Teacher At Sea Lesson Plan
Channa Comer

Activity Title: Atlantic Sea Scallop Dredge Design Challenge

Subject (Focus/Topic): Life Science –Ecology/Human Impact

Grade Level: 9 - 10

Average Learning Time: Five 50-minute periods

Lesson Summary (Overview/Purpose):
This is lesson number six in a series on sea scallops. In this lesson, student will be challenged to design a sea scallop dredge to collect scallops within a given set of constraints and conditions.

Overall Concept (Big Idea/Essential Question):

What is the impact of human activity on ocean ecology?
How can the engineering/design process be used to solve problems?

Specific Concepts (Key Concepts):

- Plants and animals depend on each other and their physical environment.
- Human activity has an impact on the physical and living environment.
- Engineering design is an iterative process involving *modeling* and *optimization* used to develop technological solutions to problems within given constraints.
- Technology can have positive and negative impacts on individuals, society, and the environment and humans have the capability and responsibility to constrain or promote technological development.

Focus Questions (Specific Questions)*:*

1. What are the effects of sea scallop dredging on the ocean? (Habitat for other organisms, ocean pollution, effects on other organisms in the ocean, etc.).
2. What is the relationship between the design of your dredge and the size of the organisms that will be caught?
3. How are people affected by dredging for sea scallops?
4. What can be done to minimize the negative impacts of sea scallop dredging?

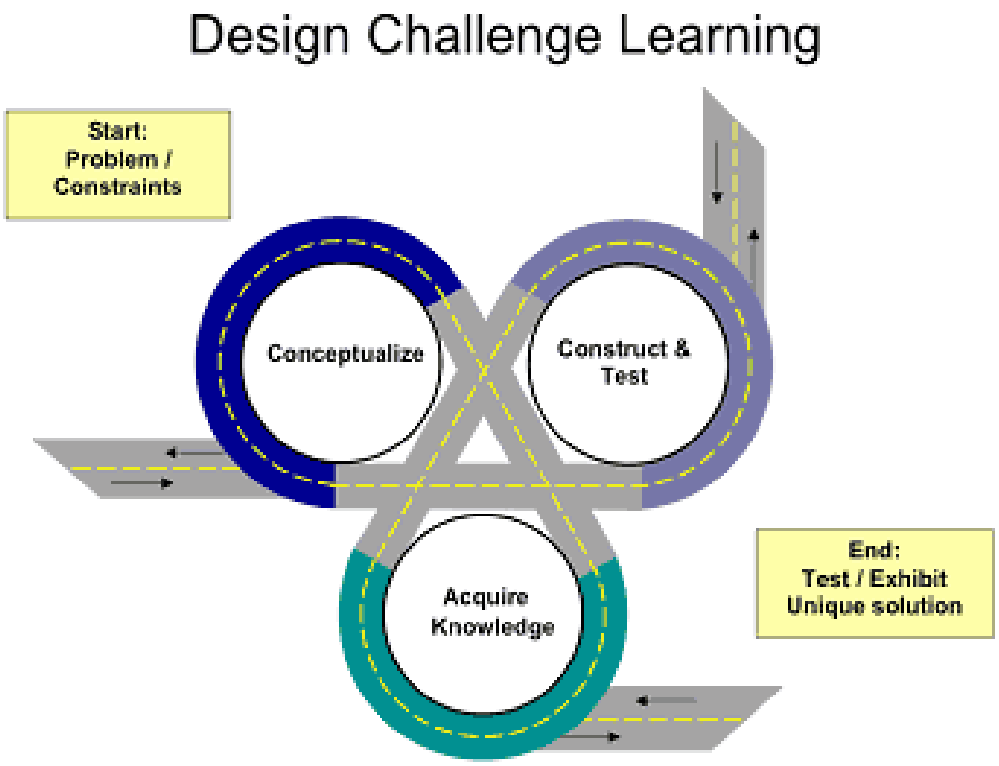
Objectives/Learning Goals:

- Understanding of human activity on ocean ecosystem
- Development of critical thinking and problem solving skills
- Understanding of the design and engineering process
- Work effectively in collaboration with others

