Hawaiian and Greater Pacific Ocean Fisheries

by Robert Lozano, Waikoloa Elementary

The focus for the lesson will be on fisheries in Hawaiian and Greater Pacific waters of the open ocean. This includes areas where one cannot see the bottom. Students will be tasked with identifying problem(s) with a fishery and suggesting a course of action aimed at alleviating the problem(s). The grade level is 5th grade. Prior to the Webquest, students will be given lessons and conduct experiments detailing the physical and biotic aspects of the open ocean around Hawaii and in the Pacific at large. Based on this information, students will be informed on habitats for organisms fished in Hawaii and the greater Pacific Ocean. This Webquest will introduce five different animals fished in Hawaiian and/or Pacific waters. Then, five major areas will be explored. 1. Find a problem/issue with a Hawaiian or Pacific Ocean fishery. 2. Find sources that give background information on the fishery and issue. 3. Propose potential solutions. 4. Consider pros and cons of implementing the potential solutions (to industry, fish, and ocean). 5. Describe how the effectiveness of the solution will be measured.

Teacher Introduction

Hawaiian and Greater Pacific Ocean Fisheries

This Webquest focuses on researching problems and solutions for fisheries in Hawaii and the Greater Pacific Ocean. Students will be responsible for researching problems with fisheries and proposing solutions in addition to coming up with a way of assessing the effectiveness of their proposals. The lesson has been designed as an addendum to an Open Ocean unit developed from a MARE Gems Guide from UC Berkeley Lawrence Hall of Science. It places an emphasis on Hawaiian fisheries.

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Prior to conducting the Webquest, students will be given lessons and conduct experiments detailing the physical and biotic aspects of the open ocean around Hawaii and in the Greater Pacific Ocean. Based on this information, students will be informed on habitats for organisms fished in Hawaii and the greater Pacific Ocean.

Task:
1. Find a problem/issue with a fishery.
2. Find sources that give background information on the fishery and issue.
4. Consider pros and cons of implementing the potential solutions (to industry, fish, and ocean).
5. Describe how to assess the effectiveness of the proposed solution.
6. Present findings in the form of a poster, diorama, etc.

Learners

This Webquest is intended for fifth grade students using standards from the State of Hawaii Department of Education. It fits within a larger Marine Science Open Ocean unit. The unit details both physical and biotic properties of the open ocean including currents, temperature, salinity, depth, and food webs.

The Webquest seeks to guide learners through the factors that help to create sustainable fisheries. For the final product, students are tasked with presenting their ideas for potential solutions that create sustainable fisheries.

Standards

Content standards directly addressed: (Science)

Standard 1: Scientific Investigation: Discover, Invent, and Investigate
Activities: What do you know?, Currents Labs, Squid Dissection, Map a Habitat, Investigating Fish Populations, Foodweb Modeling

Science Standard 2: Nature of Science: Science, Technology, and Society are Interrelated
Activities: Fishery Info Cards, Marine Debris, Fishery Issue (Final Presentation), Foodweb Modeling.

Science Standard 3: Organisms and Environment: Unity, Diversity, and Interrelationships
Activities: Intro to Open Ocean Organisms, Map an Open Ocean Organism’s Habitat, Fish Cards (Who Eats Me?) Predator-Prey Tag Game, Foodweb Modeling, Marine Debris.

Information literacy standards directly addressed:

Standard 1: Students access information efficiently and effectively.

Standard 2: Students evaluate information critically and competently.

Standard 3: Students use information accurately and creatively.
Standard 9: Students participate effectively in groups to pursue and generate information.

**Teacher Process**

This Webquest will take at least three class periods (approximately 45 min each) in the classroom and computer lab to conduct the research. Students will likely require additional time at home or in school to finish their research and the Webquest. Additionally, two class periods of 45 min each will be necessary to conduct the group activity after conducting the research in order to put the research together and decide upon a product to share as a group.

Suggested Delivery Tip:

1. If possible, give the students a paper copy of their fish card and the fishery card outline (linked in the Process section under step 3). Allow them to do this for homework if there is limited class time to spend on research.

2. Give the students the Webquest url so that they may conduct further research at home should they have access and permission to use the Internet.

Try the first link and if it doesn’t work try the second one.

http://205.234.97.72/45/79/3/070129002849/

Note: More suggestions and information will be forthcoming as the unit is revised and updated. Be sure to check back in Spring 2007 for an updated list of resources and delivery tips. Among the scheduled updates are a Fishery PowerPoint presentation to introduce the topic and student work samples.

**Teacher Resources**

Additional Resources:

In order to open links, having Microsoft Office (for Word and PowerPoint) and Adobe Reader (for pdf), is necessary.

MARE Open Ocean Gems Guide from UC Berkeley Lawrence Hall of Science

Use of fish cards found in guide (linked in Process Section).

For more information on the Big 6 Skills, click on the following links:

**Big 6 Skills Overview**


**How to Do Each Skill**

http://www.crlsresearchguide.org/Big_Six_Steps.asp
Kid-Friendly Version


For questions and/or comments on this Webquest, the author can be reached by email: rlozano@hawaii.edu
The focus for the lesson will be on fisheries in Hawaiian and Greater Pacific waters of the open ocean. This includes areas where one cannot see the bottom. Students will be tasked with identifying problem(s) with a fishery and suggesting a course of action aimed at alleviating the problem(s). The grade level is 5th grade. Prior to the Webquest, students will be given lessons and conduct experiments detailing the physical and biotic aspects of the open ocean around Hawaii and in the Pacific at large. Based on this information, students will be informed on habitats for organisms fished in Hawaii and the greater Pacific Ocean. This Webquest will introduce five different animals fished in Hawaiian and/or Pacific waters. Then, five major areas will be explored. 1. Find a problem/issue with a Hawaiian or Pacific Ocean fishery. 2. Find sources that give background information on the fishery and issue. 3. Propose potential solutions. 4. Consider pros and cons of implementing the potential solutions (to industry, fish, and ocean). 5. Describe how the effectiveness of the solution will be measured.

Student Introduction

Hawaiian and Greater Pacific Ocean Fisheries

The world's fish populations face a number of problems including becoming extinct, or endangered. How we fish, where we fish, and what we fish can have either positive and/or negative effects on our ocean.

You will be finding out some real problems that exist today with fishing and finding potential solutions to those problems.

Task

Challenge: Save the Ocean
What does the future hold for our ocean? Will current fishing techniques wipe out life in the ocean or can we find better ways to conserve it for future generations?

**Task Overview** (be sure to follow the Process steps using the Process link on the left tool bar to complete the Webquest):

1. Find sources that give background information on the fishery.
2. Find sources that detail the issue or problem with a fishery and possible solutions.
4. Consider pros and cons of implementing the potential solutions (to industry, fish, and ocean).
5. Detail how you will measure the success of your solution.
6. Create a display of your work to share with others. You may use a poster, diorama, brochure, etc.
7. Be sure to read the Evaluation Rubric on the Evaluation link on the left tool bar to see what is expected for both the process and product.

**Example Problems:** There are number of issues with keeping our fisheries sustainable. They include bycatch, overfishing, habitat destruction, etc. Identify the issues for your fishery and propose potential solutions.
Task Summary

Read through the 3 steps for an explanation of the task and then go to the Process link in the left tool bar to start your work.

**Step 1.** You should research all sides of the problem/issue (fisheries in Hawaii and the Pacific Ocean). Begin by answering the questions posed by interested parties as well as any other questions that come to mind. Again, this is explained in more detail in the Process section.

1. **Marine Scientist**
   - What do we know about the fish? What does it eat? What eats it?

2. **Fisher**
   - What is the fish’s habitat? How do we catch it?

3. **Fishery Manager**
   - What’s happening with the fishery and why does it matter to us? Is there any overfishing, bycatch, or habitat destruction linked to the fishery? What are the impacts on marine life?

**Step 2.** Share what you found out about your questions. Create and present the group recommendations. Be sure to include all three sides of the issue (scientific, fishery, and conservation/environmental). You will chose as a group what product to use to present your fishery’s problem(s) and proposed solutions. Examples include: poster, diorama, brochure, pamphlet, etc. Remember to include proposed solutions to problems that you’ve uncovered during research. You should list what your recommendation is for the fishery to solve
specific problems that you've uncovered and how you will judge its effectiveness. Again, your
group will choose what product to present.

