



Balance in the Bay

In this activity, students will take part in a simulated fishery, harvesting California market squid - *Doryteuthis opalescens* (formerly *Loligo opalescens*) - that are common in Monterey Bay and the Pacific Ocean. Because of their quick response time to environmental conditions, market squid can provide an interesting example of ecosystem-based management at work. Student groups will take on various roles in a simulated fishing community, making decisions while also facing a range of natural and man-made challenges. These decisions will impact their own well-being in addition to the well-being of the natural squid population as a shared or “common” resource. Maintaining a balance that sustains both the squid population and the squid fishery that relies on that population will prove to be challenging. Students will analyze their decisions and recognize the difficulty associated with maintaining a healthy “balance in the bay.”





Grade Level: 8-12,
Community College

Time Frame

Preparation:

- 30 minutes to review complete module and prepare student materials.

Facilitation:

- Day 1: 50 minutes to conduct the initial fishing simulation, discuss the outcomes, and challenge students to devise strategies for a better “balance in the bay.”
- Day 2: 50 minutes to view Balance in the Bay PowerPoint slides, reach consensus on student devised strategies for sustainability, and introduce added roles for a Marine Scientist and Regulatory Agency Representative.
- Day 3: 50 minutes to conduct second round of simulation and discuss how sustainable strategies and ecosystem-based management practices help maintain a better “balance in the bay.”
- Additional 1-2 class periods for optional extensions.

Brief Overview

The Monterey Bay National Marine Sanctuary, and the Pacific Ocean beyond, are rich and valuable resources shared by many. The living organisms that populate these vast ocean **ecosystems** are also a shared resource, as well as being biologically interconnected for their own survival and sustainability. Managing these resources on behalf of the many individuals, businesses, states, and nations that share them can be a challenge. Maintaining a balance between the health and long-term **sustainability** of the natural resources as well as the health and economic vigor of the individuals and communities that depend on these resources makes the challenge even more complex. **Ecosystem-based management** is an exciting new approach to resource management that addresses these challenges. Looking at an entire ecosystem, usually containing many interrelated and interdependent resources and users, is becoming a more common approach for measuring and maintaining balance within an ecosystem and the communities supported by that ecosystem.

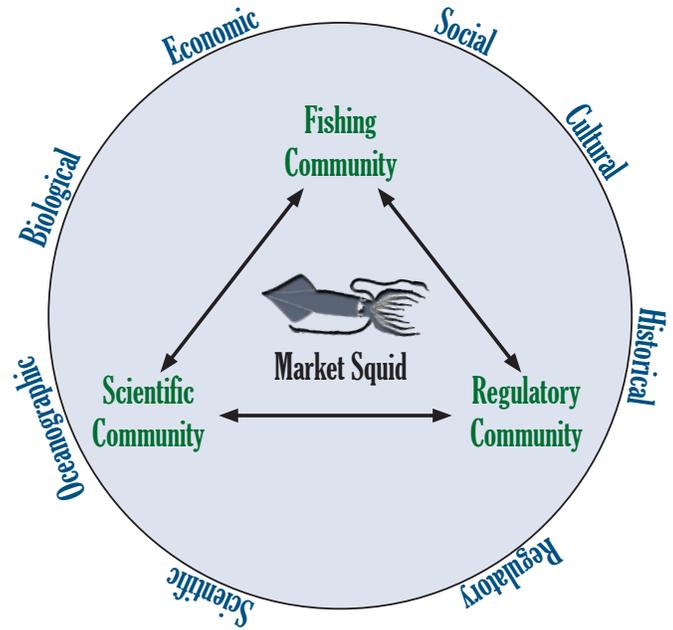


Figure 1. Ecosystems-based Factors Influencing Squid Fisheries Management.

Skills/Outcomes

- Students will gain an understanding of some of the inter-related factors involved in the ecosystem-based management of a marine resource.
- Students will learn to effectively apply critical thinking and problem-solving skills to respond to natural and man-made challenges.
- Students will learn how to apply ecosystem-based management principles to find solutions.
- Students will learn to use basic arithmetic to calculate and record numerical values, prepare and interpret graphs and charts, and make decisions based on their understanding of these numbers.



Purse seiner spreading a net for squid, 1957. (J. B. Phillips photograph; courtesy Tim Thomas, Monterey Maritime and History Museum.)

Key Subjects/Standards

Biology, economics, mathematics, ecosystem-based management.