Background Information:

The diagram below represents the engineering and/or design process. Teams do not follow a linear path from problem to solution, but rather weave in and out of conceptualizing, constructing and testing, and acquiring knowledge, all the while applying multiple skills and habits of mind of innovators. Through the Design Challenge process, students have the opportunity to build broad skills useful throughout their lives, regardless of the specifics of the challenge. In using this open-

ended approach that leads to the creation of numerous designs, students are challenged to apply their domain knowledge, personal experiences, interests and talents to the process of creating an inventive, team driven solution. This approach creates a powerful learning experience, where students are intrinsically inspired to learn and have pride in achieving a goal as a team. In a traditional design approach, students would research before developing potential solutions. Your order will depend on the goal of the design challenge and your students.



Conceptualize

- Identify problem, materials & constraints
- Brainstorm ideas and possible solutions

Construct & Test

- Select a solution
- Design and Construct
- Prototype
- Redesign or modify
- Retest

Acquire Knowledge

- Research
- Share solutions
- Reflect and discuss

<u>Sea Scallop Dredge</u>

It is acknowledged by nearly everyone working on the ocean that fishing gear causes some alteration of the seabed, although the significance and duration of this alteration continues to be debated. In the absence of clear scientific evidence, qualitative rankings of relative impacts of different fishing gears have been made based on observations and experience. Scallop dredges are generally felt to have a large impact compared to other gears.

The Atlantic sea scallop *Placopecten magellanicus* industry contributes significantly to the economy of New England. The Northeastern United States sea scallop fishery landed over 60 million pounds of scallop in the 2005-2006 season. This stock now produces a value of over $300 million annually. In 2005, the overall biomass of scallops exceeded BMSY and was therefore no longer overfished.

Scallop dredges used in New England are constructed of heavy steel bar welded into a triangular-shaped frame, with a bag hung from the back made of steel rings (Figures 1 & 2). Current regulations require a 4” ring for scallop size selectivity and a 10” twine mesh on the upper side to reduce finfish bycatch. The dredge rides along the sea floor on shoes welded to the dredge at the corners of the triangle where the bag is attached. A pressure plate is mounted along the top rear of the triangular frame to provide some downward hydrodynamic pressure, however, the weight of the frame and chain bag is the predominant downward force assuring bottom contact. A cutting bar (Figure 2) provides structural support to the dredge and plays a much debated role in scallop capture. From underwater video, it is known that the cutting bar can remove the tops of bottom features such as small sand dunes.

The underside of the chain bag is supported by a chain sweep that hangs in a catenary from either side of the frame. As shown in the photo, it is also common to have tickler chains preceding this sweep chain, presumably in order to lift scallops from the bottom in anticipation of the approaching chain bag. Also shown are rock chains intended to prevent rocks and boulders from entering the bag and damaging the gear and the catch.