![Fishing Diorama](image1.png) ![Fishing Poster](image2.png)

**Process**

As stated in the task, you are to determine the problem(s) with a fishery. Are our oceans in peril? Are we on the brink of disaster? Are the fish and other marine life in our ocean doomed to extinction? There are a number of hurdles to overcome to keep our fisheries sustainable. They include bycatch, overfishing, habitat destruction, etc. Identify the problems for your fishery and propose potential solutions. What can we do to help?

![Marlin Hooked with Mahimahi & Ono](image3.png) ![Albatross Hooked with Longline Drowned](image4.png)

Using the worksheets, information, and links that follow, find out what's going on with our ocean and what we can do to take better care of it.
Let's Learn How to Navigate All That Information

Follow the Big 6 Skills Procedure in your research. The following link should be used to make sure your project is on track:

**Big 6 Skills Worksheet**

**Step 1.** Divide up into groups of three and take 2 cards/pages each. Each of you will be responsible for reading the information on the card and reporting your findings back to the group. If you have three members in your group, each person reads two cards/pages. Groups with four members will include two conservationists and will divide cards/pages 5 and 6. Groups with five members have two fishers who divide cards/pages 3 and 4, as well as two conservationists. Groups with six members have two marine scientists who divide cards/pages 5 and 6, as well as two fishers and conservationists. See Figure P-1

![Figure P-1](image)

**Figure P-1**

<table>
<thead>
<tr>
<th>Role</th>
<th>Cards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine Scientist</td>
<td>1 &amp; 2</td>
</tr>
<tr>
<td>Fisher</td>
<td>3 &amp; 4</td>
</tr>
<tr>
<td>Conservationist</td>
<td>5 &amp; 6</td>
</tr>
</tbody>
</table>

**Step 2.** Divide the team into the following roles: Marine Scientist, Fisher, Marine Conservationist

a. **Marine Scientist** - responsible for detailing the specifics of the fish including what’s known about it and its prey/predators using the First Two Cards/Pages (linked below).

![Diver](image) Courtesy of Reefnews

b. **Fisher** - responsible for describing the habitat and catching methods using the Cards/Pages 3 and 4 (same link).
c. Conservationist - describe what's happening with the fishery and why does it matter to us using Cards/Pages 5 and 6 (same link).

Click on your fishery cards/pages and read through the link as detailed above. Remember that each of the team members has a specific role. Note: sites are large (up to 28MB) and may take some time to download.

**Bottomfish**  
[Image: Bottomfish courtesy of NOAA]

**Squid**  
[Image: Squid courtesy of University of Oregon]

**Swordfish**  
[Image: Swordfish courtesy of National Geographic]

**Tuna**  
[Image: Tuna courtesy of wikimedia]
Step 2b. After reading the fishery cards on pdf, click on the blog and share your comments based on information you found on them that is related to the outline you received in class.

Step 2c. Post your comments to the blog following this link:

**Hawaiian Fisheries Blog**

Step 3. After reading your fishery's link, be sure to report back the findings to the group and answer the following prompts/questions:

a. Define problems that your Hawaiian or Pacific Ocean fishery is having. Examples: overfishing, bycatch, habitat destruction, killing endangered or protected animals. After defining a problem with your fishery, suggest a solution. How would you scientifically research this (go in the water, dive to the bottom of the fish, tag fish)? How would you know if the solution works?

b. Essential question: What practices could potentially help to create sustainable fisheries in our ocean?

c. Foundation questions: What abiotic and biotic features shape your fishery's food webs in the ocean? What is a fishery? What defines a sustainable fishery?

Use the following outline to help organize your thoughts and focus on your role:

**Fishery Card Outline**

Step 4. After reporting back to the group and answering the questions in number 3 above and the fishery card outline link, conduct further web searches using the web links and search engines listed below.

Note: Each student is responsible for searching an equal share of the websites. Again, you should mostly be looking for information that applies to your role (Marine Scientist, Fisher, Conservationist). The websites are broken down into five categories. **Again, be sure to pay particular attention to your assigned role.**

1. General
2. Marine Scientist
3. Fisher
4. Conservationist
5. Research Methods.

Conduct information searches on the websites focusing on problems with fisheries and solutions. Be sure to write down important information to share later with your group. Also,
record the website name and address to cite it in the bibliography. Use the bibliography link to help you organize and record your sources.

Bibliography (from Key Middle School Library)

general background information pages

Monterey Bay Aquarium
http://www.mbayaq.org/
Background information on a number of fish and other marine animals. Also gives relevant information on fisheries including fishing methods and environmental concerns.

Hawaii’s Division of Aquatic Resources
http://www.hawaii.gov/dlnr/dar/index.html
This division is in charge of managing our marine resources in state waters. Click on the fishing regulations tab to learn about current state laws protecting our oceans. This tab also has great information about bottom fishing.

Federal Fishery Management
http://www.nmfs.noaa.gov/
This is the website of the arm of the federal government that manages federal fisheries. That’s any fishing going on by US vessels past 3 miles of the coastline. Search for Hawaii fisheries here though a lot of the information may be technical. Click on the bycatch link for good info.

International Whaling Commission
http://www.iwcoffice.org/index.htm
This is the official website of the International Whaling Commission (IWC) and has lots of great information on different whaling species and how many whales are being captured each year.

Fishing Technology and Methods
This page is a great resource for information on different kinds of fishing technology (nets,
boat type, turtle exclusion device, etc.). Want more information on how many different kinds of fishing nets there are, then this is the site for you!

**Impacts of Fishing**
This page has good info about some of the impacts of fishing.

**Squid Fishing**
http://ca-seafood.ucdavis.edu/squid/index.htm
Want to learn about squid fishing? This website has some great pictures of how the squid gets from the ocean to our table.

**Hawaii Prep Academy**
http://facstaff.hpa.edu/~mrice/turtle/turtleindex.html
Contains info on turtle tagging as well as links to other sites on fishery and Hawaiian fishery issues.

**The Kohala Center**
http://www.kohalacenter.org/
Information on Marine Science in Hawaii including aquaculture.

**Lawrence Hall of Science Kid's Corner**
http://www.lhs.berkeley.edu/kids/
Science is something everyone can do and enjoy. Here is an offline activity under the "Home Activities" link: Mapping Fish Habitats (practice in locating fish).

**MARINE SCIENCE PAGES** - Role 1 (related to Fish Cards 1 & 2)

**Fish Information**
http://www.fishbase.org
This is a great website to find information on fish. Search for your fish by name or by topic. This website also has a lot of good links.

**Ocean Biogeographic Information System (OBIS)**
http://www.iobis.org/
Allows user to plot known habitats of particular marine organisms.

**Swordfish, Tuna, and Fish Adaptations**
http://www.flmnh.ufl.edu/FISH/
This website has great information about tuna and swordfish under biological
profiles. Plenty of incredible pictures under images. Also check out the just for kids section to learn more about fish adaptations or other topics.

**Squids, Octopus, and Cuttlefish**
http://www.thecephalopodpage.org/Lopal.php
Learn about all kinds of cephalopods (squids, octopus, and cuttlefish). Some cool movies and good scientific information about squids here.

**Whales**
http://www.whaletimes.org/whafshn.htm
This page provides some really good information on the biology of whales around the world.

**Ask a Marine Biologist**
http://oceanlink.island.net/ask/fishy.html#Anchor-23240
Cool link about fish and fishing? You can ask a marine biologist questions here!

**Cool Kid's Fishin'**
http://www.ncfisheries.net/kids/index.html
Features a number of activities related to fishing, crustaceans, and shellfish including: food chains, a fish quiz, fishfinder, fish clock, a fishtale to read, and fun facts about fishing. (info on food chains and fishfinder very applicable)

**FISHER PAGES - Role 2 (related to Fish Cards 3 & 4)**

![Image](image1.png)
![Image](image2.png)
![Image](image3.png)

**Hawaii Fishing News**
http://www.hawaiifishingnews.com
This site provides information on fishing in Hawaii particular current issues. Hawaii fishing news is the voice of Hawaii’s fishermen. You can e-mail the writers with any questions you have and they will write back!

**Pacific Fisheries Coalition**
http://www.pacfish.org
Fishermen created this page. Watch the videos or look at the white papers for current news. This page has a ton of links.

**Whalers**
http://www.whaling.fo
This link will bring to a page that was created by whalers in the Faroe Islands. This page has a great viewpoint on how whaling may be done sustainably.

**Fishers' Management of Fisheries**
http://www.wfoa-tuna.org
This site shows how fishermen do their own studies and manage their own fisheries. This site specifically has information about the California tuna fishery. Check out the links.

**Hawaii Commercial Fisheries**
http://www.nmfs.hawaii.edu/wpacfin/hi/dar/Pages/hi_fish_menu.php
Great link for information on Hawaii’s commercial fisheries.