National	<p><u>Science</u>: NS.9-12.1 Science as Inquiry. NS.9-12.6 Personal and Social Perspectives: population growth, natural resources, environmental quality.</p> <p><u>Math</u>: NM-NUM.9-12.3 Number and Operations: compute fluently and make reasonable estimates. NM-PROB.CONN.PK-12.3 Connections: recognize and apply mathematics in contexts outside of mathematics.</p> <p><u>Economics</u>: NSS-EC.9-12.1 Scarcity. NSS-EC.9-12.11 Role of Money. NSS-EC.9-12.13 Role of Resources in Determining Income.</p> <p><u>Social Sciences</u>: NSS-G.K-12.2 Places and Regions. NSS-G.K-12.3 Physical Systems.</p>
California	<p><u>Science</u>: Grade 9-12, Ecology (6): Sustainability in an ecosystem is a balance between competing effects. Grade 9-12, Investigation & Experimentation (1): Scientific progress is made by asking meaningful questions and conducting careful investigations.</p> <p><u>Math</u>: Algebra I (3.0): Students solve equations and inequalities involving absolute values. Algebra I (5.0): Students solve multi-step problems, including word problems, involving linear equations and linear inequalities in one variable and provide justification for each step.</p>
Ocean Literacy	<p>1. The Earth has one big ocean with many features. (h)</p> <p>5. The ocean supports a great diversity of life and ecosystems. (f)</p> <p>6. The ocean and humans are inextricably interconnected. (b, c, e, g)</p>

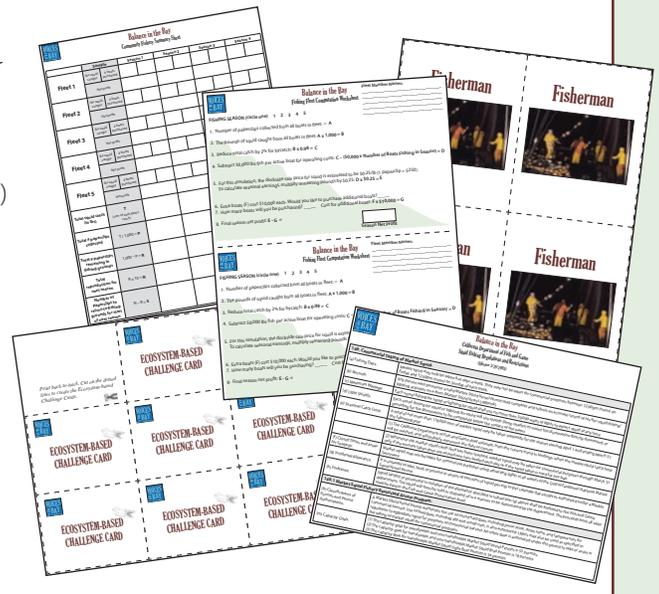
Teacher Preparation

1. Read entire activity and review all student handout materials and the Balance in the Bay PowerPoint in advance.
2. Print/copy materials as listed in the Materials List section.
3. Locate a relatively open space that is approximately 20ft x 20ft square. A school cafeteria, courtyard, parking lot, gymnasium, large classroom, or hallway will work. Arrange exclusive use of this space for at least two 50-minute class periods.
4. If using an overhead projector, make a transparency of the Community Fishery Summary Sheet chart for recording fishing season results. Otherwise, reproduce chart on a large white board or on paper to facilitate sharing group results with the entire class.

Materials List

For a classroom of 30 students:

- Squid Fisheries PowerPoint slides, pre-loaded into presenting computer or printed out for each student for use on Day 2
- 1,000 standard paperclips (each paperclip = 1,000 pounds of market squid)
- A relatively open area roughly 20ft x 20ft square (ocean fishing grounds)
- Pencil/pen for each fishing fleet of five students
- 30 paper cups (representing purse seine boats)
- 60 Fishing Fleet Computation Worksheets, ten for each fishing fleet
- 8 calculators, one per fishing fleet and two extras for Marine Scientist and Regulatory Agency Representative roles for Day 3 simulation
- 1 set of Role Cards (includes 6 Fisherman, 1 Marine Scientist, and 1 Regulatory Agency Representative)
- 1 set of Ecosystem-based Challenge Cards
- 2 Community Fishery Summary Sheets, as overhead transparencies or large wall chart
- 30 California Department of Fish and Game (CDFG) Squid Fishing Regulations and Restrictions handouts