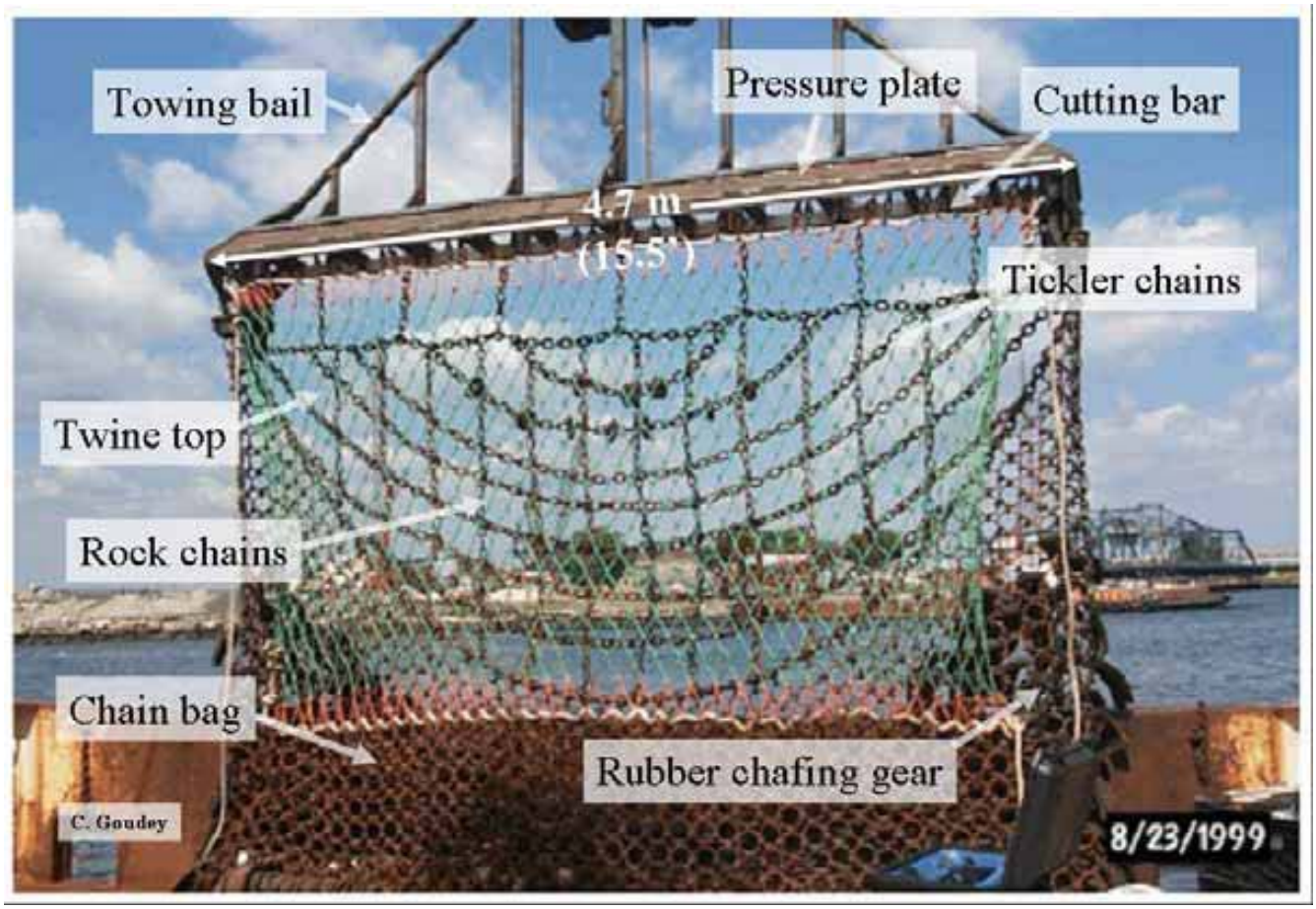
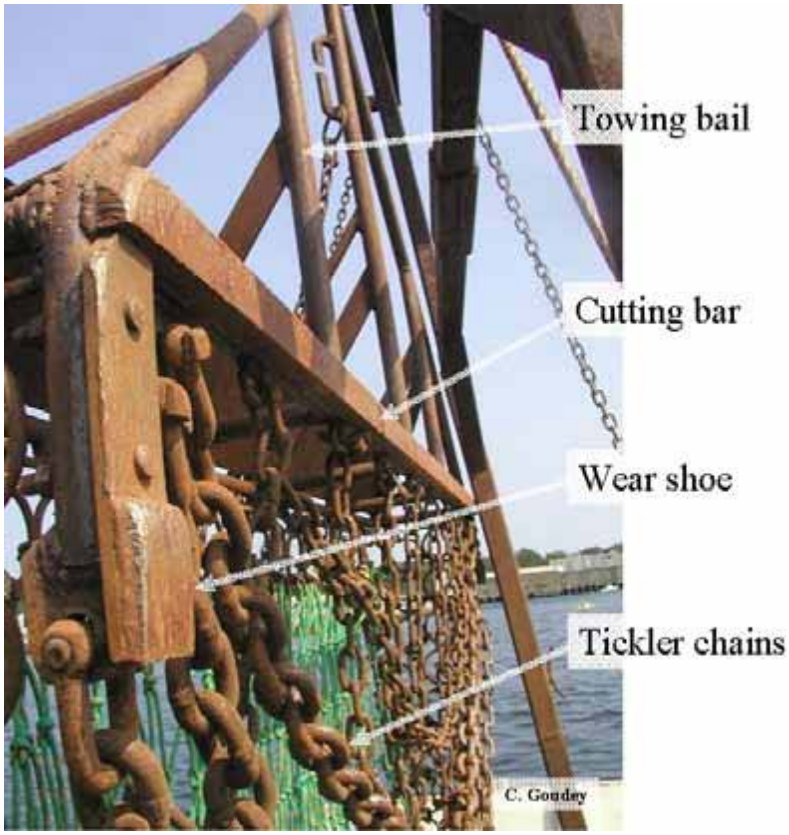