**Sign on San Diego**  http://www.signonsandiego.com/news/metro/20061215-9999-7m15tuna.html
Describes the perspective of fisheries especially that their impacts on big fish are not as bad as have been reported.

**Fishery Manager PAGES**  - Role 3  (related to Fish Cards 5 & 6)

![Whale](courtesy of Duke University)

![Hanauma Bay](courtesy of Hawaiiweb.com)

**Ocean Alliance**
http://www.oceanaalliance.org
This is an awesome ocean conservation page. Check it out!

**Oceans Alive**
http://www.oceansalive.org/home.cfm
This website provides all sorts of information about conservation issues in the ocean and the world. This website provides a good perspective on ocean conservation.

**Greenpeace**
This website goes right to Greenpeace’s position on whaling but there is tons of awesome information here.

**Fisheries Around the World**
http://www.savethehighseas.org/highseas.cfm
Don’t miss this link because it has current news on fisheries all over the world.

**Hawaii Conservation Group**
http://www.envirowatch.org
This link is for a Hawaii based conservation organization. Scroll down the left side of the page for news and stories about fishing in Hawaii.

**Environmental Defense**
http://www.environmentaldefense.org/page.cfm?tagid=88
Interesting site with descriptions of sustainable fisheries, problems with fisheries, and links to solutions.
**David Suzuki Foundation**
http://www.davidsuzuki.org/Oceans/Fishing/
Check out the "ten principles" suggested for sustainable fisheries.

**National Geographic News**

**Audobon Magazine**
http://magazine.audubon.org/audubonathome/audubonathome0701.html Describes the pros and cons of aquaculture (potential solution) vs. ocean fishing of shrimp.

**Bird Life International**
Details on the effects of longline fishing on birds.

Describes a project to reduce whale, dolphin, and porpoise deaths caused by net fishing.

**RESEARCH METHODS PAGES**

**Tagging of Pacific Pelagics Website**
On this really cool website you can view how scientists are using tags to research pelagic (open ocean) animals. Read how a bluefin tuna crossed the Pacific Ocean 3 times in one year. Click on whatever group of animals you are interested in for the latest news.

**Open Ocean Animal Studies**
http://www.fadio.ird.fr/whyfadio.htm
This website shows how open ocean animals are being studied by using floating objects equipped with cameras, underwater microphones, and other instruments. This site has some cool videos.

**Southwest Fishery Science Center**
This link takes you right to great information about squid research. If you click on research the site also has some methods about studying fish. Cool movies here!

**Hawaii Institute of Marine Biology**
http://www.hawaii.edu/HIMB/Research.html
Check out this link for lots of information on current research of whales, sharks, and fish in Hawaii.
In addition to the above links, feel free to uncover more information on search engines. Suggested keywords precede the search engines.

Suggested keywords and subject headings for search engines (words you use to find your resources): fisheries, fishing, fish, ocean ecology, bycatch, overfishing, endangered species habitat destruction, fisheries regulation.

Search Engines:

- Kids Click!  http://www.kidsclick.org/
- Yahoo! Kids  http://kids.yahoo.com/
- Ask for Kids  http://www.askforkids.com/
- Fact Monster  http://www.factmonster.com/
- Google for Kids  http://www.google.com/Top/Kids_and_Teens/
- Kids Search Tool  http://www.rcls.org/ksearch.htm

**Step 5.** Define consensus building process, ground rules and expectations. Provide transformation scaffolding to help the group incorporate the interests of each role and make a meaningful recommendation. See the teacher for ideas and/or read on.

Decide on what the research information means and share with your partners.

Specifically state the problem(s) with the fishery. Choose a recorder from your group to be sure that all problems are listed. Choose a leader that will make sure that everyone gets a chance to share. Choose a checker to make sure that the problem has been detailed correctly.

**Step 6.** Present individual positions to the group with appropriate evidence.

State current solutions and comment on their effectiveness. Use the same roles as for the problem.

Propose a new solution that might be tried. Be sure to consider an implementation plan (a step-by-step guide) to follow. For this part, the majority of members must have chosen the solution. Also, each person must check to see that the solution includes pros and cons for implementation. Also, be sure to include how you will assess your proposed solution to tell if it is working.
This is where you make sure that you’ve covered all three points of view (Marine Scientist, Fisher, Conservationist) and filled in all necessary information from the fishery card outline link at the end of Step 3.

**Step 7.** Group develops a recommendation according to the consensus building process and creates a product to present their recommendation. Again use the fishery card outline link found at the end of Step 3 as a production scaffold that helps your group clearly articulate its recommendation and how it was reached.

Group chooses one or more potential solution(s) to make a product and present.

Be sure to view the evaluation rubric under the evaluation link on the left bar.

Create a product that showcases your description of the problem and possible solutions (poster, diorama, pamphlet, etc.)

Also, be sure to list your sources (bibliography) with 10 or more sources.

**Evaluation**

<table>
<thead>
<tr>
<th>Content</th>
<th>Well Below Proficiency</th>
<th>Approaching Proficiency</th>
<th>Meets Proficiency</th>
<th>Meets &amp; Exceeds Proficiency ME</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Essential Problem</td>
<td>The problem is neither related to fisheries nor based in Hawaiian or Pacific waters.</td>
<td>Problem is either not about fisheries or not based in Hawaiian or Pacific waters.</td>
<td>Problem about a fishery in Hawaiian or Pacific waters is stated.</td>
<td>Student clearly states a problem related to a fishery in Hawaiian or Pacific waters.</td>
<td></td>
</tr>
<tr>
<td>2. Find sources that give background information on the fishery</td>
<td>Student finds and cites &lt;5 sources directly related to the problem.</td>
<td>Student finds and cites 5-7 sources directly related to the problem.</td>
<td>Student finds and cites 8-10 sources directly related to the problem.</td>
<td>Student finds and cites 10+ sources directly related to the problem.</td>
<td></td>
</tr>
<tr>
<td>and issue.</td>
<td></td>
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</tr>
<tr>
<td><strong>3. Propose and research potential solutions.</strong></td>
<td>Student offers no solutions or supporting research.</td>
<td>Student offers 1 solution with supporting research.</td>
<td>Student offers 2 solutions with supporting research.</td>
<td>Student offers &gt;2 solutions with supporting research.</td>
<td></td>
</tr>
<tr>
<td><strong>4. Consider pros and cons of implementing the potential solutions (to fish, fishery, and ocean)</strong></td>
<td>Student lists no pros/cons of the potential solutions to fish, fishery, and ocean.</td>
<td>Student lists 1-2 pros/cons of the potential solutions to fish, fishery, and ocean.</td>
<td>Student lists 3 pros/cons of the potential solutions to fish, fishery, and ocean.</td>
<td>Student lists &gt;3 pros/cons of the potential solutions to fish, fishery, and ocean.</td>
<td></td>
</tr>
<tr>
<td><strong>5. Group Work</strong></td>
<td>Student receives positive feedback from &lt;50% of group members.</td>
<td>Student receives positive feedback from 50% of group members.</td>
<td>Student receives positive feedback from most group members.</td>
<td>Student receives positive feedback from all group members.</td>
<td></td>
</tr>
<tr>
<td><strong>6. Big 6</strong></td>
<td>Student follows all Big 6 Skills</td>
<td>Student follows all Big 6 Skills and</td>
<td>Student follows all Big 6 Skills</td>
<td>Student follows all Big 6 Skills</td>
<td></td>
</tr>
</tbody>
</table>
## Skills and Research Organization

| and answers each gateway question. There is no folder. | and answers each gateway question. Folder is neither neat nor organized. | and answers each gateway question. Folder is neat or organized. | and answers each gateway question. Folder is neat and organized. |

## 7. How to implement your solution and measure its effectiveness.

| Student neither details the steps involved to try the solution nor to measure its success. | Student details the steps involved to try the solution or how to measure its success. | Student details the steps involved to try the solution and measure its success. | Student details the steps involved to try the solution and measure its success for all steps. |

## Conclusion

You have researched a problem with a fishery. You have suggested a solution to the problem and considered how the solution might be implemented in the real world. Think about what you have learned about doing research. For extra credit, interview someone interested in fisheries and get their opinion on your proposal. Submit your interview questions and answers for the extra credit.

## Credits

Thank you to the University of Hawaii ETEC Teaching Faculty.

Dr. Michael Menchaca for scaffolding, web design support and troubleshooting.

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Mr. Blake McNaughton especially for the Fish Card Pages, web links, and Fishery PowerPoint presentation, and countless hours spent developing lessons with a relevance to Hawaii.