Instructional Strategies/Procedures

Day 1: Fishing for Market Squid

1. Randomly scatter the 1,000 paperclips throughout the designated 20ft x 20ft area which will serve as the “fishing grounds” for the simulation. It is ok if they are clustered or unevenly distributed as this, in itself, models how squid naturally congregate in massive schools.
2. Explain to students that they will be participating in a multi-day activity that explores some of the challenges associated with balancing multiple factors – biological, economic, cultural – using a fishery simulation modeled on the market squid fishery in the Monterey Bay National Marine Sanctuary.
3. Divide class into six “fishing fleets” of five students each.
4. Evenly position student “fleets” along the edge of the 20ft x 20ft fishing grounds. Provide each fisherman with a paper cup (boat hold) and a “Fisherman” role card for the fleet.
 - a. Have them read aloud the text on the back of the card.
 - b. Then, have them select one fisherman from their fleet who will be the only boat to fish in the first season.
 - c. Tell the students to imagine that the designated area represents a portion of the market squid’s habitat: an open-water space, within 200 miles of the central California coastline.
 - d. Announce that each fleet will be allowed to send one boat (one student) in the first season (1 minute) to harvest squid (paperclips).
5. Announce the start of the first season. One fisherman from each fleet should enter the fishing grounds to collect squid (paperclips), storing them in their paper cup. At the end of 1 minute, shout “stop.” Fishermen return to their fleet’s port to count their catch.
6. Hand out 5 Fishing Fleet Computation Worksheets to each fleet. Instruct students to follow the instructions on their worksheet to calculate their squid catch (in pounds) and their net profit after expenses and re-investments. Allow students 5-10 minutes to complete their calculations.
7. Ask each student fleet to report the following numbers from Season 1. Record these numbers on the Community Fishery Summary Sheet:
 - Pounds of squid caught (#2 on Fishing Fleet Computation Worksheet)
 - Number of new boats purchased (#6 on Fishing Fleet Computation Worksheet)
 - Net profit (#8 on Fishing Fleet Computation Worksheet)
8. Using the numbers reported by each fleet on the Community Fishery Summary Sheet, calculate the number of paperclips to return to the fishing grounds for the next season. Note: for this simulation it is assumed that the reproduction rate will be 10x annually. This means that if, after the first fishing season, there were 85 paperclips left in the fishing grounds, the number to start the next season with should be 850. The maximum number of paperclips in the fishing grounds at any one time is 1,000. If the calculated number of paperclips to return (“S” from the Community Fishing Summary Sheet) is over 1,000, introduce the concept of **carrying capacity**.
9. Collect all the paperclips from each fleet. Randomly scatter the appropriate number of paperclips to the fishing grounds (“S” from the Community Fishing Summary Sheet) and set aside the remaining paperclips.
10. Repeat steps 5-10 for two more seasons of fishing, adding additional fishermen if new boats are purchased.
11. After three seasons have passed and all calculations completed, ask each student fleet to make a prediction about the squid population and their fleet’s on-going profits and success based on their data so far. If time allows, have each group share their predictions with the entire class.



Boat fishing for squid off the Monterey coast. (Photo: Sabrina Beyer.)

12. If time allows, have the students complete a fourth season and record their data.
13. *Class Discussion:* At this juncture, various trends may be emerging. Gather the students and discuss the following questions:
 - a. Which fishing fleet was the most profitable?
 - b. What happened to the catch numbers as the seasons progressed?
 - c. What were the effects of having more boats fishing in the common waters?
 - d. What happened to the total number of available squid as the seasons progressed?
14. Inform the students that in two days they will repeat the fishing simulation with a new goal: sustaining the greatest number of boats for the longest period of time while maintaining a healthy squid population season to season. Ask them to think over night about strategies that their community might put in place in order to realize such a goal.

Day 2: Seeking Balance in the Bay

1. Ask the students to share some of their ideas for sustaining the market squid fishery simulated the previous day. Record these potential strategies for later class reference.
2. Show students the Balance in the Bay PowerPoint presentation. These slides will introduce the students to some basic squid biology, fishery history, and economic factors that can impact the fishery. Students will be introduced to additional members of the community, such as Marine Scientists and Regulatory Agency Representatives, who can help sustain a fishery through the application of ecosystem-based management practices.
3. Remind students of their new community-wide challenge: sustaining the greatest number of boats for the longest



Sicilian squid fisherman asleep on his boat. The Sicilians first came to Monterey, circa 1905, bringing with them the lampara net. At this time in America, squid was considered a junk fish, so the Sicilians sold it to the Chinese. (Courtesy Tim Thomas, Monterey Maritime and History Museum.)

period of time while maintaining a healthy squid population season to season.