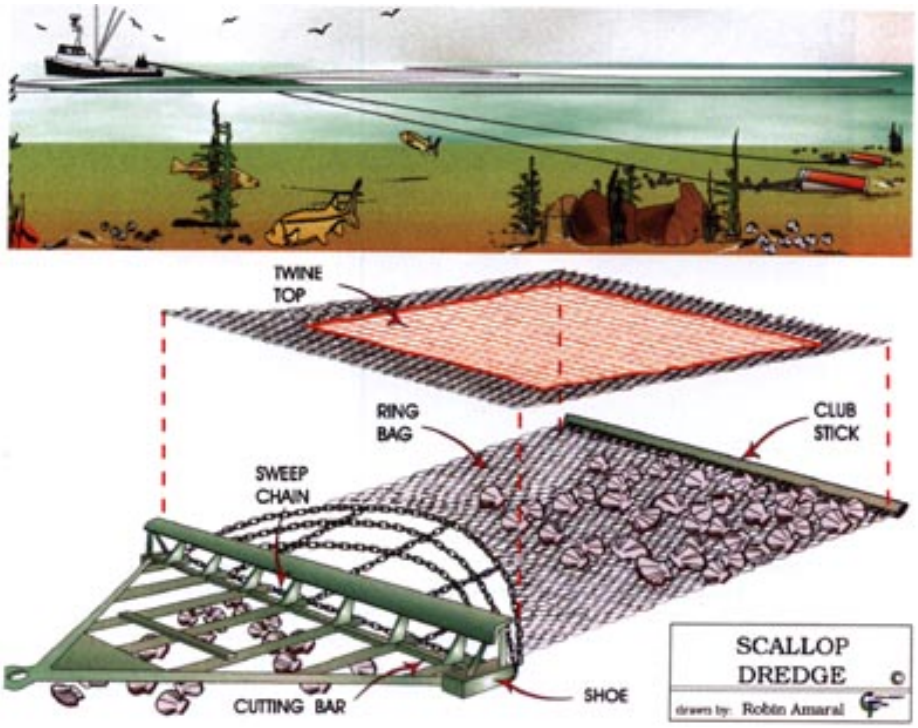
Figure 1. A typical New Bedford scallop dredge



Chain bag is constructed of individual iron rings connected by smaller iron rings.

Figure 2: Side view of scallop dredge

SMOLOWITZ FIGURE 2 (page 48) The New Bedford style scallop dredge, with top removed for illustration. Drawing by Robin Amaral.



The combined weight and amount of hardware in contact with the seabed explains why this type of gear is singled out as uniquely damaging to ocean habitat. Yet, the economic significance of the east coast sea scallop fishery and the traditional use of this gear make the adoption of alternate gear challenging. In spite of this challenge, a clear mandate exists for developing a habitat-friendly and economically viable method of catching scallops.

Common Misconceptions/Preconceptions:

Materials:

Per Class

- Paper towel
- Plastic tablecloths to cover tables

Per Team

- 10 straws
- 15 hex nuts (2 sizes)
- netting
- 5 ft string
- 40 paperclips (2 sizes)
- scissors
- ruler
- graph paper for sketching diagram
- chart paper and markers for brainstorming
- Samples of objects used to simulate scallops (one of each size)

Simulated Ocean Ecosystem

- 30 gallon fish tank with sand bottom, filled with water
- various objects to represent sea life (plants and animals)
- small round objects in various sizes to simulate scallops (I used glass beads)

Videos*

1. Simulation of scallop dredging: http://youtu.be/_ew7xYKEr94
2. Footage of actual NOAA Sea Scallop tow: http://s1229.photobucket.com/albums/ee472/channacomer/?action=view&current=EditedTASVideo.mp4

*If your school has a firewall that prevents you from accessing You Tube videos, you can use any free video conversion site (like this one) to convert the video into and FLV file which can be opened on any video viewer installed on your computer.