PRISM GK-12 Leaders:

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Cal State San Marcos College of Education who showed the value of collaboration.

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This WebQuest was created in QuestGarden
Science Letter Update

Date:

Dear Parents:

Your child has been studying the open ocean this year in science. We began by introducing both living and non-living factors that shape the ocean. Next, we studied habitats, foodwebs, and adaptations that marine animals and plants have made so that they thrive in their respective habitats.

Over the next three weeks we will be studying fisheries in Hawaii and the greater Pacific ocean. Students will be assigned a research project that will be completed in class, in the computer lab, in the library, and at home. This year there is a webpage that allows students to access and work on their project at home.

This webpage is called a webquest and was designed by Robert Lozano, the 5th grade teacher at Waikoloa elementary school. The webquest allows the students to work on their science class project from any computer with internet access. Students are able to access relevant links to websites. Please help your student to access the webquest and navigate through the assigned tasks. You may learn something new! The webquest link is outlined at the bottom of this letter.

If you have any questions, feel free to call or write at ________

Teacher
At teachers r us

Try the first link and if it doesn’t work use the second one.

http://questgarden.com/45/79/3/070129002849 or

http://205.234.97.72/45/79/3/070129002849/
Fishery Card Worksheet

This worksheet will help you to summarize the information on your fishery information cards. You should be able to find all of the information asked for on your card. If you cannot then skip that question but you should find out later. If you find a fact that you think is cool then write it down. You will be sharing this information with the rest of your group so don’t let them down!

Use the back of the worksheet if you run out of room on the front.

I. Marine Scientist Role (What’s known about it and What’s for dinner)
   A. Describe the animal that your fishery catches
      1. Name
      2. size
      3. body
      4. eyes
      5. fins
      6. reproduction (slow or fast)
      Any other things
   B. Habitat- Where does your fish live?
      1. Depth
      2. Alone or together
      3. Anything else it needs in its habitat
   C. Position in Food Web
      1. what does it prey on
      2. what are its predators

II. Fisher Role (Where in the world and How are they caught)
   A. Where is it caught-
      1. The Region
      2. temp, salinity, time of day, seasons
   B. Who catches them
      1. Who catches the most in the world
      2. Who catches the most in Hawaii
      3. How much is caught
   C. Catching Methods (how are they caught)
      1. jig, hook, net, longline, handline, or a combination
      2. Is anything else caught along with the main fish/animal

III. Fishery Manager Role (What’s Happening with the Fishery and What’s the big deal)
   A. What’s happening with the fishery?
      1. What is the major problem with the fishery (bycatch, pollution, less fish)
      2. What is being done to stop the problem (management??)
   B. Why does it matter to us?
      1. Who eats it all
      2. Are fish numbers decreasing
      3. What other effects to the environment are there
Fisheries Project Outline

This outline will help you to design your final poster presentation. Your poster should have an all of the following information. The more original thoughts you have in your poster the better grade you will receive. DO NOT put direct print-outs of websites or website information if you do not correctly cite it or understand it. The fishery information cards, webquest’s links, and your instructor should help you to outline all of the following information. The first three sections should be done already!

I. Information about your fish
   a. What is your fishery/fish?
   b. What does your animal look like and why?
   c. What does the main animal in your fishery eat and what eats it?
   d. Where does your animal live?

II. Information about your fishery
   a. Where does your fishery fish?
   b. How much fish does your fishery catch?
   c. Who is catching all that fish?
   d. How is the fish caught?

III. What are the trends and problems with the fishery
   a. Is your fishery catching less fish now than in the past?
   b. Who manages the fishery?
   c. What is the major problem with the fishery? (habitat destruction, no fish, etc.)
   d. Why is this the main problem (fishermen, bad management, people keep eating, bad fishing technique, what is it?)?

IV. Propose a solution to the main problem with your fishery and write down the pros and cons of solution.
   a. What is your solution and why did you choose it?
   b. How does your solution specifically help the problem?
   c. How does the solution affect fishermen, marine scientists, and the consumers (people that eat the food)?
   d. Are there any other negative consequences from your solution?

V. How would you know if your solution was working??
   a. How do you observe your solution at work? (direct observation, collect data from the fishermen, tagging, etc)
   b. Why did you choose this type of observation?
   c. If you could only look at numbers of fish to see if your solution was working what would you expect them to do? (go up, go down, go down for a little while and then up, do nothing, etc.)
There are many different kinds of ways to help stop overfishing, habitat destruction, bycatch and some of the other issues caused by commercial fisheries. These fishery solutions should be focused on the ISSUE and the FISHERY. Review the following table for potential solutions to the problems you have with your fishery and pick the one that works best for your fishery. If you aren’t satisfied with one of the following solutions then use several or create your own!

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bycatch</td>
<td>Change the fishing gear to catch less bycatch. Example: Circle hooks</td>
<td>Allows fishermen to catch the same amount of fish</td>
<td>May be expensive. Requires a lot of testing.</td>
</tr>
<tr>
<td>Bycatch</td>
<td>Incidental Take Limit: If bycatch goes over a limit you stop fishing.</td>
<td>Makes absolutely sure you do not have too much bycatch</td>
<td>May hurt fishermen if they have to stop fishing.</td>
</tr>
<tr>
<td>Bycatch</td>
<td>Require the fishermen to use everything they catch.</td>
<td>Fishermen can catch as much as they want but they must use it.</td>
<td>Hard to enforce: There are not too many police for the whole open ocean</td>
</tr>
<tr>
<td>Overfishing</td>
<td>Limit the number of fish that are caught</td>
<td>Makes sure fishermen are only taking a certain amount.</td>
<td>In order to set a limit you must know how many fish are in the sea: That’s hard!</td>
</tr>
<tr>
<td>Overfishing</td>
<td>Size limits: Only fish of a certain length or weight can be caught and sold.</td>
<td>Protect young fish so they grow and protect old fish because they make a lot of eggs</td>
<td>What happens if a fishery catches undersized fish? They may still die and be dumped back into ocean</td>
</tr>
<tr>
<td>Overfishing</td>
<td>Allow fishing during certain times of year or certain areas.</td>
<td>May protect fish when they are spawning or areas that are very important to the fish.</td>
<td>Sometimes it may be hard to protect fish in open ocean areas: they are far from shore and fish move!</td>
</tr>
<tr>
<td>EndangeredSpecies are caught</td>
<td>Incidental Take Limit: If you catch more that a given amount you stop!</td>
<td>Ensures protection of that species.</td>
<td>May hurt fishermen and encourages them to not talk about any caught animals.</td>
</tr>
<tr>
<td>EndangeredSpecies are caught</td>
<td>Stop commercial fishing. Allow some to be caught for food or research.</td>
<td>Helps to stop the majority of fishing for that species and still allow some fishing.</td>
<td>People may take advantage of the chance to catch fish for science or subsistence.</td>
</tr>
<tr>
<td>Habitat Destruction or Change</td>
<td>Change the gear to stop destroying or changing habitat.</td>
<td>This will often help the fishery in the long run by preserving habitat.</td>
<td>Fishing may not be as easy and fish will cost much more.</td>
</tr>
<tr>
<td>No rules or Knowledge of fishery</td>
<td>Conduct research to determine how many fish can be caught.</td>
<td>Need to know what the fishery is doing before we can make rules.</td>
<td>We don’t usually make rules until a fishery has taken too many fish!</td>
</tr>
</tbody>
</table>
Big 6 Research Skills  (example topic: squid)

Step 1: Task Definition
Students brainstorm a topic that they would like to study. For my class, I suggested they choose a marine animal that is fished since we will study that in 3Q Science.

1. What you need/want to know (size, color, smell, prey, weight, types)

2. 5 Ws: Who, what, when, where, why about the squid
   - Who is interested in squid? scientists, fishers
   - What is a squid? sea animal
   - When can a squid be seen? Day/night, certain seasons or months
   - Where can a squid be found? Certain depths, where prey is
   - Why do I want to know about squid?

3. Make up questions that you’d like to find the answers to.
   - How long do they live?
   - Do they swim alone or in schools?
   - Do they follow certain currents?
   - What temperature water do they like the best?

Step 2: Information Seeking Strategies
Students shared what resources they would try using to find information on their animal.

1. Decide what resources to use.
   - Book of Questions and Answers, Internet, ask.com, encyclopedia, Google, person/scientist

End of 20-30 minute lesson.

Step 3: Location and Access

1. Locate and gather resources
   - Students assigned finding one source that leads to finding the information listed in Step 1.