4. Appoint one student from the class to serve as a Marine Scientist and another student to serve as a Regulatory Agency Representative in the next rounds of the simulation. Provide role cards to these two students and have them read their duties aloud to the class.



Leeanne Laughlin, Marine Scientist for CDFG, dissecting squid. (Photo: Briana Brady.)

5. Ask the students to brainstorm within their fleets preferred strategies for sustaining the squid population. Brainstormed ideas may include: limiting the number of fishing boats, shorter fishing seasons, closing off areas to fishing, etc. Encourage students to be creative in brainstorming strategies for sustainability. Once each fleet has a few ideas, instruct all the fleets to cooperate and agree to a community-wide strategy or set of strategies before repeating the multi-season simulation the next day. Have the Regulatory Agency Representative help facilitate this discussion and ask the Marine Scientist to propose their own ideas based on their role and responsibility in the community.

Day 3: Ecosystem-based Management in Action

1. Review with the students the sustainability strategies they agreed to the previous day. Also, remind them of the two additional community roles that were added – Marine Scientist and Regulatory Agency Representative.
2. Introduce them to a third parameter that they will need to address: Ecosystem-based Challenges. These challenges, introduced at the start of each season by cards drawn randomly by the Marine Scientist, will provide an additional, realistic dimension to the simulation.
3. Provide each student fleet with five more blank Fishing Fleet Computation Worksheets. Using a fresh Community Fishery Summary Sheet for recording, conduct another multi-season simulation adding the new community roles (Marine Scientist and Regulatory Agency Representative), Ecosystem-based Challenge Cards, and sustainability strategies agreed to by the whole community. Remind the Regulatory Agency Representative to choose a fleet each fishing season and count their catch when they return to port. Remind the Marine Scientist to record data on the Community Fishery Summary Sheet.
4. *Class Discussion:* After four seasons have been recorded, gather the students to discuss their observations and to what extent they were able to maintain a better balance applying their chosen strategies. Ask the following questions:
 - a. What are the factors now affecting availability of squid?
 - b. Were the fishing fleets still profitable?
 - c. How did the agreed upon strategies affect fishing? Fleet profitability? Numbers of squid returning each season? Number of seasons with strong squid populations available?
 - d. How did certain Ecosystem-based Challenges affect the above?
5. Hand out copies of the California Department of Fish and Game Squid Fishing Regulations and Restrictions. Ask students to read these and compare them to their own agreed upon strategies for sustainability. Which strategies, regulations, and restrictions do they think contribute the most to maintaining a better “balance in the bay”?



“Squid Mountain,” circa 1930. The Chinese bought the squid from the Sicilian fishermen and trucked it away from the city to drying fields located off the Monterey-Salinas Highway (across from what is now the Monterey Airport) because of the strong smell. (J. B. Phillips photograph; courtesy Tim Thomas, Monterey Maritime and History Museum.)

Extensions & Connections

1. Have students read Garrett Hardin's paper titled “Tragedy of the Commons” published in *Science Magazine* in 1968. Or, simply read them the excerpt in the Background section of this module. After reading the paper, have students discuss how the fishing simulation relates. What was the commons? What was the tragedy? Did the particular strategies described in the article help prevent the tragedy from happening? How does this article relate to their own experience trying to maintain a “balance in the bay”?
2. Allow students time to discuss additional (or different) ecosystem-based management strategies to apply to their squid fishery simulation. Repeat the simulation 1-2 more times to test their ideas even while accommodating new ecosystem-based challenges. The ultimate goal is to settle on a set of cooperative strategies that result in true sustainability regardless of the challenges faced.
3. Have students select a particular fishery and research its history over time. Over a 50-100 year period, what happened to the number of fish landed, the number of boats/fishermen supported by the fishery? Were there strategies put in place to sustain a healthy balance? Was the balance sustained?
4. Have the students research the different fisheries found in Monterey Bay (sardine, salmon, rockfish, crab, etc.). Have them adapt the Balance in the Bay activity to simulate one or more of these fisheries or accommodate multiple fisheries in a single simulation. Keep in mind species-specific reproductive rates, fishing methods, boat costs, economic value, typical landings, etc. Allow the students to try their ideas in a future class period.



