VOICES of the BAY

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."

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

PRESERVE AMERICA
Explore and Enjoy Our Heritage

National Marine Sanctuaries

Grade Level: 8-12, Community College

Time Frame

Preparation:

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

Facilitation:

- One 50-minute period to conduct the initial fishing simulation, discuss the outcomes, and challenge students to devise strategies for a better "balance in the bay."
- One 50-minute period 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.
- One 50-minute period 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**.

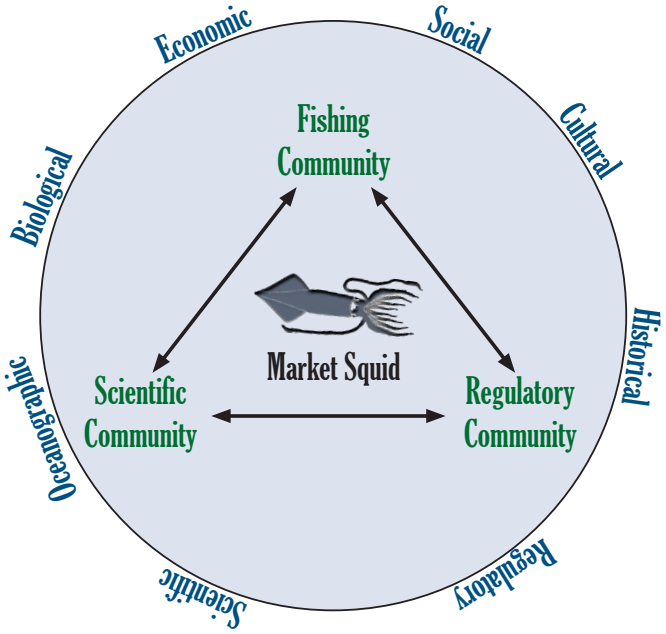


Figure 1. Ecosystems-based factors influencing squid fisheries management.

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	Science: NS.9-12.1 Science as Inquiry. NS.9-12.6 Personal and Social Perspectives: population growth, natural resources, environmental quality. Math: 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. Economics: 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. Social Sciences: NSS-G.K-12.2 Places and Regions. NSS-G.K-12.3 Physical Systems.
California	Science: 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. Math: 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.
Ocean Literacy	1. The Earth has one big ocean with many features (h). 5. The ocean supports a great diversity of life and ecosystems (f). 6. The ocean and humans are inextricably interconnected (b, c, e, g).

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.

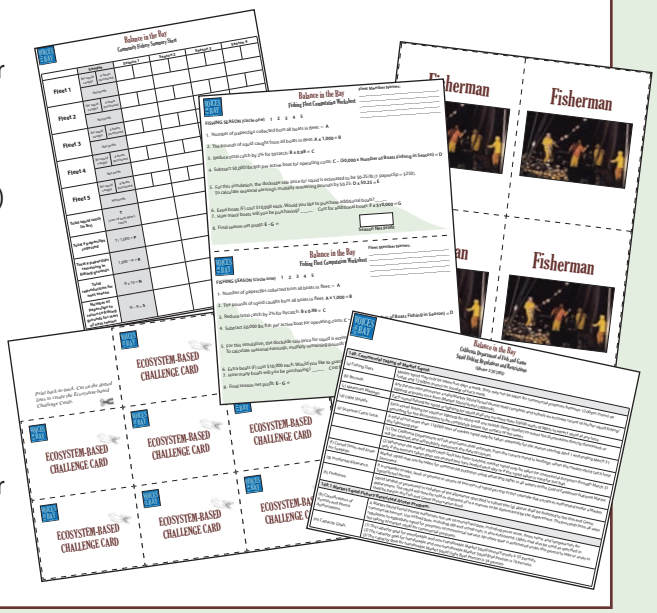
3. Locate a relatively open space that is approximately 20ft x 20ft square. A school cafeteria, courtyard, parking lot, gymnasium, large classroom, or hallway will work. Arrange exclusive use of this space for at least two 50-minute class periods.

4. If using an overhead projector, make a transparency of the Community Fishery Summary Sheet chart for recording fishing season results. Otherwise, reproduce the 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

For a classroom of 30 students:

Fishing for Market Squid

1. Randomly scatter the 1,000 paperclips throughout the designated 20 ft x 20 ft 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 – in a fishery using a fishery simulation modeled on the market squid fishery in the Monterey Bay National Marine Sanctuary.

3. Divide class into five "fishing fleets" of six students each (hereafter called student fleet).

4. Evenly position student fleets along the edge of the 20ft x 20ft fishing grounds. Provide each fisherman with a paper cup (boat hold). Provide a "Fisherman" role card to each student 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 student fleet will be allowed to send one boat (one student) in the first season (1 minute) to harvest squid (paperclips).
   e. Each paperclip will represent 1,000 pounds of market squid. Each student fleet needs at least 50 paperclips (50,000 pounds of squid) per boat per season just to feed their families and pay their bills. Financially, each paperclip is worth $250 in the simulation (1,000 pounds of squid at $0.25/lb).

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

5. Announce the start of the first season. One fisherman from each student 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 student 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 Fishing Fleet Computation Worksheet)
   - Number of new boats purchased (#6 Fishing Fleet Computation Worksheet)
   - Net profit (#8 Fishing Fleet Computation Worksheet)

8. Using the numbers reported by each student fleet, calculate the number of paperclips to return to the fishing grounds for the next season (S on the Community Fishery Summary Sheet). 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 student 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 within a student fleet.

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.

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. Complete the Community Fishery Graph. Gather the students and discuss the following questions:
    a. Which student 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 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 about strategies that their community might put in place in order to realize such a goal.

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 the class to reference later.

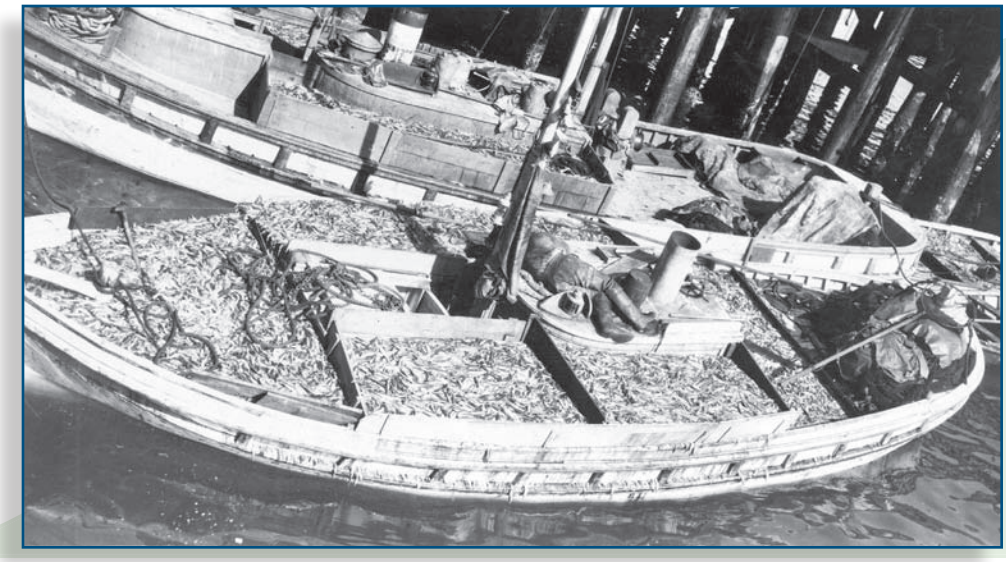
2. Show students the Balance in the Bay PowerPoint presentation. These slides will introduce the students to some basic squid biology, fishery history, and economic factors that can impact the fishery. Students will be introduced to additional members of the community - Marine Scientists and Regulatory 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 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 up coming 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 student fleets preferred strategies for sustaining the squid population. Brainstormed ideas may include: limiting the number of fishing boats, shortening the fishing seasons, closing off areas to fishing, etc. Encourage students to be creative in brainstorming strategies for **sustainability**. Once each student fleet has a few ideas, instruct all the student fleets to cooperate and agree to a community-wide strategy or set of strategies before repeating the multi-season simulation. Have the Regulatory Agency Representative help facilitate this discussion and ask the Marine Scientist to propose ideas based on his/her role and responsibility in the community.



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.)

Ecosystem-based Management in Action

1. Review with the students the **sustainability** strategies they agreed to previously. 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 student 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 the availability of squid?
   b. Were the student fleets still profitable?
   c. How did the agreed upon strategies affect fishing? Student 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 most to maintaining a "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 a 50-100 year period, what happened to the number of fish landed, or 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**, **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. This is referred to as "the tragedy of the **commons**." In "The Tragedy of the **Commons**," Garrett Hardin reminds the reader that "a finite world can support only a finite population."

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 **Magnuson-Stevens Fishery and Conservation Management Act** (MSA, 1976). 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 California, the California Resources Agency, California Department of Fish and Game, and the Fish and Game Commission) is responsible for managing fisheries within three miles of shore while 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 **MSA** was the creation of eight regional fishery management councils. These councils create Fishery Management Plans (FMPs). The FMPs describe the nature of a fishery, including an assessment of a 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 **MSA** 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. For those reasons and more, it is critical to have an effective, contemporary, and dynamic approach to fisheries management. 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. **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* 162: 1243-48.

Monterey Bay National Marine Sanctuary. Available from: http://montereybay.noaa.gov/

References Specific to this Activity

California Department of Fish and Game. 2008. Status of the Fisheries Report - an Update Through 2006. Available from: http://www.dfg.ca.gov/marine/status/.

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

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National Oceanic and Atmospheric Administration. 2007. Ecosystem-based Management. [cited 2008 Jul 8] Available from: http://celebrating200years.noaa.gov/magazine/chesapeake_fish_mgmt/side1.html

Acknowledgments

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Additional Credit

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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.

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.

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

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 upon 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 the shore 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 (MSA): 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 (EEZ) extending from shore 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.

Balance in the Bay

California Department of Fish and Game
Squid Fishing Regulations and Restrictions

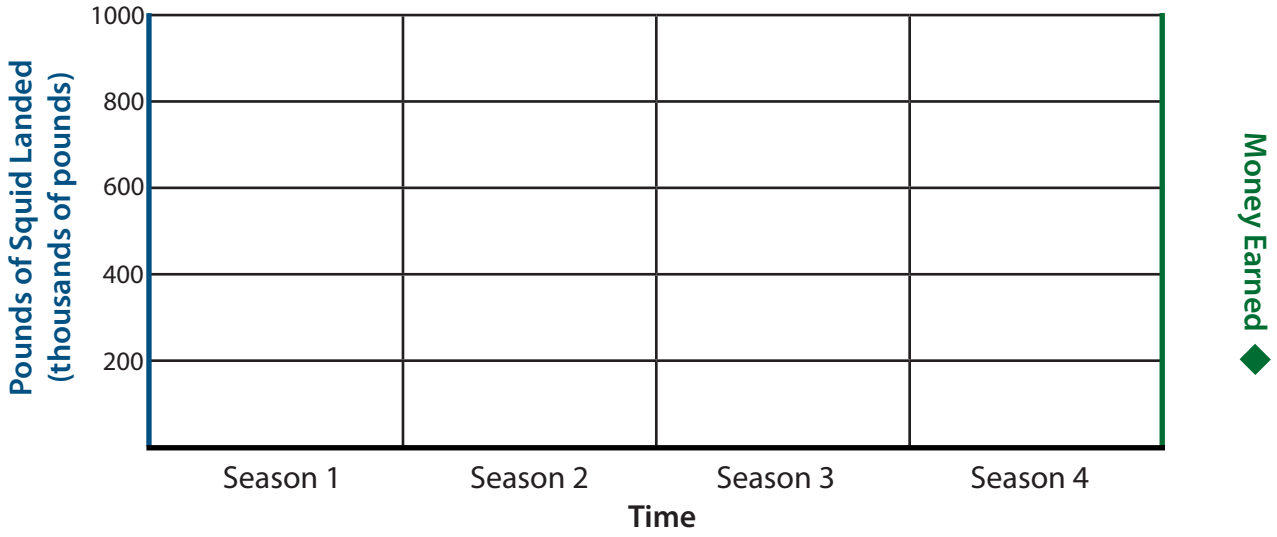
(Effective 3/28/2005)

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.