2. Be able to locate the information needed in a resource.
We will follow up in Computer Lab and/or Library with how to
   a. Do kid-friendly search engine subject searches
   b. Use a table of contents and index in a nonfiction book.
   c. Model how to use guide words and entry words in an encyclopedia.

Step 4: Use of Information
   1. Divide questions up among the class. Write one question on an index card.
   2. Read information from sources from those whose reading levels are lower.
   3. Take notes from the source. Practice writing key words, not entire pages. Focus on answering only the question on the index card.
   4. Remember to cite the sources on back of index card (website, book, author).

Step 5: Synthesis: create a product or display board to communicate what you found.
   1. Share your information from your index card with the class.
   2. Decide, as a class, how you would like to put the information together. Put it together as a class and decide what would look good (report, poster, brochure, diorama, etc)
   3. Check to see that detailed information is included in the presentation.
   4. Create a bibliography.

Step 6: Evaluation of process and product.
   1. Complete Rubric Attached
<table>
<thead>
<tr>
<th>Big6 Step 1: Task Definition</th>
<th>Attempted</th>
<th>Acceptable</th>
<th>Admirable</th>
<th>Awesome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our topic was not defined. We generated very few questions.</td>
<td>Our topic was defined. We generated some questions relevant to the topic.</td>
<td>Our topic was clearly defined. We generated several questions relevant to the topic.</td>
<td>Our topic was clearly defined. We generated many questions, issues.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Big6 Step 2: Information Seeking Strategies</th>
<th>Attempted</th>
<th>Acceptable</th>
<th>Admirable</th>
<th>Awesome</th>
</tr>
</thead>
<tbody>
<tr>
<td>We brainstormed very few possible sources and selected inappropriate, or only one type of source.</td>
<td>We brainstormed some possible sources and selected more than one print and electronic source.</td>
<td>We brainstormed several possible sources and selected some appropriate print and electronic sources.</td>
<td>We brainstormed an abundance of possible sources and selected several appropriate, quality sources.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Big6 Step 3: Location &amp; Access</th>
<th>Attempted</th>
<th>Acceptable</th>
<th>Admirable</th>
<th>Awesome</th>
</tr>
</thead>
<tbody>
<tr>
<td>We located a few questionable print or electronic sources with information.</td>
<td>We located a few print and electronic sources containing current, accurate and relevant information.</td>
<td>We located adequate print and electronic sources containing current, accurate and relevant information.</td>
<td>We located several print and electronic sources containing current, accurate and relevant information.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Big6 Step 4: Use of Information</th>
<th>Attempted</th>
<th>Acceptable</th>
<th>Admirable</th>
<th>Awesome</th>
</tr>
</thead>
<tbody>
<tr>
<td>We used a few print and electronic sources and no organized note taking method to complete a few questions. We did not cite sources.</td>
<td>We used a few print and electronic sources and a fairly organized note taking method to complete all questions. We cited most sources correctly.</td>
<td>We used an adequate amount of print and electronic sources and an organized note taking method to complete most questions. We cited all sources correctly.</td>
<td>We used multiple print and electronic sources and an organized note taking method to complete all questions. We cited all sources correctly.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Big6 Step 5: Synthesis</th>
<th>Attempted</th>
<th>Acceptable</th>
<th>Admirable</th>
<th>Awesome</th>
</tr>
</thead>
<tbody>
<tr>
<td>We created a product that contains unorganized content and demonstrates little knowledge and understanding of the topic. Our bibliography is incomplete.</td>
<td>We created an original product that contains somewhat organized, relevant, content and demonstrates fair knowledge and understanding of the topic.</td>
<td>We created an original product that contains organized, relevant, content and demonstrates fair knowledge and understanding of the topic.</td>
<td>We created an original product that contains organized, relevant, content and demonstrates thorough knowledge of the topic.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Big6 Step 6: Evaluation</th>
<th>Attempted</th>
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<th>Admirable</th>
<th>Awesome</th>
</tr>
</thead>
<tbody>
<tr>
<td>We did not evaluate all steps of the research process or the product. We did not reflect on individual or group strengths and weaknesses.</td>
<td>We evaluated all steps of the research process and product. We reflected on individual strengths and weaknesses.</td>
<td>We evaluated all steps of the research process and product. We reflected on individual and group strengths and weaknesses.</td>
<td>We evaluated all steps of the research process and product. We reflected on individual and group strengths and weaknesses, demonstrating thorough knowledge of the topic.</td>
<td></td>
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## Big6 Research Rubric

<table>
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<tr>
<th>Big6 Step 1: Task Definition</th>
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<td>Our topic was clearly defined. We generated many questions, issues and problems relevant to the topic.</td>
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<th>Big6 Step 2: Information Seeking Strategies</th>
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<tr>
<th>Big6 Step 5: Synthesis</th>
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</thead>
<tbody>
<tr>
<td>We created a product that contains unorganized content and demonstrates little knowledge and understanding of the topic. Our bibliography is incomplete or has several errors.</td>
</tr>
<tr>
<td>We created an original product that contains somewhat organized, relevant, content and demonstrates fair knowledge and understanding of the topic. Our bibliography has several errors.</td>
</tr>
<tr>
<td>We created an original product that contains organized, relevant, detailed and accurate content and demonstrates knowledge and understanding of the topic. Our bibliography has few errors.</td>
</tr>
<tr>
<td>We created an original product that contains well organized, relevant, detailed and accurate content. It demonstrates our thorough knowledge and understanding of the topic. Our bibliography with no errors.</td>
</tr>
</tbody>
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<th>Big6 Step 6: Evaluation</th>
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<td>We did not evaluate all steps of the research process or the product. We did not reflect on individual or group strengths and weaknesses.</td>
</tr>
<tr>
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</tr>
<tr>
<td>We evaluated all steps of the research process and product. We reflected on individual and group strengths and weaknesses.</td>
</tr>
<tr>
<td>We evaluated all steps of the research process and product. We reflected on individual and group strengths and weaknesses. We discussed it.</td>
</tr>
</tbody>
</table>
What Are They
Hawaii’s deepwater bottomfish fishery catches about 20 different kinds of snappers, jacks, and groupers. The most important seven commercial species are the deepwater snappers: Opakapaka, Ehu, Onaga, Lehi, Kalekale, Uukiki (Gindai) and one species of deepwater grouper, Hapuupuu, which is found nowhere else in the world. These fish are very important for a commercial fishery and a recreational fishery in Hawaii.

Where They Hang Out
Bottomfish hang out at depths from 100 to 1,200 ft along the seafloor. They swim within several feet of the bottom. Types of fish that stay at the bottom are called demersal fishes. Bottomfish are found throughout the Hawaiian Archipelago in the Main Hawaiian Islands and the Northwest Hawaiian Islands. These fish live in special types of habitat including ridges, terraces, pinnacles, cliffs, canyons, and steep slopes that have cracks and holes for the fishes to hide in. Different species of fish prefer different habitats and depths. The environment at those depths is dark, cold (around 40-50 degrees F), and the pressure at 1000 ft deep is 30 times greater than at the surface. Can you imagine living in the dark all the time?

What They Look Like
The largest fish of the primary seven is the Hapuupuu, which may reach lengths of up to four feet and 60 pounds. The smallest fish is the uukiki (gindai) which are only 20 inches long and weigh 6 pounds. Lehi, ehu, and onaga are bright red for camouflage because red color looks black in the deep sea. They have large mouths to grab fish. Opakapaka and kalekale are pinkish and have smaller mouths to eat zooplankton. All the deepwater fish have large eyes to see in an environment that is very dark.

How They Feed
Bottomfish biology is poorly known because they live in these deepwater habitats that are extremely hard to study first-hand. Studies that research how bottomfish feed must rely on looking at the stomach contents of caught fish. Some work has been done in Hawaii using anchored cameras to record behavior around baited traps and as well as using submersibles to record behavior. These methods cost a lot of money.

How Long They Live
An opakapaka was known to live for 18 years. That’s old for a fish! Most of these species do not reproduce until they get to be 2 to 5 years old. The age at which the fish reproduce is very important for regulating how many fish should be caught in a fishery.
What's For Dinner?

A study looking at the stomach contents of fish (Haight 1993) found that the six snapper species ate a lot of different animals. Onaga and ehu primarily eat fish, like the longtailed slopefish (*Symphysanodon maunaloae*). Opakapaka and kalekale primarily feed on zooplankton like crab larvae and salps (see pic). Ukikiki (Gindai) appeared to eat both those groups. Salps made a significant contribution to the diet even for some of the fish-eating species. Opakapaka appeared to change what it was eating according to the seasons. Some prey may become much more abundant in the winter or the summer. Also fish that live at different depths prey on different items. Research suggests that these deepwater fish live in different areas and feed on different things in order to share the bottom environment without competition (getting in each other’s way).