Background

The ocean waters around the United States (out to 200 miles, the limit of our **Exclusive Economic Zone**, or EEZ) are common property – every citizen “owns” a share in those resources, with the government managing it for the common good. However, history has shown us that communal resources are often maximized to individual benefit, sometimes to the detriment of the resource as a whole. In “The Tragedy of the Commons,” Garrett Hardin writes, “A finite world can support only a finite population.” This is referred to as “the tragedy of the commons.”

In Garrett Hardin’s own words:

*The tragedy of the commons develops in this way. Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the **commons**. Such an arrangement may work reasonably satisfactorily for centuries because tribal wars, poaching, and disease keep the numbers of both man and beast well below the carrying capacity of the land. Finally, however, comes the day of reckoning, that is, the day when the long-desired goal of social stability becomes a reality. At this point, the inherent logic of the commons remorselessly generates tragedy.*

As a rational being, each herdsman seeks to maximize his gain. Explicitly or implicitly, more or less consciously, he asks, “What is the utility to me of adding one more animal to my herd?” This utility has one negative and one positive component.

1. The positive component is a function of the increment of one animal. Since the herdsman receives all the proceeds from the sale of the additional animal, the positive utility is nearly + 1.

2. The negative component is a function of the additional overgrazing created by one more animal. Since, however, the effects of overgrazing are shared by all the herdsmen, the negative utility for any particular decision-making herdsman is only a fraction of - 1.

Adding together the component partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another.... But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit -- in a world that is limited.

(Hardin, 1968)

To prevent this “tragedy,” fisheries are managed by both the state and federal governments for the benefit of all citizens. The legislation that directs how our federal government manages fishery resources is the 1976 **Magnuson-Stevens Fishery and Conservation Management Act**. This act was first revised in 1996 with the Sustainable Fisheries Act, and was revised again in 2006, reaffirming America’s commitment to fishery protection.

Generally speaking, the state (in this case the California Resources Agency, California Department of Fish and Game, and the Fish and Game Commission) is responsible for managing fisheries within three miles from shore and the federal government, National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries) is responsible for managing fisheries between 3-200 miles from shore. In California, many fisheries are managed jointly by state and federal agencies. A result of the Magnuson Act was the creation of eight regional fishery management councils. These councils create Fishery Management Plans (FMPs). These FMPs describe the nature of a fishery, including an assessment of fish population, and provide recommendations on how the fishery should be managed. The Pacific Fishery Management Council develops management measures for the EEZ off the coasts of Washington, Oregon, and California.

Those working in the fishing industry have the responsibility to comply with state and federal regulations. In the late 1990s, amendments to the Magnuson Act were passed that mandated more conservative management of marine resources. Working to minimize the negative effects posed by the “tragedy of the commons,” the full implementation of these new laws often results in more restrictive regulations to prevent overfishing, limit **bycatch**, preserve essential fish habitat, and whenever possible, rebuild depleted fish stocks. More restrictive regulations have led to shorter seasons and lower quotas for many species, thus reducing the flexibility and economic viability of many fishing enterprises.

Scientific research performed on specific fish species provides an understanding of the nature and biology of that particular species. For successful and effective management, however, resource managers must have an understanding of the entire marine environment while also accounting for the rights and success of those in the fishing industry. Ecosystem-based management is a comprehensive method for managing and assessing the biological, ecological, economic, political, and social aspects of fisheries and environmental quality. Ecosystem-based management accounts for many elements including water quality, climate, predator/prey interactions, harvest pressure, regulatory policy, and the economic and social factors that result from harvesting the resource. The Monterey Bay National Marine Sanctuary is one of the most diverse marine environments in the world, with 345 species of fish, 33 species of marine mammals, 94 species of seabirds, and home to the largest kelp forest in the nation. For those reasons and more, it is critical to have an effective, contemporary, and dynamic approach to fisheries management. This is why ecosystem-based management practices are increasingly being used in the Monterey Bay National Marine Sanctuary and other sensitive and productive fishing grounds around the globe.

Resources for Teachers

Hardin, G. (1968) The Tragedy of Commons. *Science Magazine*, 162: 1243-48.

