MIDDLE and HIGH SCHOOL

Next Gen Science Standards:
MS-LS2-4
HS-LS2-6
HS-LS4-5

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Climate of Change Part IV: The Future of Aquaculture

Marine Ecosystems: Sea urchins, kelp and lobster

Developed by the Island Institute, Rockland, Maine
Revised and formatted by Maine Agriculture in the Classroom

Overview:

Students will gain a better understanding of the intricacies within the Gulf of Maine marine ecosystem after completing this lesson. A classic example of how small changes can affect an entire ecosystem is the sea urchin-kelp story in Maine. Following the collapse of the cod fishery in Maine, green sea urchin populations exploded. The ecosystem became an urchin-dominated system. In the 1980s, fishermen discovered the high value of harvesting sea urchins and the aggressive overharvesting of the green sea urchin resulted in massive declines along the coast. Because urchins are grazers (they eat kelp and other macroalgae), the decline of the urchin population resulted in a shift towards a kelp forest ecosystem. Most fishermen today report seeing a lot of kelp and few urchins. The relatively new kelp forest system is the perfect environment for American lobster and crabs, both of which are natural predators of urchins. This is an example of a tipping point in an ecosystem, shifting from an urchin-dominated system to a dense kelp forest system.

What can we learn from this story? Does it make sense to manage individual species or an ecosystem as a whole? There is a new movement to shift from single species management to Marine Ecosystem-Based Management (EBM). According to the Scientific Consensus Statement on Marine Ecosystem-Based Management, "EBM is an integrated approach to management that considers the entire ecosystem, including humans. The goal of EBM is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. EBM differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the cumulative impacts of different sectors". In New England there is work being done to transition to this management framework. It will take a lot of effort and it is expensive to implement but once it is established, EBM has the potential to greatly benefit all who rely on a healthy ocean for their livelihoods.

There are two parts to this lesson. The first half of the lesson is devoted to the urchin-kelp story. Teachers can use the resources below to introduce this topic and help students understand the lessons learned from this story. The second half of the lesson is a hands-on activity from NOAA that will allow students to model a marine food web and a potential ecosystem collapse. Students will write an explanation of what they think might happen if a small change were to occur in the marine ecosystem in their backyards.

Essential Questions:

- Since the ocean is so large, why do small changes make a difference?
- How do humans interact with the marine ecosystem?
- What is ecosystem-based management?

Learning Objectives:

Students will

- explain recent changes in the Gulf of Maine (GoM) ecosystem with regard to ground fish, sea urchins and kelp.
- describe the human factor in the changing GoM ecosystem and the role that EBM could have on the GoM ecosystem.

Materials:

- Vocabulary handout
- Urchin-kelp diagram handout
- Jenga game
- Markers
- Scissors
- Glue or tape
- 1 stack of Jenga playing cards: **Whale Jenga: A Food Web Game**

Background Information:

The urchin-kelp story is complicated but **Ocean Tipping Points** has summarized the concepts into a one-page document. The diagram *Sea Urchins in Kelp Forests, Maine* was also created by Ocean Tipping Points.

There are certain vocabulary words that students will have to learn in order to be successful in this lesson. Teachers may either provide the definitions of each term or have students define them on their own. For younger students, teachers may provide the vocab matching handout (see below).