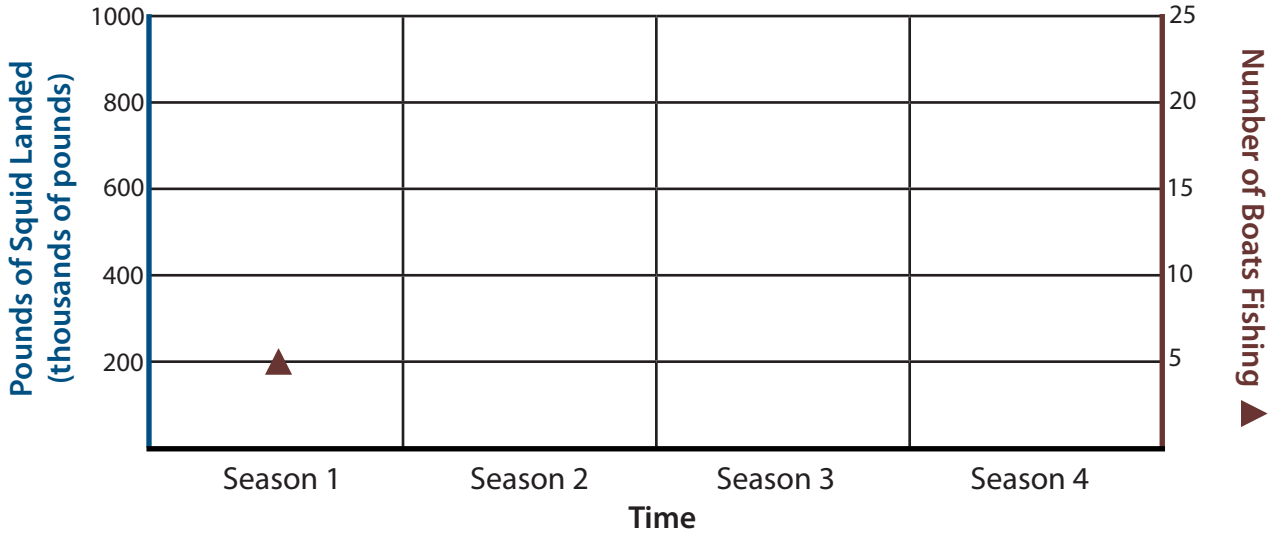
Balance in the Bay

Community Fishery Graphs

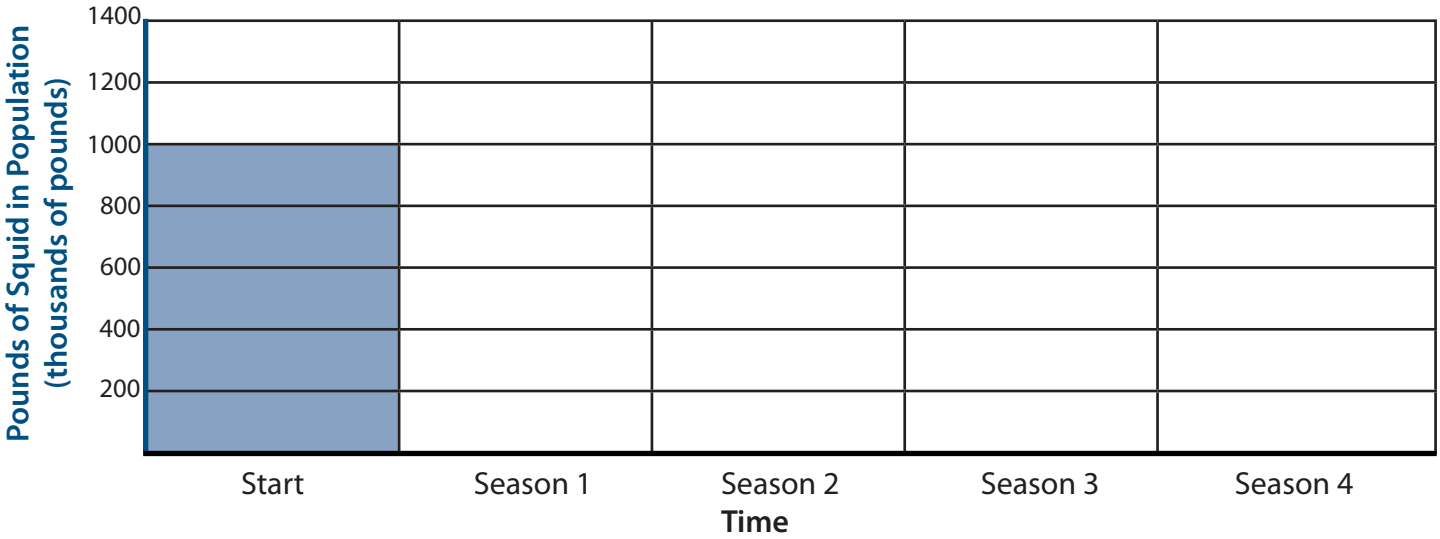
1. Compare the pounds of squid landed (T) and the money earned (summed net profits/ losses) each season.



2. Compare the pounds of squid landed (T) and total number of boats fishing each season.



3. Compare the pounds of squid in the population (S + R) at the end of each season.



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

Balance in the Bay
Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

_____
_____
_____
_____
_____

FISHING SEASON (circle one) 1 2 3 4 5

1. Number of paperclips collected from all boats in your fleet: = **A**

2. The pounds of squid caught (A) from all boats in your fleet: **A x 1,000 = B**

3. Reduce total catch (B) by 2% for bycatch: **B x 0.98 = C**

4. Subtract 50,000 lbs squid per active boat in your fleet for operating costs: **C – (50,000 x Number of Boats Fishing in your fleet) = D**

5. For this simulation, the dockside sale price for squid is estimated to be $0.25/lb. To calculate seasonal earnings, multiply remaining pounds (D) by $0.25: **D x $0.25 = E**

6. Did you make a profit this season or did you lose money? _____

7. Extra boats (F) cost $10,000 each. Would you like to purchase additional boats?_____
   How many boats will you be purchasing? _____ Cost for additional boats (F): **F x $10,000 = G**

8. Final season net profit/losses: **E - G =** **Season Net Profit/Losses** [ ]

Balance in the Bay
Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

_____
_____
_____
_____
_____

FISHING SEASON (circle one) 1 2 3 4 5

1. Number of paperclips collected from all boats in your fleet: = **A**

2. The pounds of squid caught (A) from all boats in your fleet: **A x 1,000 = B**

3. Reduce total catch (B) by 2% for bycatch: **B x 0.98 = C**

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8. Final season net profit/losses: **E - G =** **Season Net Profit/Losses** [ ]

Balance in the Bay
Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

_____
_____
_____
_____
_____

FISHING SEASON (circle one) 1 2 3 4 5

1. How many paperclips did your fleet collect?
   A = _____ paperclips

2. If one paperclip is equal to 1,000 pounds of squid, how many pounds of squid did your fleet catch? **B = A paperclips x 1,000 lbs/paperclip**
   B = _____ lbs

3. If only 98% of the total number of pounds that your fleet caught were actually squid (the rest are called bycatch, fish that are not squid), how many pounds of squid did you catch? **C = B lbs x 0.98**
   C = _____ lbs

4. If it costs 50,000 pounds of squid per boat to keep it operating, how many pounds of squid are needed to pay the operating costs for your fleet? **D = 50,000 lbs/boat x Number of Your Boats Fishing**
   D = _____ lbs

5. How many pounds of squid do you have left to sell after paying the operating costs? **E = C lbs - D lbs**
   E =_____ lbs

6. In this simulation the dockside sale price for squid is $0.25/lb. How much money will you get paid for your squid? **F = E lbs x $0.25/lb**
   F = $ _____

7. Did you make a profit this season (F is positive) or did you lose money (F is negative)? _____

8. If you made a profit, extra boats cost $10,000 each. Would you like to buy more boats?_____

9. How many boat(s) do you want to buy?
   G = _____ boat(s)

10. How much will it cost you to buy those extra boats? **H = G boat(s) x $10,000/boat**
    H = $ _____

11. How much money do you have in your account at the end of the season?

If **F** is positive, **Season Net Profits = F - H**

Season Net Profits

OR

Or, if **F** is negative, **Season Net Losses = F**

Season Net Losses

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

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ECOSYSTEM-BASED CHALLENGE CARD

VOICES of the BAY

ECOSYSTEM-BASED CHALLENGE CARD

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ECOSYSTEM-BASED CHALLENGE CARD

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ECOSYSTEM-BASED CHALLENGE CARD

VOICES of the BAY

ECOSYSTEM-BASED CHALLENGE CARD

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

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

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

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

Conservationists are concerned that lights used by fishermen 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 each fishing fleet's season earnings for modifying the attracting lights on your fleet's boats.

A 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.

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.

A 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.

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.

Lines from a bottom trawler drag on the ocean floor,
disturbing squid spawning grounds.

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

Voices of the Bay Fisheries Education – Balance in the Bay
PowerPoint Notes

Slide 1: Balance in the Bay

We are going to use this presentation to gain more background information about ecosystem-based management and the California market squid fishery.

Slide 2: Fisheries Management

Fisheries management works to sustain the greatest number of boats for the longest period of time while maintaining a healthy fish population. This can be a large challenge!

It is important to account for all factors – biological, regulatory, historical, and economic – when conducting fisheries management. Including all of these factors can help maintain balance within an ecosystem and the communities supported by that ecosystem. This is the way that fisheries management is moving towards, rather than just managing one species at a time.

The ultimate goal of fisheries management is to manage the stock sustainably over the long term, to reduce the potential for overfishing, and to be flexible to environmental and socio-economic changes.

Slide 3: Ecosystem-Based Management

When you take all of these factors into account it is called Ecosystem-Based Management. 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.

For example, some of the specific factors that may impact the health of the marine environment and fish populations include pollution, coastal development, harvest pressure, predator/prey and other ecological interactions, as well as nearby watershed management.

In this example we are going to focus on the California Market Squid.

Slide 4: California Market Squid

Let's meet the Market Squid. Here we provide you with information about the Market Squid to share with your students. More information is available on our website under the Fish & Fishery Fact pages (http://sanctuaries.noaa.gov/education/voicesofthebay.html)

Scientific name: Market squid genus and species name was recently changed from *Loligo opalescens* to *Doryteuthis opalescens*.

Habitat: The Market Squid is a pelagic mollusk. Market squid are harvested near the surface and generally considered pelagic (open ocean), but are actually found over

the continental shelf from the surface to depths of at least 2,600 feet. They prefer the salty ocean and are rarely found in estuaries, bays, or river mouths. They can live in close to shore or as much as 300 km from the shoreline

Diel Migration: During the day Market Squid are often off of the continental shelf at depth, but they come to the surface during the night to forage. Therefore their vertical distribution each day can be from 100-600ms. They often aggregate around light during the night.

Lifespan: Market squid are short lived – their entire lifespan is approximately 4-10 months (often commercially harvested at an average of 6 months old). After reproduction, they die and the entire stock is replaced biannually (twice/year). Because of high predation on squid, survival rates can be very low.

Growth rate: Fast! Temperature and food availability influence the growth rate and abundance of Market Squid. The population size is dependent upon the previous generation's spawning success and the new generation's survival against environmental conditions and predators.

Maximum size: 1 foot total length, including 8 arms, which are like tentacles but with suckers along most of their length, and 2 feeding tentacles. They weigh between 56 and 84 grams (2-3 ounces).

Reproduction: Market squid are terminal spawners - they spawn at the end of their lifespan, generally around 6 months of age. However, they are also semelparous, meaning they spawn multiple times within a season. Spawning squid concentrate in dense schools in spawning grounds. Males deposit spermatophores into the mantle cavity of females. Eggs are fertilized as they are extruded. Females produce 20 to 30 egg capsules, each capsule containing 50 to 250 eggs. Females attach each egg capsule to the substrate. As spawning continues, mounds of egg capsules covering more than 330 square feet may be formed. Spawning is continuous, and eggs of varying developmental stages may be present at one site. Eggs take several days to a few months to hatch, depending on temperature. Newly hatched squid (paralarvae) resemble miniature adults and are dispersed by currents.

Distinguishing characteristics: Market squid have eight arms and two tentacles that extend from the ends of their bodies around their mouths. They have a mixed, iridescent coloration of milky white and purple. Coloring can change due to behavioral responses or changing environmental conditions, as the chromatophores are exposed when the muscles contract.

Slide 5: Life History

More information about Market Squid.

Spawning season: Year-round. In Monterey Bay, spawning peaks in April but may continue into fall. Off Oregon, squid spawning has been observed from May to July. Off Washington and Canada, spawning begins in late summer.

Spawning grounds: Habitat requirements for spawning are not well understood. Spawning occurs over a wide depth range. Known spawning areas include shallow semi-protected nearshore areas with sandy or muddy bottoms adjacent to submarine canyons, where most fishing occurs. The male transfer a bundle of spermatophores into the female's mantle cavity near the oviduct. Then the female lays the fertilized eggs in elongated cigar-shaped capsules that she attaches to the

seafloor. Each capsule can have up to 300 eggs embedded in the gelatinous mixture inside. Multiple capsules will be laid together by multiple females (it is called an egg mop or cluster). Females will lay between 20-30 capsules in her lifetime. Depending on the water temperature the eggs hatch within 2-5 weeks.

Range: Market squid are found along the Pacific coast from Southeast Alaska to central Baja Mexico. The largest populations are found along the California coast.

Interesting facts:

- Market squid swim backwards by pumping water through valves and a tube near their head.
- Market squid are members of the mollusk family known as cephalopods, which means "foot-on-head."
- Like most squid species, market squid have an ink sac, which serves as a defense mechanism. Squid expel ink to confuse predators.
- Squid are attracted to lights. This is called phototaxis, which is the response of a plant or organism to light, either toward the light (positive phototaxis) or away from it (negative phototaxis).

Slide 6: Squid Food Web

Beyond squid being predators in the food chain (as shown here eating anchovies and krill), they are also a common forage species for many species in the marine ecosystem.

Preferred food: Market squid eat small crustaceans (euphausids, copepods, krill) and small fish (anchovy). They also eat other small squid, gastropods, polychaete worms.

Predators: Few organisms eat squid eggs, although bat stars and sea urchins have been observed doing so. Like other coastal pelagic species such as anchovy and sardine, market squid are an important prey to a long list of fish, birds, and mammals including threatened, endangered, and depleted species. Some important predators of squid include king and Coho salmon, lingcod, rockfish, harbor seals, California sea lion, sea otters, elephant seal, Dall's porpoise, sooty shearwater, Brandt's cormorant, rhinoceros auklet, and common murre.