Monterey Bay National Marine Sanctuary website:
<http://montereybay.noaa.gov/>

References Specific to this Activity

Leos, B. (2007). *Commercial landings tables*. California Department of Fish and Game.

Magnuson-Stevens Fishery Conservation and Management Act. (1996). Public Law 94-265. Retrieved from <http://www.nmfs.noaa.gov/sfa/magact/>

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National Oceanic and Atmospheric Administration. (2007) *Ecosystem-based Management*. Retrieved July 8, 2008, from: http://celebrating200years.noaa.gov/magazine/chesapeake_fish_mgmt/side1.html

Acknowledgments

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NOAA's National Marine Sanctuary Program
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Additional Credit

The simulation part of this activity was adapted with permission from a previous activity titled *Tragedies in the Commons* developed by the Biological Sciences Curriculum Study (BSCS) to celebrate National Science & Technology Week. April, 1990.

Original Artwork

© Ray Troll & NOAA Fisheries Service's "Green Seas/Blue Seas Project" (<http://swfsc.noaa.gov/GreenSeas-BlueSeas>)

Market squid drawing. © Lynn McMaster, 1996.

Vocabulary

Bycatch: Living creatures that are caught unintentionally by fishing gear and are often unmarketable and unused. An example of bycatch is dolphins caught in tuna nets.

Commons: Belonging to, or shared equally by two or more individuals or populations.

Carrying Capacity: The carrying capacity of a particular environment is the greatest number of individuals of a given species that can be supported with the environment's available resources.

Ecosystem: A geographically specified system of organisms, including humans, the environment, and the processes that control its dynamics.

Ecosystem-based Management: A broader more comprehensive management approach that takes into account the interaction of ecological, economic, cultural, and regulatory factors impacting the overall health of an ecosystem and the communities dependent on that ecosystem. Specific factors may include pollution, coastal development, harvest pressure, predator/prey and other ecological interactions, as well as nearby watershed management.

Exclusive Economic Zone (EEZ): An area along a country's coastline, extending from 3 to 200 nautical miles from shore, to which a country claims exclusive rights for economic activities.

Limited Entry: A strategy used to control the size of fishing fleets by limiting the number of fishing vessels allowed to legally harvest seafood.

Magnuson-Stevens Fishery Conservation and Management Act:

This act provides for the conservation and management of fishery resources found off the coasts of the United States. The act established a national fishery conservation zone (Exclusive Economic Zone or EEZ) extending from 3 to 200 nautical miles off the coast of the United States, set up a council system, mandated fishery management plans, and set standards for fishery conservation and management practices.

Sustainability: A state that can be maintained at a certain level indefinitely. The potential longevity of ecological systems, such as the planet's climatic system, systems of agriculture, industry, forestry, fisheries, and the ecological infrastructure on which they depend.



Fisherman



Fisherman



Fisherman



Fisherman



You are a fisherman with a 50-foot vessel. Your boat is equipped for purse seine fishing, allowing you to fish for squid and other wetfish (sardine, anchovy, mackerel). Your livelihood depends on the size of your catch. You are a part of a multi-boat fleet fishing in shared or common waters in the Monterey Bay National Marine Sanctuary.

1. In the first season, only a single fishing boat (one fisherman) goes out from each fleet.
2. Gather as many paperclips (squid) as you can using your left hand, and placing them in your paper cup (boat hold).
3. After the fishing season, count your catch (1 paperclip = 1,000 lbs of market squid).
4. As a fleet, calculate your seasonal earnings using the Fishing Fleet Computation Worksheet.
5. As net profits allow, you may choose to buy additional boats. When additional boats are purchased, additional student "fishermen" are allowed to fish in the next season.

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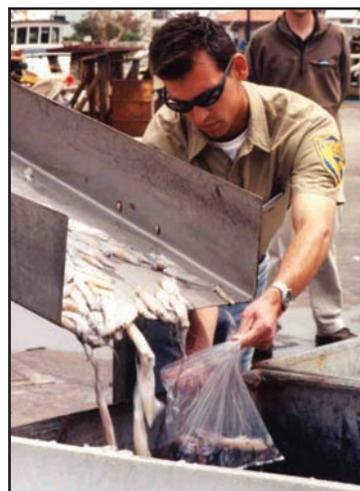
Fisherman



Marine Scientist



Regulatory Agency Representative



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You are an employee of the California Department of Fish and Game. You are responsible for maintaining a balance between the economic health of the fishing community and the ecological health of Monterey Bay. You develop and enforce regulations that define fishing boundaries, specific catch limits, types of gear allowed, etc. Your decisions are informed by assessing past environmental policy and reviewing, analyzing, and incorporating the most current fisheries, habitat, and water quality data generated by scientists.