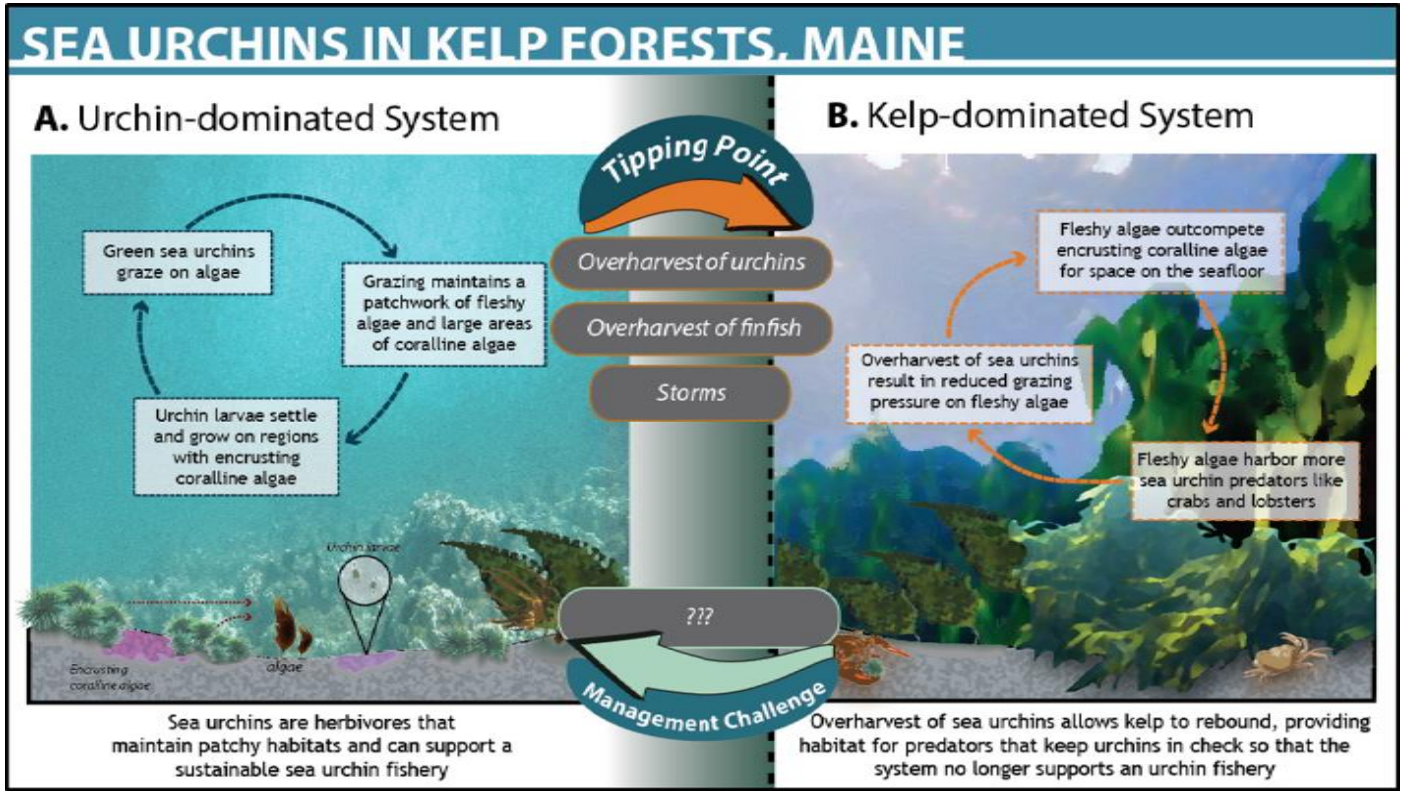
Vocabulary

- Food web – complex interaction of food chains; all the feeding relations of a community taken together; includes production, consumption, decomposition and the flow of energy
- Ecosystem based management (EBM) – an environmental management approach that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species or ecosystem services in isolation
- Macroalgae – large algae, often living attached in dense beds
- Ecological tipping point – an event in which an ecosystem experiences a shift to a new state, with significant changes to biodiversity and the services to people
- Maximum sustainable yield –maximum number or amount of a species that can be harvested each year without steady depletion of the stock; the remaining stock is able to replace the harvested members by natural reproduction
- Herbivore/herbivory – an animal that consumes only plants
- Trophic level – is the position of an organism in a food chain or food (trophic) pyramid

The hands-on food web game that students will play was developed by NOAA (National Oceanic and Atmospheric Administration) and is a fun game to play with both young and more advanced students. Students will use the game Jenga to learn about the marine food web and how small changes in the food web can have large effects in the ecosystem.

Whale Jenga: Food Web Game

http://www.cisanctuary.org/ocean-acidification/PDFs-WorkshopPage/Whale Jenga A Food Web Game_October_2015.pdf



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Procedure:

PART I

- Introduce and discuss the urchin-kelp story. Pass out the diagram and use the following questions to start classroom discussion:
    - Why did the collapse of the cod fishery lead to an increase in urchin populations? (Cod were predators and ate urchins to control population numbers.)
    - What are the interactions between urchins and kelp? (Urchins eat or graze on kelp; without urchins, kelp can continue to grow.)
    - What are the lessons learned from this story? (Small changes in the ecosystem can lead to entire ecosystem shifts.)
    - Is there a similar situation happening right now with lobsters? (Warming waters are allowing new predators, like black seabass, to come into the Gulf of Maine and prey on baby lobsters.)
- Post important vocabulary words. Students may work together to define these terms or it can be a classroom activity. For younger students, provide the vocabulary matching handout.

PART II

- To demonstrate the complex nature of ecosystems, play **Whale Jenga: A Food Web Game**, created by NOAA. Students will have to understand the importance of ecosystem health and structure to fully benefit from this activity. It is also recommended to review the vocabulary before playing the game.
- Once the game has been completed students will reflect on the following questions:
    - What surprised you during the game?
    - What are the interactions between human uses and the marine environment?
    - What are some questions you would like to investigate further?
- Students will write an explanation of what they think may happen if a small change were to occur in the ecosystem at the local level (in their backyards). This change could be either negative (i.e. overfishing) or positive (i.e. more beach cleanup days). Remind students to use the vocabulary that was introduced in this lesson and to think back to the food web game.

Additional Resources:

https://umaine.edu/news/blog/2013/03/25/flipped-and-locked/

https://cobscook.org/sea-urchins-part-i

https://www.ecologyandsociety.org/vol17/iss2/art15/

Answer key for worksheet

___C_ _Macroalgae

___F__ Herbivore

___E__ Maximum sustainable yield

___G__ Trophic level

___A__ Food web

___D__ Ecological tipping point

___B__ Ecosystem based Management (EBM)

Match the term with its definition

___ Macroalgae	A	A complex of interacting food chains; all the feeding relations of a community taken together; includes production, consumption, decomposition and the flow of energy
___ Herbivore	B	An environmental management approach that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species or ecosystem services in isolation
___ Maximum sustainable yield	C	Large algae, often living attached in dense beds
___ Trophic level	D	An event in which an ecosystem experiences a shift to a new state, with significant changes to biodiversity and services to people
___ Food web	E	Maximum number or amount of a species that can be harvested each year without steady depletion of the stock; the remaining stock is able to replace the harvested members by natural reproduction
___ Ecological tipping point	F	An animal that consumes only plants
___ Ecosystem based management (EBM)	G	The position of an organism in a food chain or food (trophic) pyramid