Predators of Eggs: Bat stars and urchins prey on the egg capsules.

Slide 7: Squid Fishing: Gear

Today purse seines, fish pumps, and light boats are all used in the commercial market squid fishery.

Purse seine: a large net used to encircle a school of squid or fish (typically 200-400m long and < 50m deep).

Light boat: a smaller boat equipped with high-powered lights that attract squid to the surface. You must have a light boat permit to operate a light boat; there are restrictions on the strength (< 30,000 watts) and angle of the light shields (to decrease the horizontal light scatter) on a light boat.

Slide 8: Squid Fishing: How it Works

Fishing occurs in shallow (50-150 ft) water over sandy substrate, sometimes with rocky outcrops. The squid aggregate in semi-protected bays to spawn, and this is when the fishermen catch the squid.

To catch the squid…

1. A skiff (small boat) is released from the purse seine boat with one end of the net.
2. The purse seine boat "sets" the net around a school of squid.
3. The end of the net attached to the skiff is connected with the purse seine boat to close the circle.
4. Fishermen purse the bottom of the net to tighten up the catch bringing the concentrated squid close to the boat. The squid are then pumped from the net into the hold with a fish pump.

The volume of squid caught is dependent upon the squid coming into shallow waters to spawn and the demand for and price paid by the international market. These two factors affect the amount of effort fishermen exert to catch the squid and thus the overall volume caught. As the size of squid populations around the world has decreased, the international demand for Market Squid has increased.

In 2008, 7% of the total landings were bycatch (comprised of 34 species). Common bycatch in the squid fishery is other coastal pelagic species, other benthic species, and Market Squid egg capsules.

Slide 9: Squid Fishing: At Night

Squid are attracted to light, a behavior called *positive phototaxis*. So most squid fishing is done at night using high-powered lights to attract schooling squid to the water's surface.

Slide 10: Squid Fishing Season

Because fishing occurs on the aggregation of adults spawning, fishing is only allowed from Sunday at noon to Friday at noon, to allow for a few days of spawning without fishing. However, light boats can be on the water at any time.

During a good fishing year (like 2010 and 2011), squid are typically caught in Monterey Bay from April through November. The market squid fishery is active in northern California and southern California at different times of the year. The northern fishery season (North of Point Conception, but mainly in Monterey Bay) traditionally occurs from April through November, while the southern fishery (mostly in the Channel Islands vicinity) begins in October and generally lasts through March (source: NOAA SWFSC).

Slide 11: Economic Importance

What happened to the Monterey Bay squid catch in 1998-1999? 1997 was an El Nino year. In an El Nino year, water temperatures increase, causing squid to move away from their traditional spawning grounds, which adversely affects squid populations in the following years. This is an example of a natural challenge that may require regulatory action in response.

Typical landings (catch): The California squid fishery accounts for most of the Pacific coast landings. Minor amounts of market squid are landed in Oregon, Washington, and Canada. A growing international market for squid and declining squid production in other parts of the world resulted in an increased demand for California market squid. As a result, commercial landings of market squid more than quadrupled from 1980 to 1997. However, landings experience large annual fluctuations due to a variety of factors. Between 2005-2008, squid were mostly caught in southern California, not Monterey Bay. However, although not yet depicted on the graph, squid were being landed in Monterey Bay in 2009.
Size of Fishery: In 2000, there were 243 purse seine boats, and 53 light boats by 2009 there were only 83 purse seine boats (of which only 70 made commercial landings and 50 made 90% of the catch) and 63 light boats.
2009 was the largest season by volume and the largest volume and value fishery in California (> 92,000 tons and the ex-vessel value was $56.5 million), because there were favorable environmental conditions.

Slide 12: Squid Products

40-65% of the squid landed in California is exported to 36 countries. Over 70% of the exports go to China. The next largest markets for exporting squid are Vietnam, Greece, Spain, and United Kingdom.

Squid are fishes for human consumption (e.g., calamari) and to be used as bait for recreational and commercial fisheries.

The final types of products are frozen, fresh, and canned.

Slide 13: Squid Fishing History

Squid fishing began in the mid-1800s by Chinese immigrants. They used small skiffs and lit torches that attracted the squid to the surface. They would then deploy purse seines to capture the squid. Most of their catch was dried and shipped to China, although a small amount was consumed locally.

Italian immigrants introduced the lampara (or round haul) net into the fishery in 1905 and out-competed the Chinese, who then focused on the processing and exporting side of the business.

Although light boats were used in the southern fishery, they were not allowed in the Monterey Bay between 1959-1988 because the fishermen banned their use.

Historically, the origins of the fishery were in Monterey Bay, however since the southern fishery began south of Santa Barbara in 1961 the southern California portion now dominates the fishery.

Until the 1970s, small brail nets were used to lift the squid out of the main lampara net and into the vessel, a couple hundred pounds at a time. Now, a centrifugal pump is

lowered into the netted school of squid. Water and squid are then pumped through a separator and into the hold of the vessel.

The late 1970s began the shift to purse seine nets and fish pumps, which is how nearly all squid are landed today. Light boats are used alongside purse seiners to attract squid to the surface at night.

Slide 14: Squid Fishery Management: Players

Scientists study squid and provide fishery managers data on biology, ecology, and population abundance. Money from the squid permits goes to the scientists to conduct research and to determine the biological assessments of the resource. They use this information to develop recommendations for the conservation and management of the Market Squid. Because we do not know specifically the age, size, and sex distribution of the squid and because the fishery targets the spawning adults, the fishery tests the squid mantle size and the number of eggs estimated to have already been spawned.

Pacific Fishery Management Council develops a squid fishery management plan.

California Department of Fish and Game (CDFG) and the California Fish and Game Commission manage and enforce squid fishing regulations in California. State provisions include a seasonal catch limitation, seasonal length and closures, monitoring programs, and a permit system.

Slide 15: Squid Fishery Management: How it Works

Market squid were included in the Pacific Fishery Management Council's (PFMC) Coastal Pelagic Species Fishery Management Plan (FMP) in 1999. The market squid resource is a "monitored" species, meaning that landings and available abundance are monitored for management purposes.

Maximum sustainable yield is calculated for market squid using egg escapement (the proportion of squid allowed to spawn prior to capture…this is estimated from the mantle thickness or gonad mass vs. the mantle length).

Currently the management is:

- Limited entry fishery – Since 1998 need a permit for the purse seine boat, light boat, and the brail boat (which brings the squid on board)
- The permits can be traded or transferred between people, meaning the only way to get into the fishery is to buy someone's permit
- Need to provide information about where fishing in a logbook to CDFG, this provides information about where the fleet is and how much they are catching
- Total Allowable Catch per year = 107,048 metric tons, this was reached in 2010 for the first time which meant the fishery was closed
- No fishing around Farallon Islands (because of birds), the light from light boats was correlated with next abandonment and increases in chick predation for the breeding seabird colonies on the Farallon Islands so you cannot fish for squid there anymore.

Slide 16: Squid Fishing Challenge

Now that we have learned a bit more about fisheries management and Market Squid you can see how the fishermen, Regulatory Agency Representatives, and Marine Scientists all work together to sustain a fishery. We also saw this through the first simulation.

As we learned, nature also plays an important role, often creating challenges that require a specific human action or response. We will account for these sources of variability in future fishing seasons. An Ecosystem-based Challenge Cards will be drawn to simulate natural and man-made challenges.

But first we need to go over our sustainability strategies to maintain a "balance in the bay" that we came up with at the end of the previous simulation. Do we want to make any changes to our strategy now that we know this information?

Slide 17: Community-wide Objective

As a reminder, the overall objective for the community (class) is to sustain the greatest number of fishing boats for the longest period of time while also maintaining a healthy squid population season to season.

Slide 18: Fishermen

Just like before the challenge will be to gather as many squid (paperclips) as you can, using your left hand only, during the fishing season (1 minute).

Slide 19: Fishermen – Calculations

1.Count your catch.
2.Calculate your seasonal earnings, while taking into account the Ecosystem-based Challenge Card.
3.As a fishing fleet, decide if you would like to purchase additional boats.

Slide 19: Regulatory Agency Representatives

1.Announce the beginning and end of each season.
2.Ensure fishing fleets are following regulations and fair fishing practices.
3.Randomly choose 1 fleet per season and count their catch to ensure accurate reporting of catch.

Slide 20: Marine Scientists

1.Draw an Ecosystem-based Challenge Card. The class must adhere to the card directions.
2.Record data on the Community Fishery Summary Sheet for all fleets to view.
3.Calculate the number of paperclips to return to the fishing grounds for the next season.

Slide 21: Acknowledgements

Balance in the Bay

An introduction to ecosystem-based management and the Monterey Bay market squid fishery.

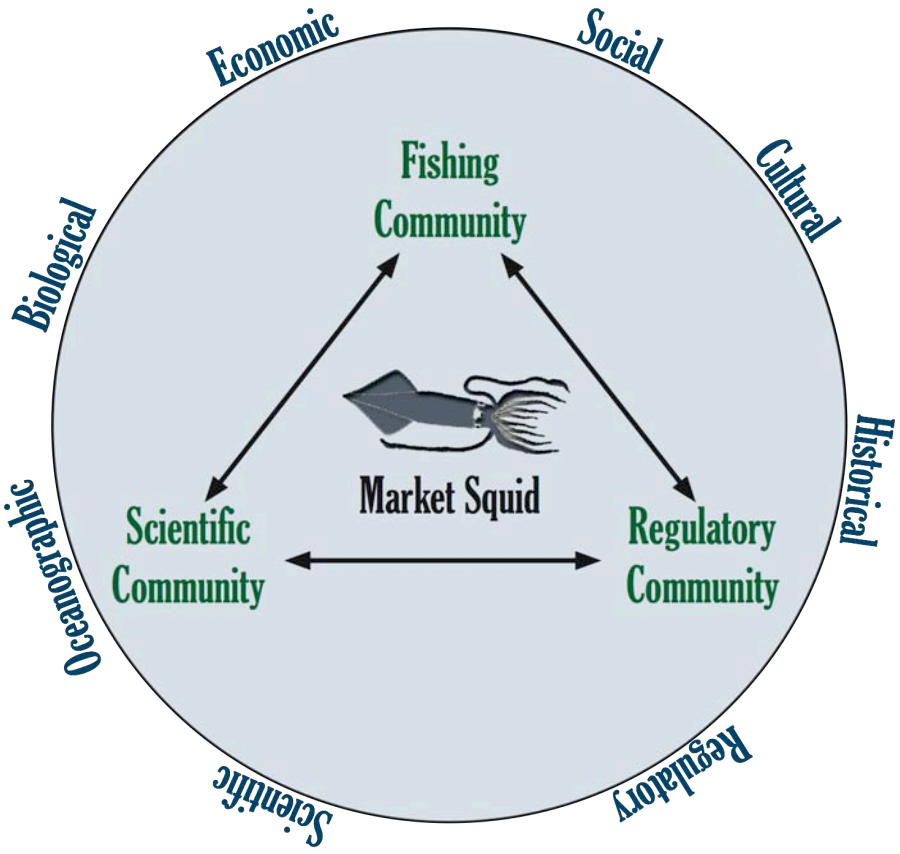
Fisheries Management

- Sustaining the greatest number of boats for the longest period of time while maintaining a healthy fish population can be challenging!
- Accounting for all factors – biological, regulatory, historical, economic – can help maintain balance within an ecosystem and the communities supported by that ecosystem.

VOICES of the BAY

Ecosystem-Based Management

- 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.



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California Market Squid

Scientific name: *Doryteuthis opalescens*

Habitat: Pelagic (open ocean)

Lifespan: Approximately 6 months

Growth rate: Fast

Maximum size/weight: Approximately 12 inches (305 mm) and 2-3 ounces (56-84 g).

Reproductive maturity: Squid spawn at the end of their lifecycle around 6 months.

