

Gonad (female) –

Gonad (male) –

Adductor muscle –

Resilium –

Pericardium –

Foot –

Digestive gland –

Stomach –

Labial palp –

Match the scallop organ to the correct function description

Shell	Where enzymes are released for food to be digested
Mantle	This organ takes in dissolved oxygen and removes food from the water.
Gills	Big, round, central organ that is responsible for opening and closing the shell - the delicious and commercially important organ.
Gonad (female)	Scallops are bivalves, meaning they have two of these, hinged and made of calcium carbonate.
Gonad (male)	This organ directs food to the mouth and can reject and discard food.
Adductor muscle	Develops and releases male gametes.
Resilium	This organ secretes the material which forms their shell (calcium carbonate) and is lined with up to 200 eyes and sensory tentacles.
Pericardium	This organ is imbedded in the digestive gland and helps break down food by mixing.
Foot	Organ protecting and isolating the heart.
Digestive gland	Develops and releases female gametes.
Stomach	The small ligament attached to the shells that holds them together.
Labial palp	This organ provides little function to adult scallops but is used for locomotion in juveniles.