What Eats Them
Predators of bottomfish include amberjack (*Seriola dumerili*) and the galapagos shark (*Carcharhinus galapagensis*). Researchers have also recently discovered that the Hawaiian Monk seal (*Monachus schauinslandi*) dives to depths of a thousand feet to prey on deepwater snappers, particularly ehu and onaga.
**Where They’re Caught**

All of the deepwater snapper species are found and fished for throughout the Pacific Ocean. The hapuupuu is found only in the Hawaiian Islands and Johnston Atoll. In Hawaii, bottomfish are fished throughout the Main Hawaiian Islands (MHI) and the Northwest Hawaiian Islands (NWHI), wherever there is appropriate habitat. The State government of Hawaii controls the water from the coastline to 3 miles out. Any further than 3 miles then the Federal government of the United States controls that water all the way out to 200 miles. The Federal government also controls the fishing in the NWHI. Most bottomfish habitat in the MHI is controlled by the State.

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60% of bottom fishermen are commercially licensed. The rest are non-commercial. Only commercially licensed fishermen are required to report how many fish they catch. These catch reports are important for studying how many bottom fish there are. The figure on the right shows how many commercial and non-commercial bottomfishermen there are on each Island. You can see that Oahu and Hawai’i (Big Island) have more bottom fishermen than any of the other islands.
How Are They Caught?

The Fishing Method
Bottomfish are caught using baited hooks attached to a main line (see pic.). The main line is sunk to the bottom using a large 4 to 5 pound weight. Each line may catch several fish per drop. Fishermen dropping lines to over 300 ft deep use electric reels that do not require muscle power. Imagine reeling 100 pounds 1000 ft!

History of the Fishery
Ancient Hawaiians have been catching bottomfish since they first colonized the islands. Bottomfishing could be done anywhere by any fisherman regardless of the ahupuaa (area) they were from. Bottomfishing technique has changed little since ancient times, although the gear has advanced. Fishing line was made of woven plant fibers or hair and fishhooks were made from bone or shells. Since 1832 native Hawaiians have sold bottomfish in a commercial fishery. In the 1970’s the fishery changed from one dominated by 10 to 20 full time commercial fishermen to one fished by hundreds of part time commercial and recreational fishermen. Currently about 3,600 fishermen have registered their boats as bottom fishing vessels.

Managing the Fishery
The Northwest Hawaiian Islands (NWHI) are divided into two different management zones, the Mau zone which is closer to the Main Hawaiian Islands (MHI) and the Hoomalu zone. The Federal government manages this area. Only 9 commercial fishermen are authorized to fish in this entire area. In 2003 the NWHI fishery caught 45% of the bottomfish in Hawaii. This area may soon be closed because the Northwest Hawaiian Islands have been declared a national monument. Where will we get our bottomfish from???
Disappearing Bottomfish
In 2005 the bottomfish population in the Hawaiian Islands was declared to be subject to overfishing. Overfishing means that if fishing continues at current levels then the population of fish will reach a point where it can’t reproduce fast enough to replenish itself. The numbers of fish may then go to zero and the fishery will collapse. The table to the right shows Hawaii’s bottomfish landings over time. You can see that landings for both the Main Hawaiian Islands (MHI) and the Northwest Hawaiian Islands (NWHI) have major drops. The difference is that the NWHI just have fewer fishermen NOT less fish!

The graph below shows catch per unit effort in the Main Hawaiian Islands (MHI) over time. Catch per unit effort is measured in how pounds per trip you catch. The general trend for each species is catch per unit effort going down. This means that fishermen are catching less fish per trip. This usually indicates that the fish may be in trouble.

<table>
<thead>
<tr>
<th>Year</th>
<th>MHI</th>
<th>Total</th>
<th>Hawaii Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>807</td>
<td>661</td>
<td>1468</td>
</tr>
<tr>
<td>1985</td>
<td>763</td>
<td>922</td>
<td>1685</td>
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<tr>
<td>1986</td>
<td>810</td>
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<tr>
<td>1991</td>
<td>548</td>
<td>386</td>
<td>934</td>
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<tr>
<td>1992</td>
<td>587</td>
<td>424</td>
<td>1011</td>
</tr>
<tr>
<td>1993</td>
<td>348</td>
<td>385</td>
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<td>1994</td>
<td>458</td>
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<td>2001</td>
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<td>2002</td>
<td>362</td>
<td>228</td>
<td>590</td>
</tr>
<tr>
<td>2003</td>
<td>273</td>
<td>222</td>
<td>495</td>
</tr>
</tbody>
</table>
FISHERY INFORMATION CARD

Bottomfish

What’s the Big Deal?

Conflicting Management
The State government has been addressing the problem of overfishing in the Main Hawaiian Islands (MHI) with a “closed area” rather than a “closed season” approach. In 1998, the state created nineteen off limit (Kapu) areas. In May 2005, various indicators suggested that the closed areas were not working to improve the fishery. Surveys indicated the problem was that the areas were not in the right areas (the rocky habitat). State managers then decided to change the system. New areas were designed that tried included locations like nursery grounds and deepwater coral beds that are very important to bottomfish and could be damaged by anchors and bottomfishing gear.

VS

The Federal government has taken a different approach to their fishery management scheme. Certain species of bottomfish reproduce, and are therefore more vulnerable to fishing (because they are very hungry) during the summer. The Federal government decided to ban all bottomfishing in the summer months for the areas that they control to help reduce overfishing. What do you think will happen if one part of the ocean is closed to bottomfishing all the time (by the State) but another part right next-door is closed only in the summer. Remember, the boundary between the two areas is 3 miles out in the ocean! There aren’t too many police out there!

Who Depends on the Fishery
The commercial bottomfish fishery in the Main Hawaiian Islands was worth 1.4 million dollars in 2004. The Northwest Hawaiian Island fishery brought in 700,000 dollars. These figures do not include all the recreational fishermen that also fish for deepwater fish. Many restaurants, fish markets, and grocery stores feature Hawaii’s bottomfish. Many stores depend on fishermen to buy their gear, gas, and ice. This is particularly true for many recreational fishermen. What will happen if the NWHI fishery is closed down? Will it force those fishermen to start fishing in the MHI fishery and deplete the MHI fishery even more?

Opakapaka
Mystery Mollusk
Squids are open-ocean mollusks related to octopuses, snails, and clams. Every spring and summer, California market squids (the most popular commercial squids) come together in large numbers, or shoals, to breed. We still know very little about the biology or population size (large, we think) of the market squid. We don't know what they do in the open ocean, or where they go before they come together in mating shoals. Researchers are now trying to study them through their entire life cycle (rather than just when adults appear in large groups to breed), to better manage the fishery.

Reproduction
Female squids spawn (lay eggs) primarily at night. They produce strands of "egg capsules" covered in a jelly-like material, and attach them in clusters to the sandy or muddy bottom. Each capsule contains as many as 300 eggs. About eight weeks after hatching, the young squids start to swim in shoals.

How Long They Live
The males and females die soon after spawning, when they're less than one year old.

What They Look Like
Like many other marine organisms, squids use countershade coloration to be less visible in the water from both above and below, generally appearing paler from below and darker from above. They can change color at will— and very rapidly—in reaction to sudden events or to camouflage themselves. They have eight arms and two, longer tentacles, and their brains and eyes are very large.

Other Squiddy Facts
• The scientific name for California market squid is Loligo opalescens. The first word probably comes from the name of a squid relative, the cuttlefish; opalescens is "iridescent" (like a polished opal).
• More than 500 species of squid inhabit the world's ocean—but fewer than 12 species make up 90 percent of the global catch!
**FISHERY INFORMATION CARD**

**SQUID**

**WHAT'S FOR DINNER?**

**What They Eat**
Squids capture and eat many kinds of prey, including worms, crabs, shrimp, fish, and even other squids. Of 100 market squids sampled for their stomach contents, 10 had eaten small fish (mainly anchovies), 50 had eaten shrimp and krill, 10 had eaten pelagic red crabs, and 30 had eaten other squids.

**What Eats Them**
Dolphins, sperm whales, pilot whales, porpoises, seals, sea lions, sea otters, salmon, swordfish, tuna, sharks, and seabirds such as shearwaters and gulls depend on squids for food. Squid is also an important "people food" in many parts of the world. New, larger boats can deliver fresher squid to market, and more North Americans are eating squid than ever before. In North American restaurant menus and stores, squid is often called calamari—which is simply the Italian word for squid!