Newly hatched squid (paralarvae)

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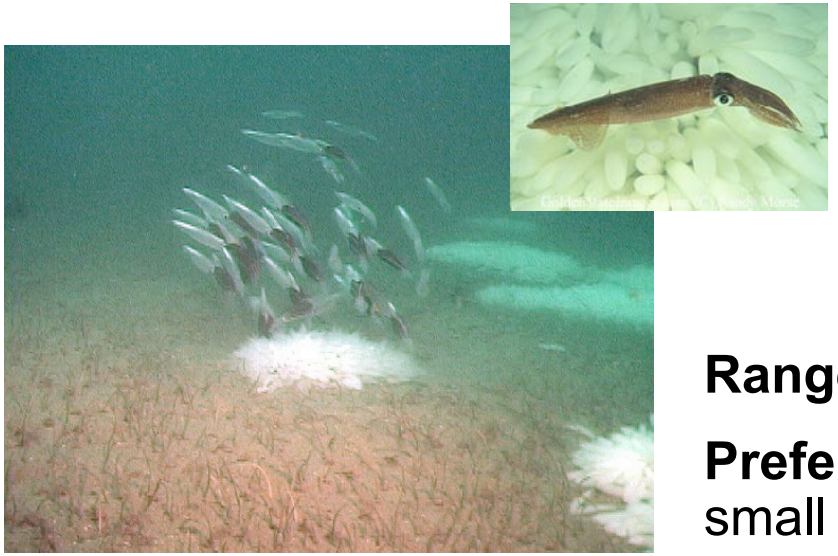
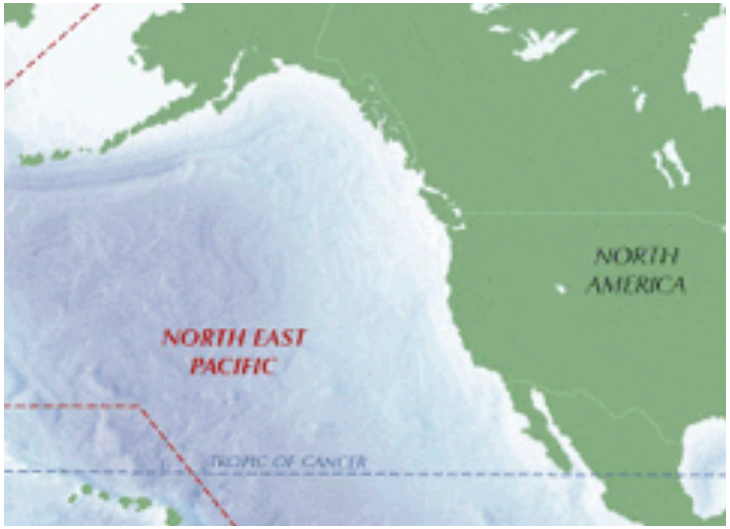
Life History

Spawning season: Peaks in April in Monterey Bay, but year-round between Northern and Southern California.

Spawning grounds: Nearshore areas with sandy or muddy bottoms.



Squid spawning in Monterey Bay. Photo: Roger Hanlon, SIMoN NOAA.



Range of Market Squid.

Range: Southeast Alaska to Baja, Mexico.

Preferred Food: Small crustaceans, small fish, and other squid.

Predators: Many species rely on squid for food.

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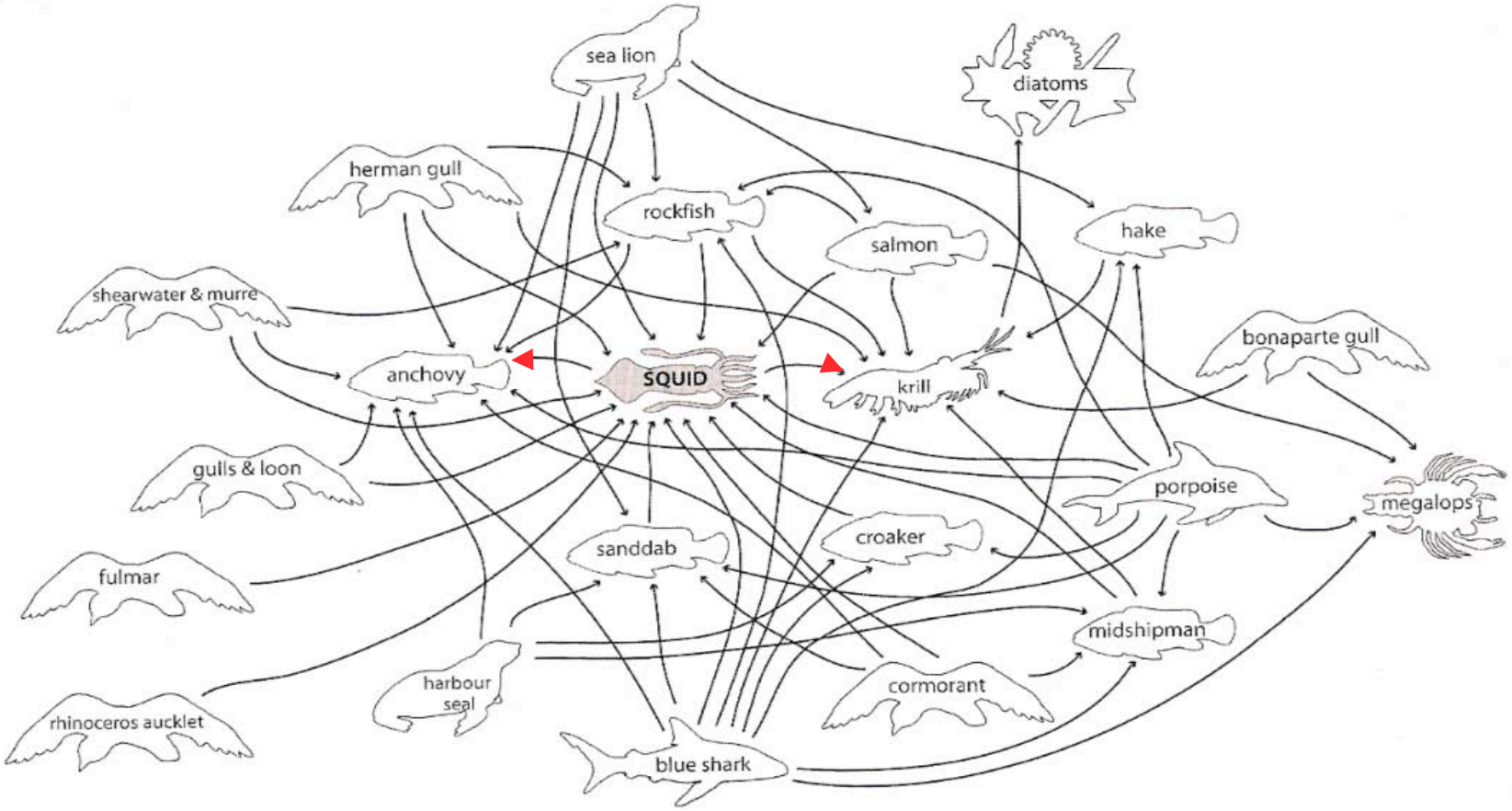
Squid Food Web

Food web involving commercially important or abundant fish, birds, mammals, and market squid.



adapted from Morejohn *et al.* 1978 in Boyle & Rodhouse 2005

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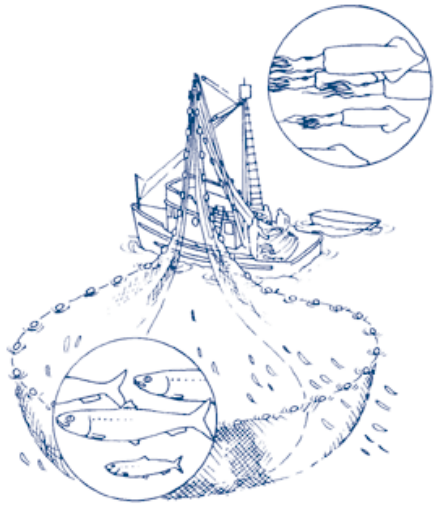
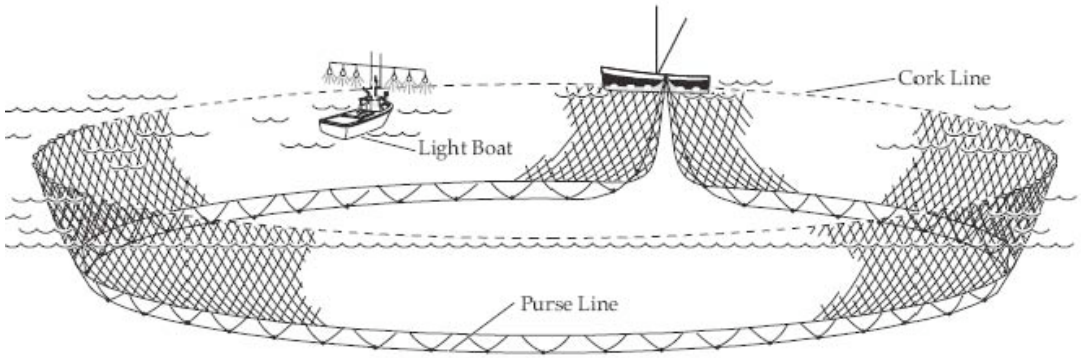
Squid Fishing: Gear



Purse seine: a large net used to encircle a school of squid or fish (typically 200-400m long and < 50m deep).

Light boat: a smaller boat equipped with high-powered lights that attract squid to the surface.



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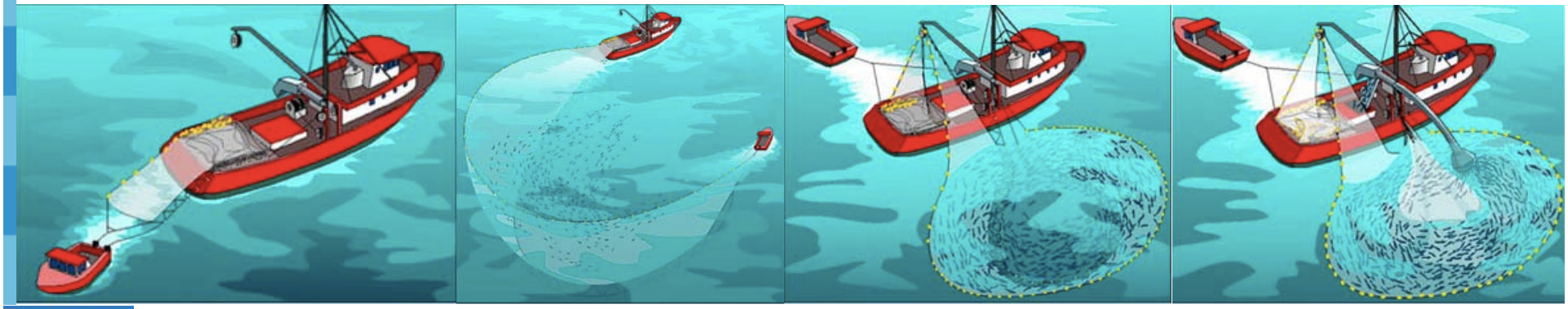
Squid Fishing: How it Works

1. A skiff (small boat) is released from the purse seine boat with one end of the net.
2. The purse seine boat “sets” the net around a school of squid.
3. The end of the net attached to the skiff is connected with the purse seine boat to close the circle.
4. Fishermen purse the bottom of the net to tighten up the catch bringing the concentrated squid close to the boat. The squid are then pumped from the net into the hold with a fish pump.



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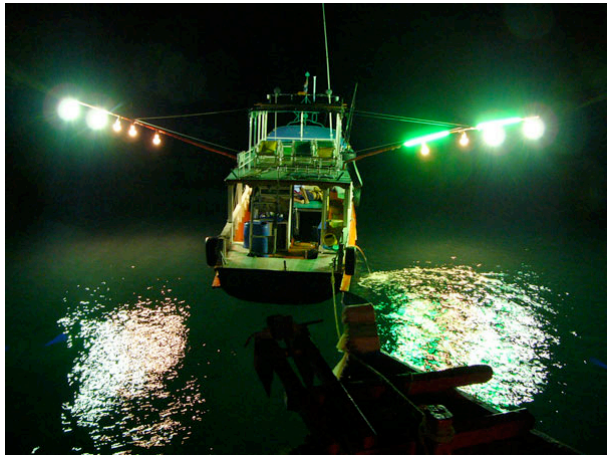
Squid Fishing: At Night

Squid are attracted to light, a behavior called ***positive phototaxis***. Most squid fishing is done at night using high-powered lights to attract schooling squid to the water's surface.

Squid fishing at night. Courtesy California Wetfish Producers Association.



A light boat at night.

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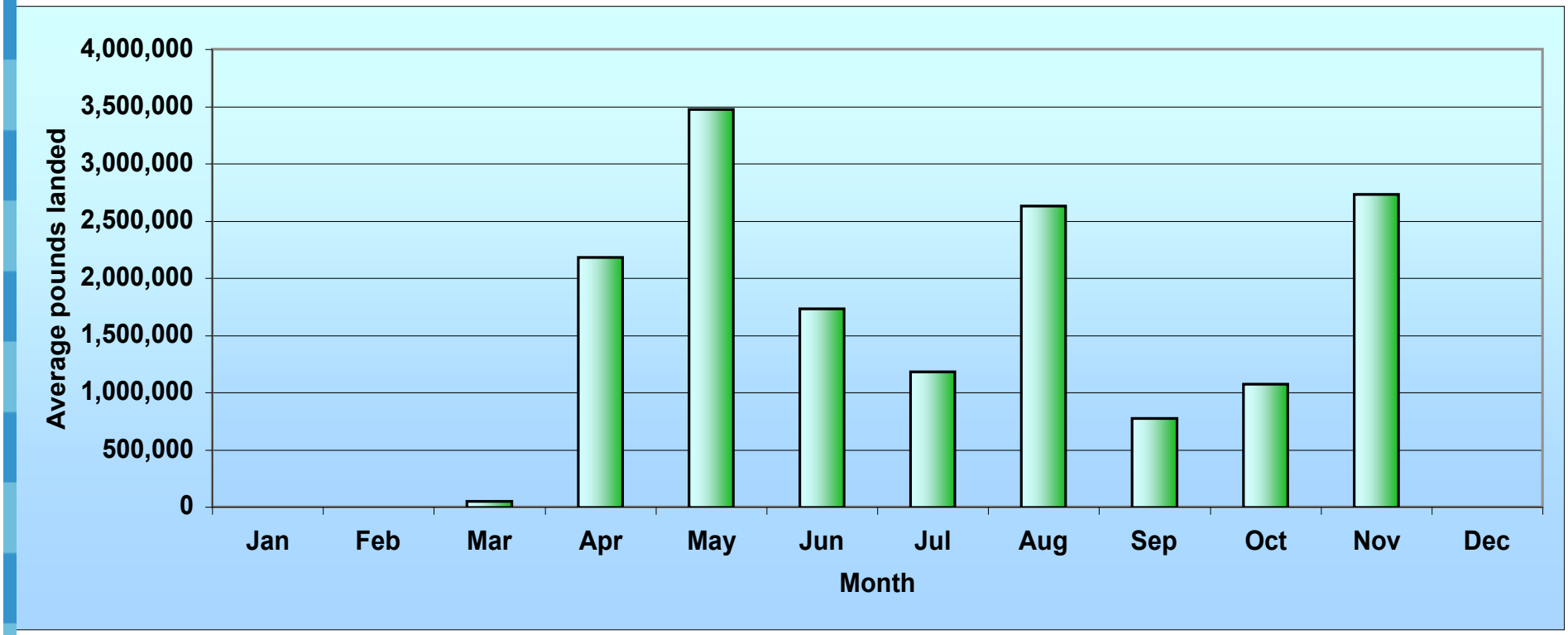
Squid Fishing Season

Average Pounds of Squid Landed in Monterey Bay Per Month
(2003-2005)



During good fishing years squid are typically caught in Monterey Bay from April through November.