1. Announce the start and stop time for each fishing season.
2. Monitor the fishing fleets for fair fishing practices.
3. Choose 1 fleet each fishing season and count their catch when they return to port to ensure accurate reporting of the catch.

You are an employee of NOAA's (National Oceanic and Atmospheric Administration) National Marine Fisheries Service. You are responsible for monitoring the marine ecosystem. You assess and predict the health and vigor of local and global fish populations, work to limit bycatch, and educate fishermen about the biology and ecology of the resources they are harvesting.

1. Before each fishing season begins, draw an Ecosystem-based Challenge Card and read aloud to the class. All fishing fleets must adhere to this challenge.
2. After the Fishermen have completed their computation worksheets, record the pounds of squid caught for the entire fishing community each season on the Community Fishery Summary Sheet.
3. Based on the number of paperclips collected in the previous season and the Ecosystem-based Challenge Card directions, calculate the number of paperclips to return to the fishing grounds for the next season.



Balance in the Bay

Fishing Fleet Computation Worksheet

Fleet Member Names:

FISHING SEASON (circle one) 1 2 3 4 5

1. Number of paperclips collected from all boats in fleet: = A
2. The pounds of squid caught from all boats in fleet: $A \times 1,000 = B$
3. Reduce total catch by 2% for bycatch: $B \times 0.98 = C$
4. Subtract 50,000 lbs fish per active boat for operating costs: $C - (50,000 \times \text{Number of Boats Fishing in Season}) = D$
5. For this simulation, the dockside sale price for squid is estimated to be \$0.25/lb (1 paperclip = \$250). To calculate seasonal earnings, multiply remaining pounds by \$0.25: $D \times \$0.25 = E$
6. Extra boats (F) cost \$10,000 each. Would you like to purchase additional boats? _____
7. How many boats will you be purchasing? _____ Cost for additional boats: $F \times \$10,000 = G$
8. Final season net profit: $E - G =$

Season Net Profit



Balance in the Bay

Fishing Fleet Computation Worksheet

Fleet Member Names:

FISHING SEASON (circle one) 1 2 3 4 5

1. Number of paperclips collected from all boats in fleet: = A
2. The pounds of squid caught from all boats in fleet: $A \times 1,000 = B$
3. Reduce total catch by 2% for bycatch: $B \times 0.98 = C$
4. Subtract 50,000 lbs fish per active boat for operating costs: $C - (50,000 \times \text{Number of Boats Fishing in Season}) = D$
5. For this simulation, the dockside sale price for squid is estimated to be \$0.25/lb (1 paperclip = \$250). To calculate seasonal earnings, multiply remaining pounds by \$0.25: $D \times \$0.25 = E$
6. Extra boats (F) cost \$10,000 each. Would you like to purchase additional boats? _____
7. How many boats will you be purchasing? _____ Cost for additional boats: $F \times \$10,000 = G$
8. Final season net profit: $E - G =$

Season Net Profit



Balance in the Bay

Community Fishery Summary Sheet

	Sample		Season 1		Season 2		Season 3		Season 4	
Fleet 1	lbs squid caught	# boats purchased								
	Net profit									
Fleet 2	lbs squid caught	# boats purchased								
	Net profit									
Fleet 3	lbs squid caught	# boats purchased								
	Net profit									
Fleet 4	lbs squid caught	# boats purchased								
	Net profit									
Fleet 5	lbs squid caught	# boats purchased								
	Net profit									
Total squid catch (in lbs)	T (sum of each fleet's catch)									
Total # paperclips collected	$T / 1,000 = P$									
Total # paperclips remaining in fishing grounds	$1,000 - P = R$									
Total reproduction for next season	$R \times 10 = N$									
Number of paperclips to return to fishing grounds for start of next season	$N - R = S$									

Print back-to-back. Cut on the dotted lines to create the Ecosystem-based Challenge Cards.