**Squid Predators at Risk**
Scientists, environmentalists, and sport fishers are very concerned about the survival of all the marine mammals, fish, and birds that depend on squids for food. Any decline in the squid fishery affects the survival of these species too. A sustainable fishery is as important to the ocean ecosystem as it is to the fishing industry.

<table>
<thead>
<tr>
<th>Prey</th>
<th>Predators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelagic red crab 5 inches long</td>
<td>Spinner Dolphin 5-7 feet long</td>
</tr>
<tr>
<td>Polychaete worm 1.5-3 inches long</td>
<td>Herring 18 inches long</td>
</tr>
<tr>
<td>California market squid 7-10 inches long</td>
<td>Albatross 10 inches long</td>
</tr>
</tbody>
</table>
Where They're Caught
Squid is fished throughout the ocean basins of the world. Squids are caught off the tip of India, around New Zealand, along the entire western Pacific from the Gulf of Siam west to the Philippines, and north throughout the Sea of Japan to Vladivostok, Russia. In the U.S., common market squids are caught from southeast Alaska to Baja California, Mexico. Most are caught in Central and Southern California, especially around the Channel Islands. In Hawaii, there are several species of squid including the diamond back squid that can reach almost 50 lbs!

Who Catches Them
Japan catches 80 percent of the world's squid, and eats the most squid of any country in the world. Korea and Argentina also catch huge amounts of squid. In the U.S., the squid catch has increased dramatically since 1992, and California now catches 67 percent of the U.S. total. The table below shows the catch of cephalopods—mostly squids—by several countries. In Hawaii there is a commercial squid fishery on Kauai, although many fishermen will catch squid for fun or bait.

Table 1: This table shows in metric tons (mt) the landings (size of the catch) for countries taking the most cephalopods (especially squids) of all kinds in 1999. (Total for 1999 was 2,314,000 metric tons)

<table>
<thead>
<tr>
<th>Country</th>
<th>Cephalopod Landings (in metric tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>650,000</td>
</tr>
<tr>
<td>United States</td>
<td>114,000</td>
</tr>
<tr>
<td>Korea</td>
<td>450,000</td>
</tr>
<tr>
<td>Argentina</td>
<td>400,000</td>
</tr>
<tr>
<td>Taiwan</td>
<td>200,000</td>
</tr>
<tr>
<td>Others (New Zealand, Philippines, India, South Africa, Russia…)</td>
<td>500,000</td>
</tr>
</tbody>
</table>

Table 2: This table shows the amount of fish and shellfish of all kinds eaten per year per person (per capita) for countries consuming the most and least fish per person

<table>
<thead>
<tr>
<th>Country</th>
<th>Fish Consumption per Capita (in Pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>152</td>
</tr>
<tr>
<td>China</td>
<td>53</td>
</tr>
<tr>
<td>United States</td>
<td>46</td>
</tr>
<tr>
<td>Indonesia</td>
<td>40</td>
</tr>
<tr>
<td>Cambodia</td>
<td>20</td>
</tr>
<tr>
<td>India</td>
<td>10</td>
</tr>
</tbody>
</table>
The Fishing Methods
1. In the U.S., 90 percent of squid fishers use a kind of net called a purse seine, nearly a mile long, to make their catch. When squids come together in big groups to spawn (lay eggs) on spring and summer nights, fishers shine large, bright lights over the water to attract the squids. The purse seine, which hangs like a curtain through the water, is then pulled by a boat about 80 feet long in a circle around the squids. Fishers close the bottom of the net by pulling a "drawstring" and creating a cone, or "purse." The purse traps the squids (and any unwanted organisms, or bycatch) in the net. The entire net is then hauled in.

2. Japan catches more squids than any country in the world, and has the most high-tech squid-fishing methods. The Japanese use a technique called jigging. It uses many lures, each with two or three rows of hooks in a ring fastened to the fishing line. Either by hand or by machine, the lures are "jigged" (wiggled) in the water from a boat about 100 feet long to attract the squids. Jigging catches the common Japanese squid, but can also catch much larger and more powerful species of squid.

One Example of Managing the Fishery
The Falkland Islands use money from fishing boat license fees to conserve and manage their squid fishery by:
• reducing the number of boats allowed to fish for squids;
• decreasing the number of squids caught as bycatch in other fisheries; and
• requiring boats to report their catches and carry observers on board.

These efforts have paid off; the Falkland Islands appear to have achieved a sustained fishery—meaning the squids can continue to reproduce despite fishing pressure. The Falklands have also created a Marine Protected Area where most of the squid's annual life cycle takes place. This allows the squids to develop and mature undisturbed.
Squids on the Edge of Disaster
From 1997 to 1998, market-squid landings (the catch that's brought to shore) decreased drastically, dropping by 67,000 tons in a single season. The combination of a number of factors threatened disaster for market squids: insufficient scientific information, an unregulated fishery, and unfavorable environmental conditions (this was an El Nino year, when weather disruption affected oceanic productivity). We just don't know how much more fishing pressure squids can handle. The number of squid boats is growing, and powerful new fishing techniques are spreading throughout the fishery.

Setting Limits
In 1999 the U.S. government enacted the Final Rule for Coastal Oceanic Species, making the market squid a "monitored" species. This allowed fishery managers to monitor its population by studying commercial catch data. The idea was to establish a maximum sustainable yield (MSY) (the number of squids that can be caught while still leaving enough animals to reproduce), which was unknown for squids at the time. Many California fishers wanted to stop any new boats from fishing for squids, because they were afraid there wouldn't be enough squids for everyone. Fishers also wanted new laws to protect the fishery—they knew that if the squid fishery collapsed, there were no other fisheries left in California to go into.

Managing the Fishery
As squids were monitored, the relationship of squid-fishing methods to size, sex, and age of the catch became clearer. Based on this information, the California Department of Fish and Game was able to start a real squid management plan in May 2001, to establish and ensure sustainable yields.

New regulations:
• limit how many lights can be used on boats to attract squids;
• limit how strong the lights can be; and
• require lamp shields to direct the light down into the water so birds won't be attracted to the boats and get caught in the nets. The management plan also includes earlier regulations that:
• close the squid fishery (make it off-limits) on weekends, so squids can spawn (lay eggs) undisturbed for several days every month;
• require market-squid fishers to keep logbooks on their catches (providing critical information on fishing practices).

More Management Needed
We still need to research the best plan to manage market squids around the planet. Squids in South African waters and around the Falkland Islands are now carefully managed. In those areas, squid biology is studied, fishing is restricted to certain places at certain times of year, and the number of boats is strictly limited. In this species, which may live less than a year, keeping enough squids for the fishery will depend almost entirely on whether their young get the chance to survive. What would you do to manage the squid fishery in California or Hawaii?
Who Depends on Fish
Of the 30 countries most dependent on fish as a protein source, 26 are in the "developing world." People in developing countries such as Haiti and Lesotho depend more on fish as their main source of protein than people in industrial countries such as the U.S. and Japan. But people in industrial countries eat 40 percent of the world's fish!

How Much We Eat
Between 1995 and 1997, people in the U.S. ate an average of 46 pounds of fish per person (per capita) per year. The Japanese, biggest harvesters of fish in the world, ate a hefty 152 pounds per capita. Spain consumed 90 pounds per capita, per year, while people in Afghanistan and Ethiopia averaged only .2 pounds per person.

What Else Gets Caught
The total worldwide catch of all fishery species is about 93 million tons. Approximately one-third of that catch is wasted—thrown back into the sea dead or dying. That's around 30 million tons—as heavy as 525 average-sized cruise ships! These unwanted marine organisms are called bycatch, or incidental take.

Shrinking World Fisheries
From 1950 to 1989, there was a 300-percent increase in the amount of marine fish caught by the world fisheries. Since then, the total catch has been decreasing due to overfishing. Nearly every individual fishery is in decline.

Table 3: This table shows in metric tons (mt) the total California Market Squid caught in the U.S. between 1981 and 1999. Notice the weight fluctuates dramatically but the overall trend is raising because of increased fishing effort NOT more squids.