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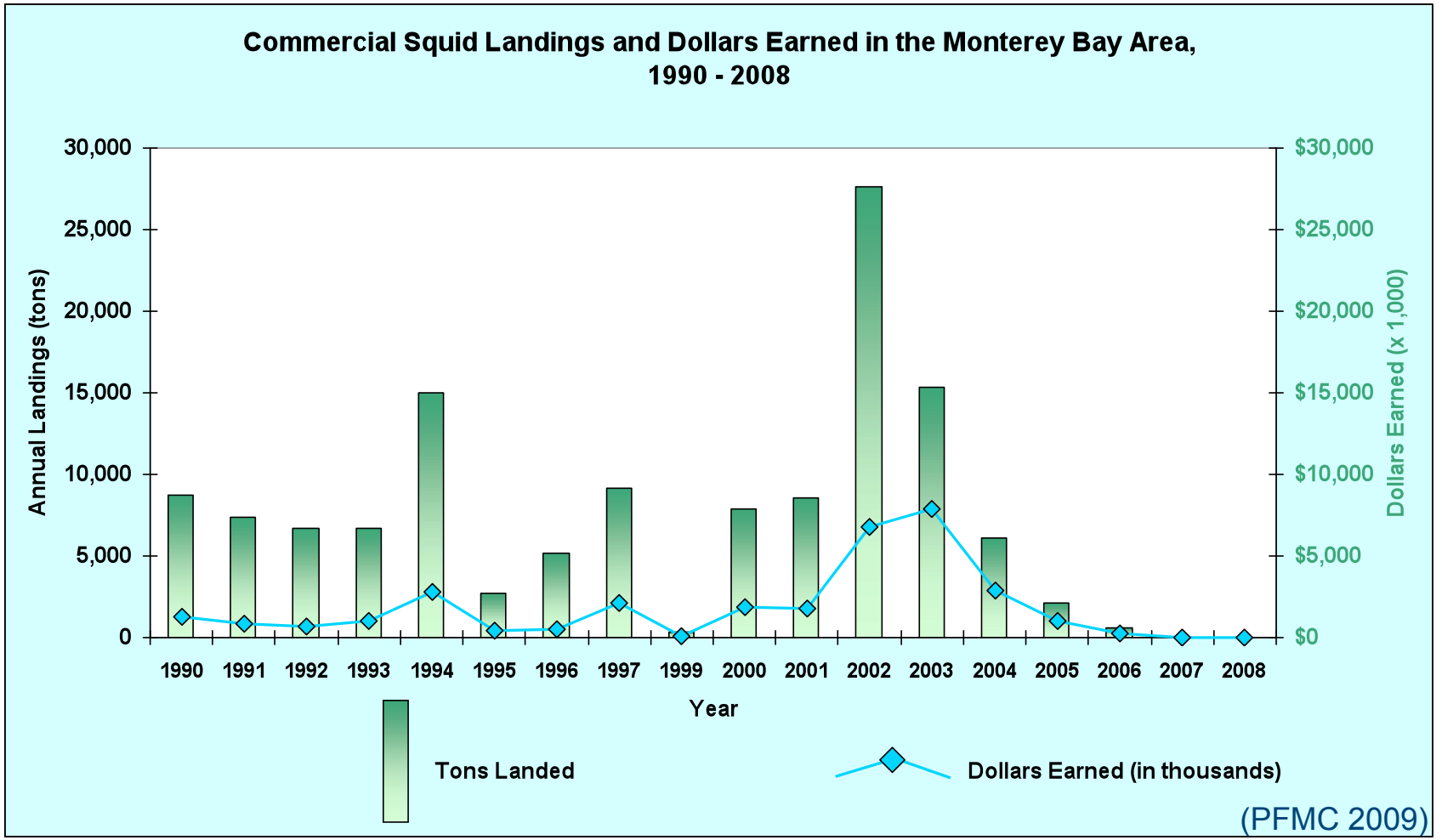
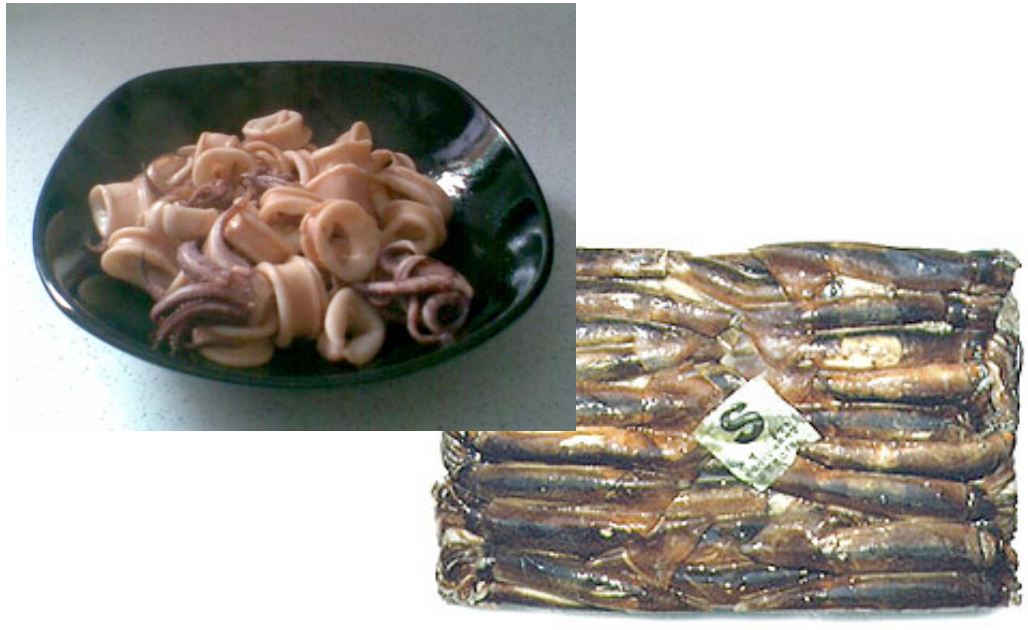
Economic Importance



What do you think happened to the squid catch in 1998-1999?

Squid Products

- 40-65% landed in California exported to 36 countries
  - Over 70% to China
  - Next largest markets: Vietnam, Greece, Spain, United Kingdom
- Human consumption of bait for recreational and commercial fisheries
- Types of products:
  - Frozen
  - Fresh
  - Canned



VOICES of the BAY

Squid Fishing History

Mid-1800's: Chinese immigrants started the commercial market squid fishery.

Early-1900's: Italian immigrants introduced lampara nets to fish for squid. And small brail nets were used to lift squid out of the net onto the fishing vessel.

Using a brail net to bring fish on the boat. Courtesy Monterey Maritime and History Museum.

Courtesy Monterey Maritime and History Museum.

1970's: motorized pumps were used to lift squid onto the boats.

Today: modern technology, purse seines, high power lights, and fish pumps aid fishermen in squid fishing.

VOICES of the BAY

Squid Fishery Management: Players

Scientists study squid and provide fishery managers data on biology, ecology, and population abundance.

Pacific Fishery Management Council develops a squid fishery management plan.

California Department of Fish and Game (CDFG) manages and enforces squid fishing regulations in California.

Courtesy California Department of Fish Game.

VOICES of the BAY

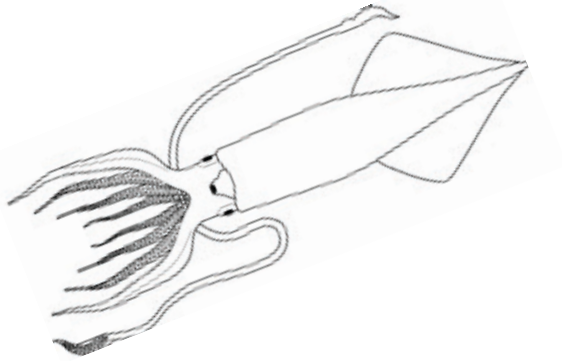
Squid Fishery Management: How it Works

- Limited entry fishery – Need a permit
- The permits can be traded or transferred between people
- Need to provide information about where fishing in a logbook
- Total Allowable Catch per year = 107,048 metric tons
- No fishing around Farallon Islands (because of birds)

VOICES of the BAY

Squid Fishing Challenge

- Fishermen, Regulatory Agency Representatives, and Marine Scientists all work together to sustain a fishery.
- In addition to the above, nature also plays an important role, often creating challenges that require a specific human action or response.
- In future fishing seasons, Ecosystem-based Challenge Cards will be drawn to simulate natural and man-made challenges.
- Use and modify your sustainability strategies to maintain a "balance in the bay."



VOICES of the BAY

Community-wide Objective

Sustain the greatest number of fishing boats for the longest period of time while also maintaining a healthy squid population season to season.

VOICES of the BAY

Fishermen – Fishing

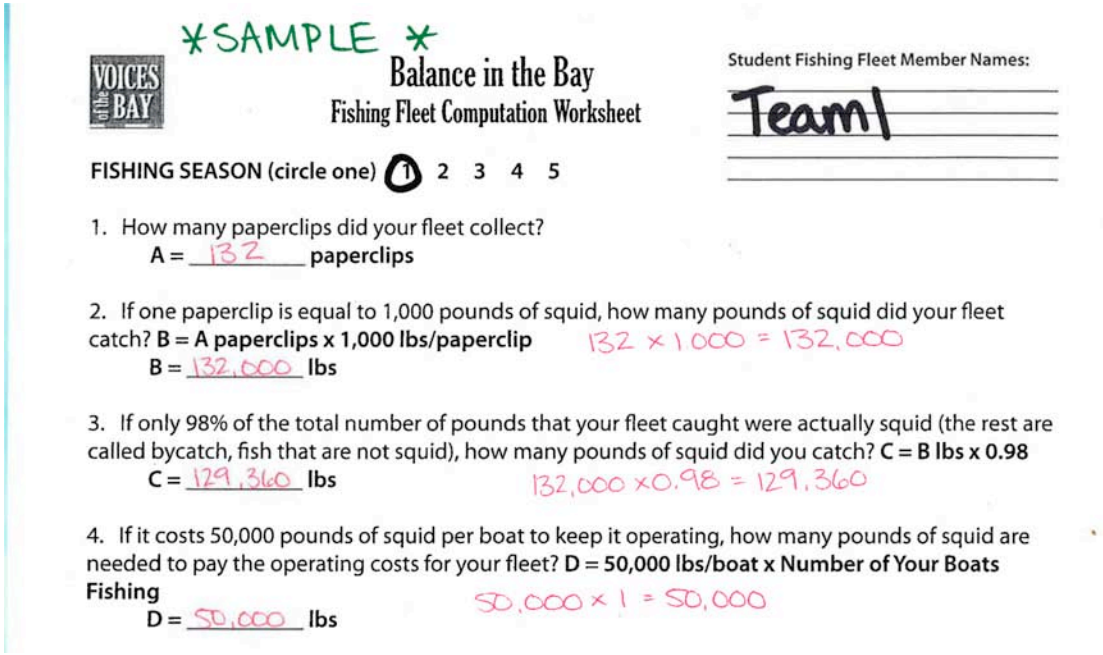
The challenge:

Gather as many squid (paperclips) as you can, using your left hand only, during the fishing season (1 minute).

VOICES of the BAY

Fishermen – Calculations

1. Count your catch.
2. Calculate your seasonal earnings.
3. As a fishing fleet, decide if you would like to purchase additional boats.



*SAMPLE *

VOICES of the BAY

Balance in the Bay

Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

Team1

FISHING SEASON (circle one) 1 2 3 4 5

1. How many paperclips did your fleet collect?
   A = 132 paperclips

2. If one paperclip is equal to 1,000 pounds of squid, how many pounds of squid did your fleet catch? **B = A paperclips x 1,000 lbs/paperclip** 132 x 1000 = 132,000
   B = 132,000 lbs

3. If only 98% of the total number of pounds that your fleet caught were actually squid (the rest are called bycatch, fish that are not squid), how many pounds of squid did you catch? **C = B lbs x 0.98**
   C = 129,360 lbs 132,000 x 0.98 = 129,360

4. If it costs 50,000 pounds of squid per boat to keep it operating, how many pounds of squid are needed to pay the operating costs for your fleet? **D = 50,000 lbs/boat x Number of Your Boats Fishing**
   D = 50,000 lbs 50,000 x 1 = 50,000

VOICES of the BAY

Regulatory Agency Representatives

1. Announce the beginning and end of each season.
2. Ensure fishing fleets are following regulations and fair fishing practices.
3. Randomly choose 1 fleet per season and count their catch to ensure accurate reporting of catch.