ECOSYSTEM-BASED CHALLENGE CARD



ECOSYSTEM-BASED CHALLENGE CARD



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ECOSYSTEM-BASED CHALLENGE CARD



ECOSYSTEM-BASED CHALLENGE CARD



ECOSYSTEM-BASED CHALLENGE CARD



ECOSYSTEM-BASED CHALLENGE CARD



An El Nino event impacts squid spawning grounds, resulting in a dramatic drop in harvestable squid the next season.

Return 2.5x the paperclips remaining from the previous season as stock for next season.

Conservationists are concerned that lights used by fisherman to attract squid may be negatively affecting nesting seabirds. Regulators require fishermen to modify their lights to reduce impact on seabirds.

Subtract \$200/boat from the fishing fleet's season earnings for modifying the attracting lights on your fleet's boats.

New ocean monitoring report finds lower than expected juvenile squid. Regulatory agency decides to shorten the length of the next squid fishing season by half.

Next fishing season lasts only 30 seconds.

Poor economic conditions in Asia result in drop in demand for market squid.

Subtract \$300 from the fishing fleet's next season's earnings for decreased sales and lost profit.

Heavy storm at sea damages boat rigging, making it unable to fish efficiently.

One boat per fleet must stay behind and skip this round of fishing.

Excellent ocean conditions result in a 50% increase in squid reproduction. Squid prefer and have a higher spawning success rate during times when there is a significant upwelling of nutrient-rich, cold, subsurface ocean water to the ocean surface.

Return 15x the remaining paperclips from the previous season as stock for next season.

An influx of Humboldt squid in the Monterey Bay National Marine Sanctuary prey on market squid.

Return only 7x the remaining paperclips from the previous season as stock for next season.

Bottom trawler lines drag on ocean floor, disturbing squid spawning grounds.

Return only 5x the remaining paperclips from the previous season as stock for next season.



Balance in the Bay

California Department of Fish and Game

Squid Fishing Regulations and Restrictions

(Effective 3/28/2005)

149. Commercial Taking of Market Squid.	
(a) Fishing Days.	Market squid may only be taken five days a week. They may not be taken for commercial purposes between 12:00pm (noon) on Friday and 12:00pm (noon) on Sunday of each week.
(b) Records.	Any person who possesses a valid Market Squid Vessel Permit shall complete and submit an accurate record of his/her squid fishing/lighting activities on a form (Market Squid Vessel Logbook).
(c) Maximum Wattage.	Each vessel fishing for squid or lighting for squid shall use no more than 30,000 watts of lights to attract squid at any time.
(d) Light Shields.	Each vessel fishing for squid or lighting for squid will use shields (lamp shades) to orient the illumination directly downward, or providing for the illumination to be completely below the surface of the water.
(e) Seasonal Catch Limit.	A total of not more than 118,000 tons of market squid may be taken statewide for the season starting April 1 and ending March 31 the following year.
	(1) The California Department of Fish and Game shall estimate, from the current trend in landings, when the market squid catch limit will be reached, and will publicly announce the date of closure.
	(2) Whenever the market squid catch limit has been reached, market squid may be taken for commercial purposes through March 31 only if the amount taken does not exceed two tons landed each day or if the squid taken is used for live bait.
(f) Closed Times and Areas for Seabirds.	Market squid may not be taken for commercial purposes using attracting lights in all waters of the Gulf of Farallones National Marine Sanctuary.
(g) Incidental Allowance.	It is unlawful to take, land, or possess in excess of two tons of squid per trip or per calendar day except as authorized under a Market Squid Vessel Permit.
(h) Forfeiture.	Squid landed or possessed in violation of the allowance specified in subsection (g) above shall be forfeited to the Fish and Game department. The squid will then be sold or disposed of in a manner to be determined by the department. The proceeds from all sales shall be paid in the Fish and Game Preservation fund.
149.1 Market Squid Fishery Restricted Access Program.	
(b) Classifications of Permits and Permit Authorization.	A Market Squid Vessel Permit authorizes the use of round haul gear, including purse seine, drum seine, and lampara nets for commercial harvest. Use of brail gear, including dip and scoop nets, is also authorized. Lights may also be used as specified in regulation to aggregate squid for purposes of commercial harvest. No other gear is authorized under this permit to take or assist in the taking of market squid for commercial purposes.
(m) Capacity Goals.	(1) The capacity goal for transferable and non-transferable Market Squid Vessel Permits is 55 permits. (2) The capacity goal for transferable and non-transferable Market Squid Brail Permits is 18 permits. (3) The capacity goal for transferable Market Squid Light Boat Permits is 34 permits.