Technical Requirements:

Computer with projector and access to the internet (to play videos).

Teacher Preparation:

- Prepare a packet of materials for each student team. Snack size zip lock bags can be used to separate small items (nuts, paper clips, etc.) and all materials can be placed in a large (gallon sized) zip lock bag.
- Plastic tablecloths can be used to protect tables and make cleanup easier.
- Prepare model ocean environment by placing sand at the bottom of the tank, then model organisms and plants. Fill the tank with water. The tank should be placed so that several groups can gather around the tank at once to make observations

Key Words: Sea Scallop, dredge, ecosystem, constraint, habitat

Anticipatory Set:

Viewing of the video and observation of the model ocean ecosystem serve as the anticipatory set for this activity.

Lesson Procedure:

- Students should work in teams of two or three. (Do not give students design supplies until they are ready to begin the actual building. Once they receive their supplies, most will want to start building right away).
- Review handout (especially constraints) and assessment rubric with an opportunity for students to ask clarifying questions.
- Have students make written observations of the model ocean environment and share out to the class.
- Show students two videos (sea scallop tow, dredging simulation). The schematics of a dredge should not be provided to the students prior to their own design attempts. The purpose of the design challenge is for students to use their own ideas to develop a solution. You may want to share the design schematics with students once they have completed two cycles of design and testing.

- Students brainstorm ideas with their team. All brainstorming ideas should be written on chart paper. Each team should have several possible solutions to choose from.
- Using graph paper, students should create a labeled drawing of their proposed solution on chart paper with dimensions.
- Students build their prototype according to their design.
- Prototype is tested in the model ocean environment.
- After the first test, students should be given time to troubleshoot and modify their design.
- Once they have modified their design, they should re-test and if time allows, make further modifications.
- Once their design is finalized, students should work together to answer the analysis questions and write their presentations.
- Each team presents their solution/rationale and answers to questions to the class.
- Class discussion with feedback and questions from other students.

Student designs must meet the following criteria/constraints:

1. Students can only use must use only the materials provided (it is not required that they use everything)
2. Dredge must fall to the ocean floor on its own.
3. Dredge must remain (flat) on the ocean floor for the duration of the tow
4. Dredge must capture scallops

Additional Notes

- Depending on student level, you may choose to assign roles within the group.
- This activity can be scaled up or down to meet the needs of younger students or more advanced students. The level of challenge will change depending on the constraints given.
- If space, time and resources permit, each team can be given a small (5 gallon fish tank) model ocean system to use as they work on their design.

Assessment and Evaluation:

Each team will be assessed on how well their design meets the provided constraints. Additionally, each group will prepare an oral and written presentation describing the rationale for their final design and their answers to the analysis questions.

Sea Scallop Dredge Design Challenge
Assessment Rubric

	1	2	3	4
Design solution met all constraints				
Rationale clearly demonstrates an understanding of the problem and shows creativity in developing a solution				
Answers to analysis questions show an understanding of how human activity affects the ocean ecosystem				

Answers to analysis questions show an understanding of how human activity affects society				
Team showed effective collaboration with everyone participating equally				

Standards:

National Science Education Standards Addressed:
Unifying Concepts and processes in science.
Evidence, models, and explanation
Evolution and equilibrium

Life science.
Interdependence of organisms

Science and technology.
Abilities of technological design

Science in personal and social perspectives.
Natural resources

Ocean Literacy Essential Principals Addressed:
5 The ocean supports a great diversity of life and ecosystems.
Fundamental Concept: e, f

6 The Ocean and humans are inextricably connected
Fundamental Concept: b, e, g

New York State Standards Addressed:
New York State Living Environment Core Curriculum
Standard 1
Key Idea 1: The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing and creative process.
Performance indicator: 1.1, 1.2

Key Idea 2: Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

Key Idea 3: The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into natural phenomena.
Performance indicator: 3.1, 3.4

Standard 4
Key Idea 6: Plants and animals depend on each other and their physical environment.