VOICES of the BAY

Marine Scientists

1. Draw an Ecosystem-based Challenge Card. The class must adhere to the card directions.
2. Record data on the Community Fishery Summary Sheet for all fleets to view.
3. Calculate the number of paperclips to return to the fishing grounds for the next season.

VOICES of the BAY

In Partnership with:

NOAA's Monterey Bay National Marine Sanctuary
Monterey Maritime and History Museum
David and Lucile Packard Foundation
Friends of Moss Landing Marine Lab
Monterey County Office of Education
Community Foundation for Monterey County
California Department of Fish and Game

Produced by:

David Heil & Associates, Inc.

VOICES of the BAY

Fisherman

Fisherman

Fisherman

Fisherman

Print back-to-back. Cut on the dotted lines to create the Role Cards.

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 (e.g., sardine, anchovy, mackerel). Your livelihood depends on the size of your catch. You are a part of a multi-boat fleet fishing in shared waters in the Monterey Bay National Marine Sanctuary.

1. In the first season, only a single fishing boat (one student "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.

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 (e.g., sardine, anchovy, mackerel). Your livelihood depends on the size of your catch. You are a part of a multi-boat fleet fishing in shared waters in the Monterey Bay National Marine Sanctuary.

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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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1. In the first season, only a single fishing boat (one student "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.

Fisherman

Fisherman

Marine Scientist

Regulatory Agency Representative

Print back-to-back. Cut on the dotted lines to create the Role Cards.

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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.

Regulatory Agency Representative

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.

Marine Scientist

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 national 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, choose 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

Worksheet/Summary/Graph Sample Key - Cover Sheet

High School/Community College/Undergraduate

Attached you will find a sample key for two fishing seasons for three fleets. For each fleet, the Fishing Fleet Computation Worksheet has been completed for each season. Additionally, we have included a completed Community Fishery Summary Sheet and Graph for the sample. We hope that this helps you facilitate the activity better with your students.

Thank you,
Voices of the Bay Fisheries Education Program

SAMPLE

Balance in the Bay
Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

Team 1

FISHING SEASON (circle one) (1) 2 3 4 5

1. Number of paperclips collected from all boats in your fleet: = **A** 132

2. The pounds of squid caught (A) from all boats in your fleet: **A x 1,000 = B** 132 × 1,000 = 132,000 lbs

3. Reduce total catch (B) by 2% for bycatch: **B x 0.98 = C** 132,000 × 0.98 = 129,360 lbs

4. Subtract 50,000 lbs squid per active boat in your fleet for operating costs: **C – (50,000 x Number of Boats Fishing in your fleet) = D**
129,360 - (50,000 × 1) = 79,360 lbs

5. For this simulation, the dockside sale price for squid is estimated to be $0.25/lb. To calculate seasonal earnings, multiply remaining pounds (D) by $0.25: **D x $0.25 = E** 79,360 × 0.25 = $19,840

6. Did you make a profit this season or did you lose money? Profit

7. Extra boats (F) cost $10,000 each. Would you like to purchase additional boats? Yes
How many boats will you be purchasing? 1 Cost for additional boats (F): **F x $10,000 = G** 1 × 10,000 = $10,000

8. Final season net profit/losses: **E - G =**
19,840 - 10,000 = $9,840

Season Net Profit/Losses $9,840

Balance in the Bay
Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

Team 1

FISHING SEASON (circle one) 1 (2) 3 4 5

1. Number of paperclips collected from all boats in your fleet: = **A** 164

2. The pounds of squid caught (A) from all boats in your fleet: **A x 1,000 = B** 164 × 1,000 = 164,000 lbs

3. Reduce total catch (B) by 2% for bycatch: **B x 0.98 = C** 164000 × 0.98 = 160,720 lbs

4. Subtract 50,000 lbs squid per active boat in your fleet for operating costs: **C – (50,000 x Number of Boats Fishing in your fleet) = D**
160,720 - (50,000 × 2) = 60,720 lbs

5. For this simulation, the dockside sale price for squid is estimated to be $0.25/lb. To calculate seasonal earnings, multiply remaining pounds (D) by $0.25: **D x $0.25 = E** 60,720 × 0.25 = $15,180

6. Did you make a profit this season or did you lose money? Profit

7. Extra boats (F) cost $10,000 each. Would you like to purchase additional boats? Yes
How many boats will you be purchasing? 1 Cost for additional boats (F): **F x $10,000 = G** 1 × 10,000 = $10,000

8. Final season net profit/losses: **E - G =**
15,180 - 10,000 = $5,180

Season Net Profit/Losses $5,180

SAMPLE

Balance in the Bay
Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

Team 2

FISHING SEASON (circle one) (1) 2 3 4 5

1. Number of paperclips collected from all boats in your fleet: = **A** 442

2. The pounds of squid caught (A) from all boats in your fleet: **A x 1,000 = B** 442 × 1,000 = 442,000 lbs

3. Reduce total catch (B) by 2% for bycatch: **B x 0.98 = C** 442,000 × 0.98 = 433,160 lbs

4. Subtract 50,000 lbs squid per active boat in your fleet for operating costs: **C – (50,000 x Number of Boats Fishing in your fleet) = D** 433,160 − (50,000 × 1) = 383,160 lbs

5. For this simulation, the dockside sale price for squid is estimated to be $0.25/lb. To calculate seasonal earnings, multiply remaining pounds (D) by $0.25: **D x $0.25 = E** 383,160 × 0.25 = $95,790

6. Did you make a profit this season or did you lose money? Profit

7. Extra boats (F) cost $10,000 each. Would you like to purchase additional boats? Yes
   How many boats will you be purchasing? 7 Cost for additional boats (F): **F x $10,000 = G** 7 × 10,000 = $70,000

8. Final season net profit/losses: **E - G =** 95,790 − 70,000 = $25,790

Season Net Profit/Losses $25,790

Balance in the Bay
Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

Team 2

FISHING SEASON (circle one) 1 (2) 3 4 5

1. Number of paperclips collected from all boats in your fleet: = **A** 695

2. The pounds of squid caught (A) from all boats in your fleet: **A x 1,000 = B** 695 × 1,000 = 695,000 lbs

3. Reduce total catch (B) by 2% for bycatch: **B x 0.98 = C** 695,000 × 0.98 = 681,100 lbs

4. Subtract 50,000 lbs squid per active boat in your fleet for operating costs: **C – (50,000 x Number of Boats Fishing in your fleet) = D** 681,100 − (50,000 × 8) = 281,100 lbs

5. For this simulation, the dockside sale price for squid is estimated to be $0.25/lb. To calculate seasonal earnings, multiply remaining pounds (D) by $0.25: **D x $0.25 = E** 281,100 × 0.25 = $70,275

6. Did you make a profit this season or did you lose money? Profit

7. Extra boats (F) cost $10,000 each. Would you like to purchase additional boats? No
   How many boats will you be purchasing? Ø Cost for additional boats (F): **F x $10,000 = G** 0 × 10,000 = $0

8. Final season net profit/losses: **E - G =** 70,275 − 0 = $70,275

Season Net Profit/Losses $70,275

SAMPLE

Balance in the Bay
Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

Team 3

FISHING SEASON (circle one) (1) 2 3 4 5

1. Number of paperclips collected from all boats in your fleet: = **A** 276

2. The pounds of squid caught (A) from all boats in your fleet: **A x 1,000 = B** 276 × 1,000 = 276,000 lbs

3. Reduce total catch (B) by 2% for bycatch: **B x 0.98 = C** 276,000 × 0.98 = 270,480 lbs

4. Subtract 50,000 lbs squid per active boat in your fleet for operating costs: **C – (50,000 x Number of Boats Fishing in your fleet) = D** 270,480 - (50,000 × 1) = 220,480 lbs

5. For this simulation, the dockside sale price for squid is estimated to be $0.25/lb. To calculate seasonal earnings, multiply remaining pounds (D) by $0.25: **D x $0.25 = E** 220,480 × 0.25 = $55,120

6. Did you make a profit this season or did you lose money? Profit

7. Extra boats (F) cost $10,000 each. Would you like to purchase additional boats? Yes
   How many boats will you be purchasing? 5 Cost for additional boats (F): **F x $10,000 = G** 5 × 10,000 = $50,000

8. Final season net profit/losses: **E - G =** 55,120 - 50,000 = $5,120

Season Net Profit/Losses $5,120

Balance in the Bay
Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

Team 3

FISHING SEASON (circle one) 1 (2) 3 4 5

1. Number of paperclips collected from all boats in your fleet: = **A** 138

2. The pounds of squid caught (A) from all boats in your fleet: **A x 1,000 = B** 138 × 1,000 = 138,000 lbs

3. Reduce total catch (B) by 2% for bycatch: **B x 0.98 = C** 138,000 × 0.98 = 135,240 lbs

4. Subtract 50,000 lbs squid per active boat in your fleet for operating costs: **C – (50,000 x Number of Boats Fishing in your fleet) = D** 135,240 - (50,000 × 6) = -164,760 lbs

5. For this simulation, the dockside sale price for squid is estimated to be $0.25/lb. To calculate seasonal earnings, multiply remaining pounds (D) by $0.25: **D x $0.25 = E** -164,760 × 0.25 = $-41,190

6. Did you make a profit this season or did you lose money? Lose

7. Extra boats (F) cost $10,000 each. Would you like to purchase additional boats? No
   How many boats will you be purchasing? 0 Cost for additional boats (F): **F x $10,000 = G** 0 × 10,000 = $0

8. Final season net profit/losses: **E - G =** -41,190 - 0 = $-41,190

Season Net Profit/Losses $-41,190

*SAMPLE *

Balance in the Bay
Community Fishery Summary Sheet

	Sample		Season 1		Season 2		Season 3		Season 4	
Fleet 1	lbs squid caught	# boats purchased	129,360	1	160,720	1				
	Net profit/losses		$9,840		$5,180					
Fleet 2	lbs squid caught	# boats purchased	433,160	7	681,100	0				
	Net profit/losses		$25,790		$70,275					
Fleet 3	lbs squid caught	# boats purchased	270,480	5	135,240	0				
	Net profit/losses		$5,120		$-41,190					
Fleet 4	lbs squid caught	# boats purchased								
	Net profit/losses									
Fleet 5	lbs squid caught	# boats purchased								
	Net profit/losses									
Total pounds of squid caught (T)	**T** (sum of each fleet's catch)		833,000		977,060					
Total # paperclips collected (P)	T / 1,000 = **P**		833		977.06					
Total # paperclips remaining in fishing grounds (R)	1,000 – P = **R**		167		22.94					
Total reproduction for next season (N)	R x 10 = **N**		1,670		229.4					
Number of paperclips to return to fishing grounds for start of next season (S)	N – R = **S**		1,503		206.5 (207)					

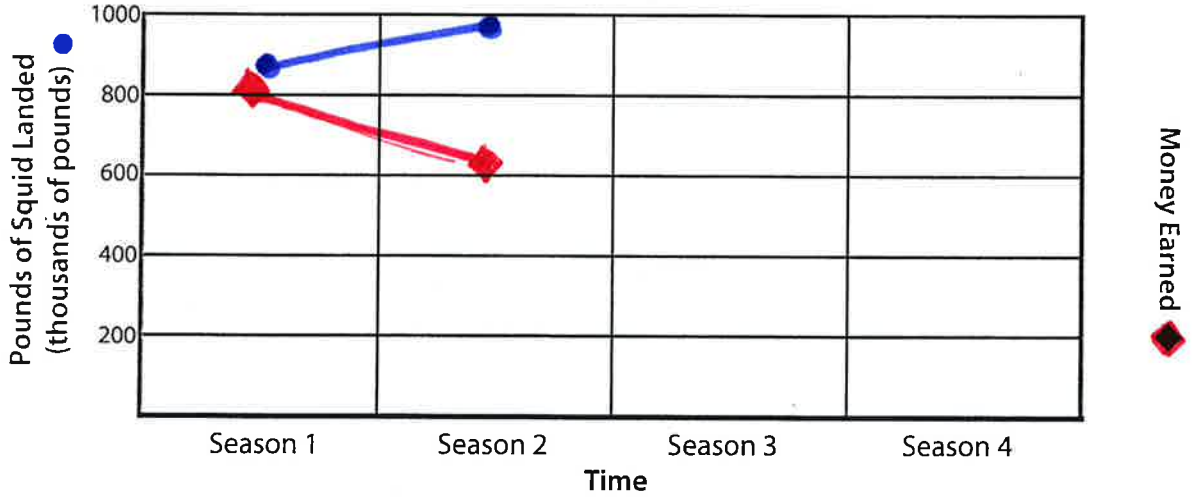
VOICES of the BAY

* SAMPLE *

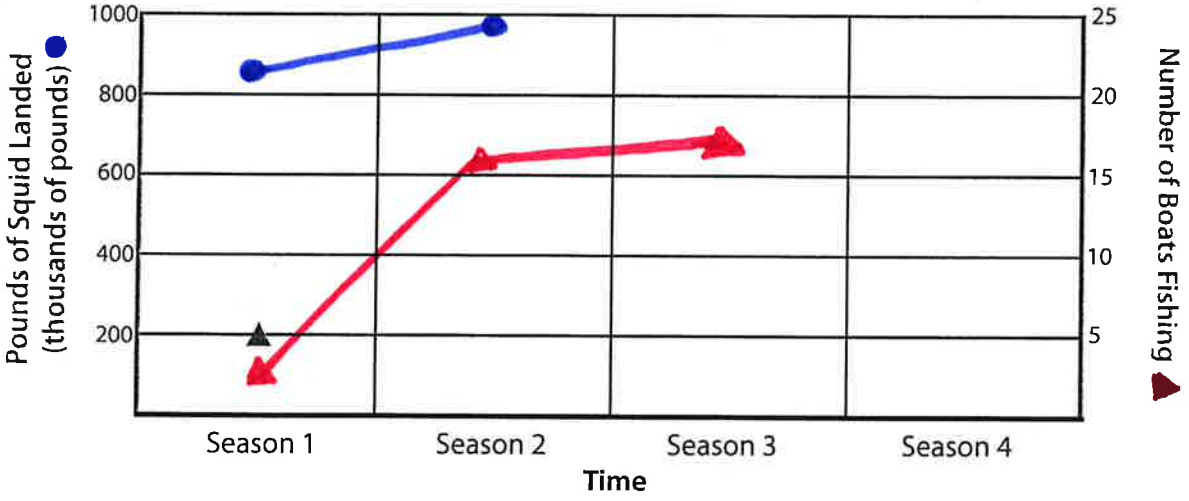
Balance in the Bay

Community Fishery Graphs

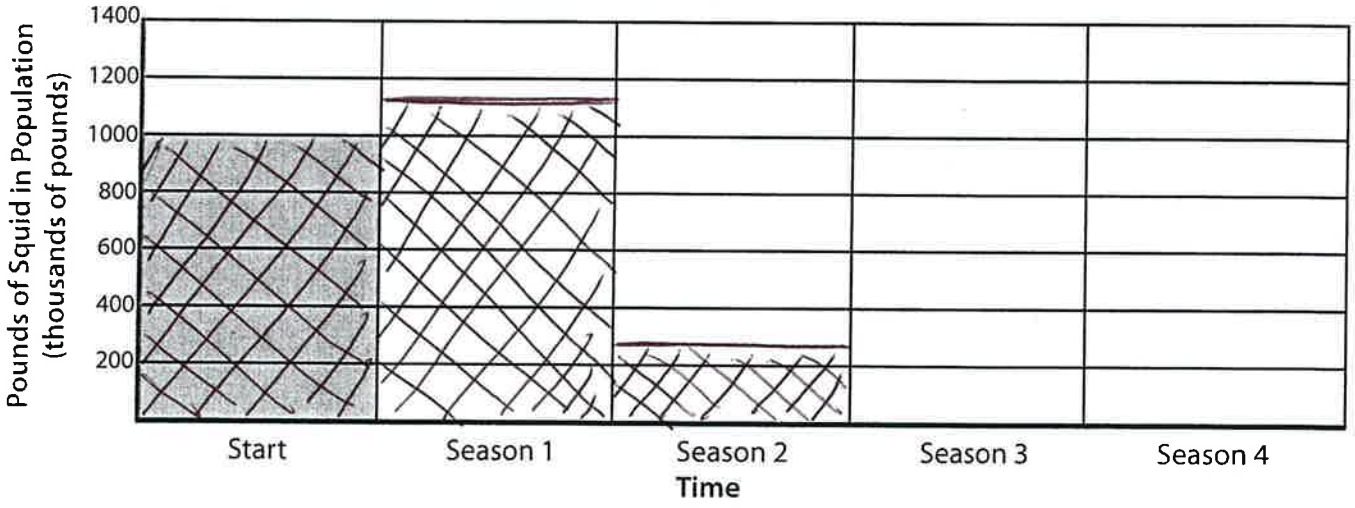
1. Compare the pounds of squid landed (T) and the money earned (summed net profits/ losses) each season.



2. Compare the pounds of squid landed (T) and total number of boats fishing each season.



3. Compare the pounds of squid in the population (S + R) at the end of each season.



Balance in the Bay

Worksheet/Summary/Graph Sample Key - Cover Sheet

Middle School

Attached you will find a sample key for two fishing seasons for three fleets. For each fleet, the Fishing Fleet Computation Worksheet has been completed for each season. Additionally, we have included a completed Community Fishery Summary Sheet and Graph for the sample. We hope that this helps you facilitate the activity better with your students.

Thank you,
Voices of the Bay Fisheries Education Program

VOICES of the BAY

Balance in the Bay
Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

Team 1

FISHING SEASON (circle one) **1** 2 3 4 5

1. How many paperclips did your fleet collect?
   A = 132 **paperclips**

2. If one paperclip is equal to 1,000 pounds of squid, how many pounds of squid did your fleet catch? **B = A paperclips x 1,000 lbs/paperclip**
   B = 132,000 **lbs**
   132 × 1,000 = 132,000 lbs

3. If only 98% of the total number of pounds that your fleet caught were actually squid (the rest are called bycatch, fish that are not squid), how many pounds of squid did you catch? **C = B lbs x 0.98**
   C = 129,360 **lbs**
   132,000 × 0.98 = 129,360

4. If it costs 50,000 pounds of squid per boat to keep it operating, how many pounds of squid are needed to pay the operating costs for your fleet? **D = 50,000 lbs/boat x Number of Your Boats Fishing**
   D = 50,000 **lbs**
   50,000 × 1 = 50,000

5. How many pounds of squid do you have left to sell after paying the operating costs? **E = C lbs - D lbs**
   E = 79,360 **lbs**
   129,360 − 50,000 = 79,360

6. In this simulation the dockside sale price for squid is $0.25/lb. How much money will you get paid for your squid? **F = E lbs x $0.25/lb**
   F = $ 19,840
   79,360 × 0.25 = 19,840

7. Did you make a profit this season (F is positive) or did you lose money (F is negative)? Profit

8. If you made a profit, extra boats cost $10,000 each. Would you like to buy more boats? Yes

9. How many boat(s) do you want to buy?
   G = 1 **boat(s)**

10. How much will it cost you to buy those extra boats? **H = G boat(s) x $10,000/boat**
    H = $ 10,000
    1 × 10,000 = 10,000

11. How much money do you have in your account at the end of the season?
    19,840 − 10,000 = 9,840

If **F** is positive, **Season Net Profits = F - H** — **Season Net Profits** $9,840

OR

Or, if **F** is negative, **Season Net Losses = F** — **Season Net Losses**

*SAMPLE *

VOICES of the BAY

Balance in the Bay

Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

Team 1

FISHING SEASON (circle one) 1 (2) 3 4 5

1. How many paperclips did your fleet collect?
   A = 164 **paperclips**

2. If one paperclip is equal to 1,000 pounds of squid, how many pounds of squid did your fleet catch? **B = A paperclips x 1,000 lbs/paperclip**
   B = 164,000 **lbs**
   164 × 1,000 = 164,000

3. If only 98% of the total number of pounds that your fleet caught were actually squid (the rest are called bycatch, fish that are not squid), how many pounds of squid did you catch? **C = B lbs x 0.98**
   C = 160,720 **lbs**
   164,000 × 0.98 = 160,720

4. If it costs 50,000 pounds of squid per boat to keep it operating, how many pounds of squid are needed to pay the operating costs for your fleet? **D = 50,000 lbs/boat x Number of Your Boats Fishing**
   D = 100,000 **lbs**
   50,000 × 2 = 100,000

5. How many pounds of squid do you have left to sell after paying the operating costs? **E = C lbs - D lbs**
   E = 60,720 **lbs**
   160,720 - 100,000 = 60,720

6. In this simulation the dockside sale price for squid is $0.25/lb. How much money will you get paid for your squid? **F = E lbs x $0.25/lb**
   F = $ 15,180
   60,720 × 0.25 = 15,180

7. Did you make a profit this season (F is positive) or did you lose money (F is negative)? Profit

8. If you made a profit, extra boats cost $10,000 each. Would you like to buy more boats? Yes

9. How many boat(s) do you want to buy?
   G = 1 **boat(s)**

10. How much will it cost you to buy those extra boats? **H = G boat(s) x $10,000/boat**
    H = $ 10,000
    1 × 10,000 = 10,000

11. How much money do you have in your account at the end of the season?
    15,180 - 10,000 = 5,180

If F is positive, **Season Net Profits = F - H**

Or, if **F** is negative, **Season Net Losses = F**

Season Net Profits $5,180

OR

Season Net Losses

*SAMPLE *

VOICES of the BAY

Balance in the Bay

Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

Team 2

FISHING SEASON (circle one) (1) 2 3 4 5

1. How many paperclips did your fleet collect?
   A = 442 **paperclips**

2. If one paperclip is equal to 1,000 pounds of squid, how many pounds of squid did your fleet catch? **B = A paperclips x 1,000 lbs/paperclip**
   B = 442,000 **lbs**
   442 × 1,000 = 442,000

3. If only 98% of the total number of pounds that your fleet caught were actually squid (the rest are called bycatch, fish that are not squid), how many pounds of squid did you catch? **C = B lbs x 0.98**
   C = 433,160 **lbs**
   442,000 × 0.98 = 433,160

4. If it costs 50,000 pounds of squid per boat to keep it operating, how many pounds of squid are needed to pay the operating costs for your fleet? **D = 50,000 lbs/boat x Number of Your Boats Fishing**
   D = 50,000 **lbs**
   50,000 × 1 = 50,000

5. How many pounds of squid do you have left to sell after paying the operating costs? **E = C lbs - D lbs**
   E = 383,160 **lbs**
   433,160 − 50,000 = 383,160

6. In this simulation the dockside sale price for squid is $0.25/lb. How much money will you get paid for your squid? **F = E lbs x $0.25/lb**
   F = $ 95,790
   383,160 × 0.25 = 95,790

7. Did you make a profit this season (F is positive) or did you lose money (F is negative)? Profit

8. If you made a profit, extra boats cost $10,000 each. Would you like to buy more boats? Yes

9. How many boat(s) do you want to buy?
   G = 7 **boat(s)**

10. How much will it cost you to buy those extra boats? **H = G boat(s) x $10,000/boat**
    H = $ 70,000
    7 × 10,000 = 70,000

11. How much money do you have in your account at the end of the season?
    95,790 − 70,000 = 25,790

If F is positive, **Season Net Profits = F - H** — **Season Net Profits** $25,790

OR

Or, if **F** is negative, **Season Net Losses = F** — **Season Net Losses**

SAMPLE

Balance in the Bay
Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

Team 2

FISHING SEASON (circle one) 1 (2) 3 4 5

1. How many paperclips did your fleet collect?
   A = 695 **paperclips**

2. If one paperclip is equal to 1,000 pounds of squid, how many pounds of squid did your fleet catch? **B = A paperclips x 1,000 lbs/paperclip**
   B = 695,000 **lbs**
   695 × 1,000 = 695,000

3. If only 98% of the total number of pounds that your fleet caught were actually squid (the rest are called bycatch, fish that are not squid), how many pounds of squid did you catch? **C = B lbs x 0.98**
   C = 681,100 **lbs**
   695,000 × 0.98 = 681,100

4. If it costs 50,000 pounds of squid per boat to keep it operating, how many pounds of squid are needed to pay the operating costs for your fleet? **D = 50,000 lbs/boat x Number of Your Boats Fishing**
   D = 400,000 **lbs**
   50,000 × 8 = 400,000

5. How many pounds of squid do you have left to sell after paying the operating costs? **E = C lbs - D lbs**
   E = 281,100 **lbs**
   681,100 − 400,000 = 281,100

6. In this simulation the dockside sale price for squid is $0.25/lb. How much money will you get paid for your squid? **F = E lbs x $0.25/lb**
   F = $ 70,275
   281,100 × 0.25 = $70,275

7. Did you make a profit this season (F is positive) or did you lose money (F is negative)? Profit

8. If you made a profit, extra boats cost $10,000 each. Would you like to buy more boats? No

9. How many boat(s) do you want to buy?
   G = Ø **boat(s)**

10. How much will it cost you to buy those extra boats? **H = G boat(s) x $10,000/boat**
    H = $ 0
    0 × 10,000 = 0

11. How much money do you have in your account at the end of the season?
    70,275 − 0 = 70,275

If **F** is positive, **Season Net Profits = F - H** — **Season Net Profits** $70,275

OR

Or, if **F** is negative, **Season Net Losses = F** — **Season Net Losses**

SAMPLE

VOICES of the BAY

Balance in the Bay

Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

Team 3

FISHING SEASON (circle one) (1) 2 3 4 5

1. How many paperclips did your fleet collect?
   A = 276 **paperclips**

2. If one paperclip is equal to 1,000 pounds of squid, how many pounds of squid did your fleet catch? **B = A paperclips x 1,000 lbs/paperclip**
   B = 276,000 **lbs** 276 × 1,000 = 276,000

3. If only 98% of the total number of pounds that your fleet caught were actually squid (the rest are called bycatch, fish that are not squid), how many pounds of squid did you catch? **C = B lbs x 0.98**
   C = 270,480 **lbs** 276,000 × 0.98 = 270,480