Performance indicator: 6.1f, 6.1g, 6.3a, 6.3c

Key Idea 7: Human decisions and activities have had a profound impact on the physical and living environment.
Performance indicator: 7.1c, 7.2a, 7.2b

New York State Technology Learning Standards
Standard 5 - Technology
Engineering Design
1. Engineering design is an iterative process involving *modeling* and *optimization* used to develop technological solutions to problems within given constraints.

Impacts of Technology
6. Technology can have positive and negative impacts on individuals, society, and the environment and humans have the capability and responsibility to constrain or promote technological development.

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Sea Scallop Dredge Design Challenge
Student Handout

Introduction

In this lesson, your team will use the materials provided to design a sea scallop dredge to collect scallops.

Objectives/Learning Goals:

- Understanding of human activity on the ocean ecosystem
- Development of critical thinking and problem solving skills
- Understanding of the design and engineering process
- Work effectively in collaboration with others

Observations

Before you begin the design challenge, write your observations of the ocean environment here:

_____
_____
_____
_____

Materials

Per team:
- 10 straws
- 15 hex nuts (2 sizes)
- netting
- 10 ft string
- 20 paperclips
- 10 medium binder clips
- scissors
- ruler
- graph paper for sketching diagram
- chart paper and markers for brainstorming

Simulated ocean floor

- 30 gallon fish tank with sand bottom, filled with water
- various objects to represent sea life (plants and animals)
- small round objects in various sizes to simulate scallops (I used glass beads)

Criteria/Constraints:

5. You must use only the materials provided (it is not required that you use everything)
   - 10 straws
   - 15 hex nuts (2 sizes)
   - netting
   - 5 ft string
   - paperclips

6. Your dredge must fall to the ocean floor on its own
7. Your dredge must remain (flat) on the ocean floor for the duration of the tow
8. Your dredge must capture scallops

Procedure

Step 1 – Brainstorm
Brainstorm ideas and questions with your team. Assign one person to be the recorder for your team. Record your ideas/questions on chart paper. Come up with several possible solutions, then choose one.

Step 2 – Create a labeled drawing of your solution on the graph paper

Step 3 – Build your prototype

Step 4 – Test your prototype

Step 5 – Make observations, research, troubleshoot and modify design.

Step 6 – Re-test

Repeat Steps 5 and 6 until you have your final design and are ready to present.

Final Step – Present your results

Analysis Questions

5. What are the effects of sea scallop dredging on the ocean? (Habitat for other organisms, ocean pollution, effects on other organisms in the ocean, etc.).

_____
_____
_____
_____

6. What is the relationship between the design of your dredge and the size of the organisms that will be caught?

_____
_____
_____
_____

7. How are people affected by dredging for sea scallops?

_____
_____
_____
_____

8. What can be done to minimize the negative impacts of sea scallop dredging?

_____
_____
_____
_____

General Specifications for Sea Scallop Dredge

Scallop dredges are used by fishermen to harvest scallops. The design and weight of the typical scallop dredge have raised concerns about its impact on ocean habitats.

Structure

A scallop dredge is made of a heavy steel bar with a triangular frame.

Chain bag

There is a bag on the back of the triangular frame that is made of steel rings. Regulations limit the size of the rings and the mesh of the bag to ensure that the scallops caught are not too small, and to reduce the catching of other sea life.

Chain bag supports

A chain sweep hangs beneath the chain bag on either side of the frame for support. Other chains often precede the chain sweep on the design to lift scallops toward the chain bag.

Pressure plate

A pressure plate on the upper back portion of the frame allows some downward pressure in the water, aided by the weight of the rest of the dredge.

Cutting bar

The cutting bar is a particularly controversial part of the dredges used to catch scallops. The cutting bar, which gives structural support to the dredge, can lop off or damage parts of the sea floor, including portions of sand dunes.