4. If it costs 50,000 pounds of squid per boat to keep it operating, how many pounds of squid are needed to pay the operating costs for your fleet? **D = 50,000 lbs/boat x Number of Your Boats Fishing**
   D = 50,000 **lbs** 50,000 × 1 = 50,000

5. How many pounds of squid do you have left to sell after paying the operating costs? **E = C lbs - D lbs**
   E = 220,480 **lbs** 270,480 − 50,000 = 220,480

6. In this simulation the dockside sale price for squid is $0.25/lb. How much money will you get paid for your squid? **F = E lbs x $0.25/lb**
   F = $ 55,120 220,480 × 0.25 = 55,120

7. Did you make a profit this season (F is positive) or did you lose money (F is negative)? Profit

8. If you made a profit, extra boats cost $10,000 each. Would you like to buy more boats? Yes

9. How many boat(s) do you want to buy?
   G = 5 **boat(s)**

10. How much will it cost you to buy those extra boats? **H = G boat(s) x $10,000/boat**
    H = $ 50,000 5 × 10,000 = 50,000

11. How much money do you have in your account at the end of the season?
    55,120 − 50,000 = 5,120

If **F** is positive, **Season Net Profits = F - H** — **Season Net Profits** $5,120

Or, if **F** is negative, **Season Net Losses = F** — **Season Net Losses**

*SAMPLE *

Balance in the Bay
Fishing Fleet Computation Worksheet

Student Fishing Fleet Member Names:

Team 3

FISHING SEASON (circle one) 1 **2** 3 4 5

1. How many paperclips did your fleet collect?
   A = 138 **paperclips**

2. If one paperclip is equal to 1,000 pounds of squid, how many pounds of squid did your fleet catch? **B = A paperclips x 1,000 lbs/paperclip**
   B = 138,000 **lbs**
   138 × 1,000 = 138,000

3. If only 98% of the total number of pounds that your fleet caught were actually squid (the rest are called bycatch, fish that are not squid), how many pounds of squid did you catch? **C = B lbs x 0.98**
   C = 135,240 **lbs**
   138,000 × 0.98 = 135,240

4. If it costs 50,000 pounds of squid per boat to keep it operating, how many pounds of squid are needed to pay the operating costs for your fleet? **D = 50,000 lbs/boat x Number of Your Boats Fishing**
   D = 300,000 **lbs**
   50,000 × 6 = 300,000

5. How many pounds of squid do you have left to sell after paying the operating costs? **E = C lbs - D lbs**
   E = -164,760 **lbs**
   135,240 - 300,000 = -164,760

6. In this simulation the dockside sale price for squid is $0.25/lb. How much money will you get paid for your squid? **F = E lbs x $0.25/lb**
   F = $ -41,190
   -164,760 × 0.25 = -41,190

7. Did you make a profit this season (F is positive) or did you lose money (F is negative)? Lose

8. If you made a profit, extra boats cost $10,000 each. Would you like to buy more boats? No

9. How many boat(s) do you want to buy?
   G = 0 **boat(s)**

10. How much will it cost you to buy those extra boats? **H = G boat(s) x $10,000/boat**
    H = $ 0
    0 × 10,000 = 0

11. How much money do you have in your account at the end of the season?
    -41,190 - 0 = -41,190

If **F** is positive, **Season Net Profits = F - H**

Or, if **F** is negative, **Season Net Losses = F**

Season Net Profits | **OR** | **Season Net Losses** $-41,190

*SAMPLE *

Balance in the Bay
Community Fishery Summary Sheet

	Sample		Season 1		Season 2		Season 3		Season 4	
Fleet 1	lbs squid caught	# boats purchased	129,360	1	160,720	1				
	Net profit/losses		$9,840		$5,180					
Fleet 2	lbs squid caught	# boats purchased	433,160	7	681,100	0				
	Net profit/losses		$25,790		$70,275					
Fleet 3	lbs squid caught	# boats purchased	270,480	5	135,240	0				
	Net profit/losses		$5,120		$ -41,190					
Fleet 4	lbs squid caught	# boats purchased								
	Net profit/losses									
Fleet 5	lbs squid caught	# boats purchased								
	Net profit/losses									
Total pounds of squid caught (T)	**T** (sum of each fleet's catch)		833,000		977,060					
Total # paperclips collected (P)	T / 1,000 = **P**		833		977					
Total # paperclips remaining in fishing grounds (R)	1,000 – P = **R**		167		23					
Total reproduction for next season (N)	R x 10 = **N**		1,670		230					
Number of paperclips to return to fishing grounds for start of next season (S)	N – R = **S**		1,503		207					

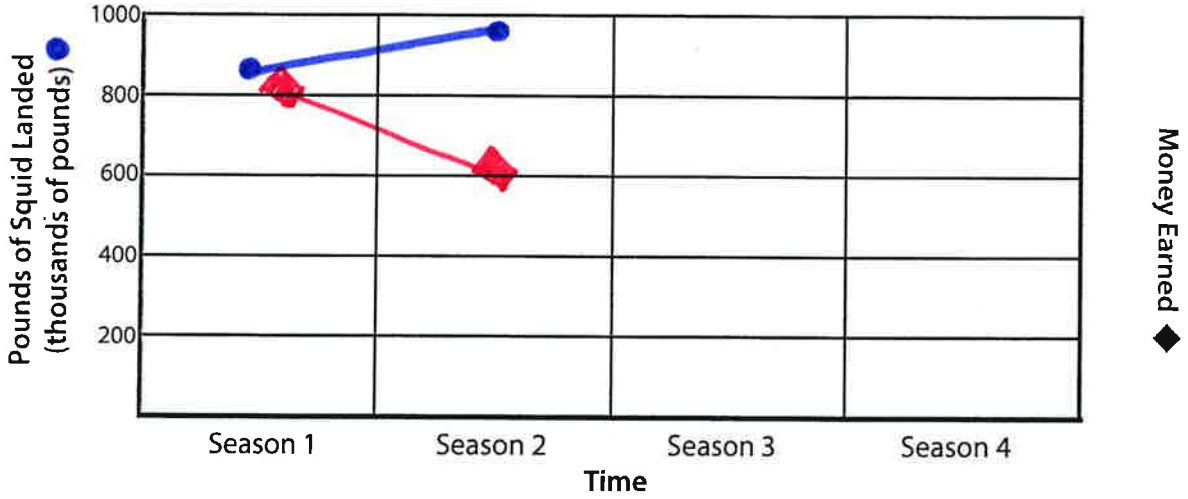
VOICES of the BAY

SAMPLE

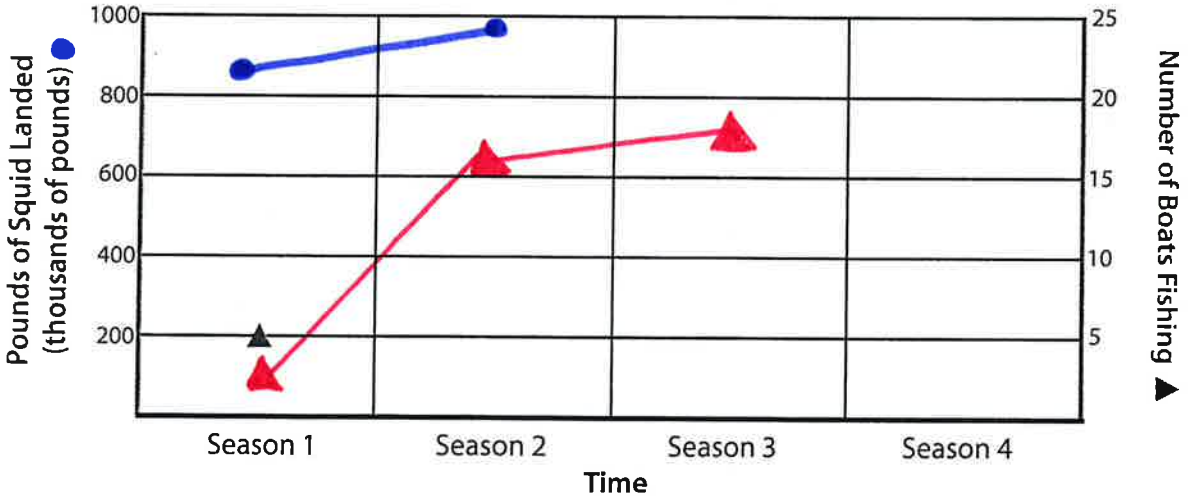
Balance in the Bay

Community Fishery Graphs

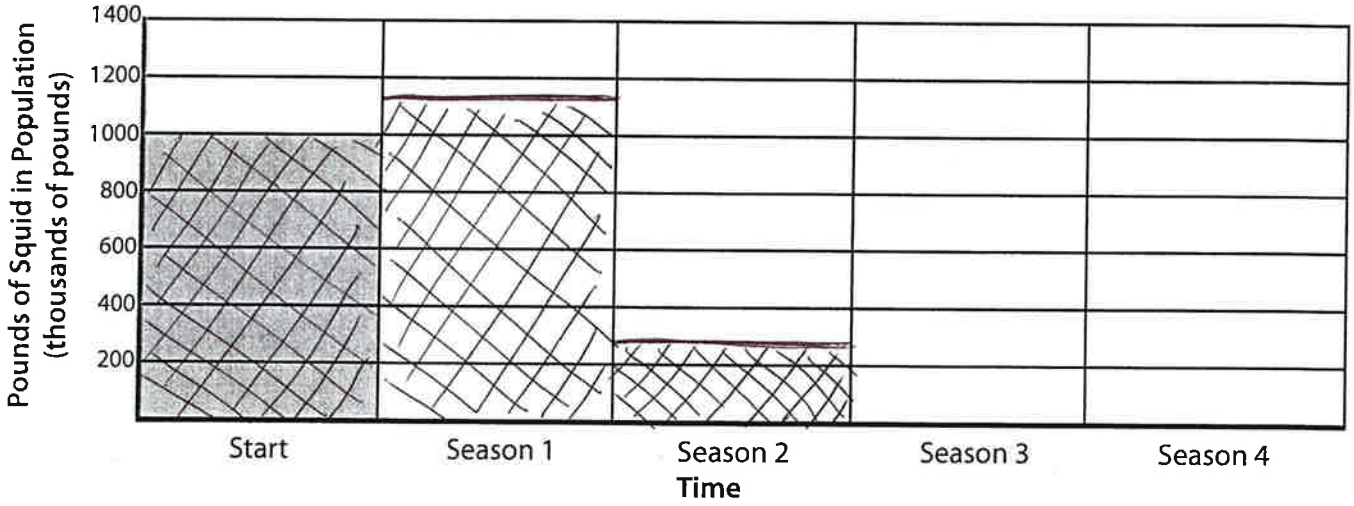
1. Compare the pounds of squid landed (T) and the money earned (summed net profits/ losses) each season.



2. Compare the pounds of squid landed (T) and total number of boats fishing each season.



3. Compare the pounds of squid in the population (S + R) at the end of each season.



Submit Form

VOICES OF THE BAY
Activity Review Form

BALANCE IN THE BAY

School Name: _____

Teacher Name: _____ Phone Number: _____

Location: _____ Email: _____

Date of Implementation: _____

Classroom Description

Course Name: _____ ☐ Elective or ☐ Required Course

Number of Students: _____ Grade Level: _____

Amount of Time Spent on Preparing for Activity(ies): _____

Amount of Time Spent on Activity: _____

Materials Used – Please check all that apply.

- ☐ Squid Fisheries PowerPoint slides
- ☐ Fishing Fleet Computation Worksheets
- ☐ Role Cards
- ☐ Ecosystem-based Challenge Cards
- ☐ Community Fishery Summary Sheets
- ☐ California Department of Fish & Game (CDFG) Squid Fishing Regulations and Restrictions handouts

Module Evaluation

Please circle the response that best represents your opinions about the activity and provide an example or reason if possible.
"1" equals "Strongly disagree" and "5" equals "Strongly agree"

	Strongly disagree			**Strongly agree**	
	1	**2**	**3**	**4**	**5**
1. Activity effectively introduced students to concepts/topics important to marine fisheries.	☐	☐	☐	☐	☐
Please provide an example or reason:					

2. Activity effectively introduced the concepts of ecosystem-based management and "tragedy of the commons" as they relate to marine fisheries.	☐	☐	☐	☐	☐
Please provide an example or reason:					
3. Activity helped students to understand the challenges associated with maintaining balance in a dynamic fishing community.	☐	☐	☐	☐	☐
Please provide an example or reason:					
4. When included, student calculations made sense and students were able to connect their calculations to real-world events.	☐	☐	☐	☐	☐
Please provide an example or reason:					
5. Students were able to apply critical thinking and problem-solving skills to their analyses.	☐	☐	☐	☐	☐
Please provide an example or reason:					
6. Timeframe was suitable for middle/high school settings.	☐	☐	☐	☐	☐
Please provide an example or reason:					
7. Teacher instructions were clear and preparation was manageable.	☐	☐	☐	☐	☐
Please provide an example or reason:					
8. Background information section was adequate, accurate, and clear.	☐	☐	☐	☐	☐
Please provide an example or reason:					
9. Activity appropriately addressed stated standards.	☐	☐	☐	☐	☐
Please provide an example or reason:					
10. Students were engaged and enjoyed the activity.	☐	☐	☐	☐	☐
Please provide an example or reason:					
11. Activity effectively fostered student collaboration.	☐	☐	☐	☐	☐
Please provide an example or reason:					
12. Other comments or suggested changes:					