<table>
<thead>
<tr>
<th>Year</th>
<th>Weight</th>
<th>Year</th>
<th>Weight</th>
<th>Year</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>16,308</td>
<td>1989</td>
<td>40,893</td>
<td>1995</td>
<td>80,561</td>
</tr>
<tr>
<td>1983</td>
<td>1,824</td>
<td>1990</td>
<td>37,389</td>
<td>1996</td>
<td>70,329</td>
</tr>
<tr>
<td>1984</td>
<td>564</td>
<td>1991</td>
<td>13,110</td>
<td>1997</td>
<td>2,894</td>
</tr>
<tr>
<td>1985</td>
<td>10,276</td>
<td>1992</td>
<td>42,830</td>
<td>1998</td>
<td>91,519</td>
</tr>
<tr>
<td>1986</td>
<td>21,278</td>
<td>1993</td>
<td>55,383</td>
<td>1999</td>
<td>115,000</td>
</tr>
<tr>
<td>1987</td>
<td>19,984</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What's Known about It?

Where They Hang Out
Swordfish are found worldwide both in temperate seas (which never get very hot or very cold) and in the tropics (where seas are always warm). Swordfish are usually solitary fish that live between the surface and 400 feet below, though they've been sighted at 2,000 feet down!

Their "Swords"
Their long bill (which gave them their name, "sword" fish) is a flattened extension of the upper jaw. It helps them swim fast by cutting through the water. The bills are also serrated (notched, like a saw or a bread knife), and are used in feeding - slashing through shoals of fish and sometimes even stabbing the prey! Don't grab a swordfish by its bill!

How They Feed
Swordfish are very muscular, and have large, bright blue eyes. They can chase their prey in deep water with little light, and it's thought that they hunt for food at night. Amazingly, swordfish aren't cold-blooded, as are almost all other fish, but warm-blooded—which means they can keep their body temperatures warmer than the surrounding ocean. (Tuna and some sharks are the same way.) Their rapid metabolism allows them to swim faster and longer than cold-blooded fish, and to hunt at greater, colder depths than many other predators. That's a great advantage in the open ocean.

How Long They Live
Female swordfish live about 25 years; they grow larger than males, but we don't know exactly why. (Is it because they grow faster or live longer? Some other reason?)

Reproduction
Swordfish can begin spawning (laying eggs) at about 5 years old, when they're about 75 pounds and 3 feet long. A female produces up to six million eggs per season. We know very little about swordfish breeding or migration patterns, but some swordfish have recently been tagged using sonic (sound-emitting) tags so they can be monitored and followed for days, both day and night.

What They Look Like
Like squids and many other marine organisms, swordfish use countershade coloration to be less visible in the water from both above and below; they're bronze-colored on the back and silver below, with black belly fins and no pelvic fins. Swordfish get about 15 feet long (measured from the eye to the fork of the tail), and the females can weigh 1,000 pounds or more.

Other Swordfishy Facts
• The scientific name for swordfish is Xiphias gladius, from the Greek and Latin words for "sword."
• Swordfish have a reputation for unprovoked aggression, occasionally attacking boats by ramming them with their bill. The submersible (underwater) research vessel Alvin was once actually rammed by a sword-fish—and as the fish was unable to get loose, the crew had swordfish for dinner!
What They Eat
Swordfish feed in every layer of the ocean, from the surface to several hundred feet deep, and will eat just about anything—including tuna, sardine, anchovy, mackerel, herring, hake, smaller swordfish, krill, pelagic red crab, and squids. Swordfish prey is often found with stab or slash marks on their bodies, which tells scientists that the bill ("sword") is sometimes used to kill or injure prey. The stomach contents of one swordfish revealed 50 pounds of prey, including 27 pounds of various oceanic fish, 12 pounds of crustaceans (krill and crabs), and 11 pounds of squid.

What Eats Them
Tuna, marlin, blue and mako sharks, and sailfish eat small swordfish. Sperm whales, killer whales (orcas), and large sharks such as great whites eat large swordfish. But humans are the major predator of this species. It's against the law in the U.S. to catch small swordfish, which are not yet old enough to reproduce—but many are caught by mistake and thrown back into the sea, dead or dying. Most of these catches are never reported.
FISHERY INFORMATION CARD

SWORDFISH

Where in the World?

Where They're Caught
Swordfish are found throughout the world both in temperate seas (which never get very hot or very cold) and in the tropics (where seas are always warm), and are fished just about everywhere they occur. The major fisheries are located in the northern and central Pacific, from just below Russia's Kamchatka Peninsula across the entire width of the Pacific Rim and as far south as the tropic of Cancer. In Hawaii the majority of swordfish are caught north of the islands where an area of high nutrient cold water meets an area of low nutrient warm water (see map).

Who Catches Them
Japanese boats bring in most of the Pacific swordfish, and swordfish is now the second biggest U.S. fishery in the Pacific of which Hawaii is an important part. Taiwan, Korea, France, and Brazil take large amounts of swordfish in the Pacific as bycatch (unintentional or "incidental" catch) while fishing for other species. The Hawaii fleet caught 542,000 pounds of swordfish in 2004 that was worth an estimated 1.1 million dollars. The table to the left shows the annual swordfish catch for Hawaii. You can see that in 2001 there was a big drop in the catch. That drop is because there was a new law passed that significantly changed the fishery. It's very difficult to get an accurate estimate of the swordfish catch worldwide, because much of it comes from unregulated fishing and is unreported.

This Table shows the amount (in pounds) of swordfish caught in Hawaii from 1987 to 2004.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>POUNDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>52,000</td>
</tr>
<tr>
<td>1988</td>
<td>52,000</td>
</tr>
<tr>
<td>1989</td>
<td>619,000</td>
</tr>
<tr>
<td>1990</td>
<td>5,372,000</td>
</tr>
<tr>
<td>1991</td>
<td>9,939,000</td>
</tr>
<tr>
<td>1992</td>
<td>12,566,000</td>
</tr>
<tr>
<td>1993</td>
<td>13,027,000</td>
</tr>
<tr>
<td>1994</td>
<td>7,002,000</td>
</tr>
<tr>
<td>1995</td>
<td>5,981,000</td>
</tr>
<tr>
<td>1996</td>
<td>5,517,000</td>
</tr>
<tr>
<td>1997</td>
<td>6,652,000</td>
</tr>
<tr>
<td>1998</td>
<td>7,193,000</td>
</tr>
<tr>
<td>1999</td>
<td>6,835,000</td>
</tr>
<tr>
<td>2000</td>
<td>6,502,000</td>
</tr>
<tr>
<td>2001</td>
<td>485,000</td>
</tr>
<tr>
<td>2002</td>
<td>699,000</td>
</tr>
<tr>
<td>2003</td>
<td>301,000</td>
</tr>
<tr>
<td>2004</td>
<td>542,000</td>
</tr>
</tbody>
</table>

This Figure shows the line where warm, nutrient poor water (in purple) meets cold, nutrient rich water north of Hawaii. This is an area that is very productive for swordfishing. This figure is from a study done in 2001 by Polovina et al.
The Fishing Method
Almost all swordfish are caught by longline fishing at night, when they feed at the surface. Each longline has up to 3,000 shorter lines attached to it, each with a baited hook at the end. A set of longline gear from a single 130-foot boat can stretch up to 80 miles across the ocean! Usually lines are set anywhere from 150 feet deep to 400 feet deep. Longline vessels travel far offshore, fishing for several months at a time, day and night. The average trip in Hawaii is about two or three weeks.

What Else Gets Caught
Longline fishing accidentally kills thousands of other, untargeted animals (called bycatch), including the sea turtles and albatross (large seabirds) that are attracted to the bait and get caught before the hooks can sink below the surface.

Managing the Fishery
The faster the hooks sink, the less bycatch of birds and turtles there is—so North Pacific longline fishers must now use weighted hooks. They're also required to use fewer lights on the boat when they fish at night, so that seabirds are less attracted to the bait. And they have to hang lines above the baited hooks to scare the birds away. Another strategy used in Hawaii is to dye the bait blue so the birds can't see it as well!

A Good Management Example: Hawaii
Rapid growth of the swordfish fishing fleet has also hurt some endangered species, including the endangered Hawaiian monk seal and the endangered loggerhead turtle. Commercial fishing is being moved to areas where bycatch will be lower. Protected areas are closed to swordfish fishing at certain times of year. No longline fishing is allowed within 75 miles of the Main Hawaiian Islands for much of the year where most monk seals live. All boats around Hawaii are monitored every hour to make sure they're staying out of protected areas.

The Hawaii swordfish fishery also has an incidental take limit for endangered loggerhead turtles. This means that if the fishery accidentally catches (takes) a certain amount of loggerheads (the limit in 2006 was 17) the whole fishery shuts down. In 2006 the fishery reached its limit in October, 3 months before the end of the year! Consequently the longline fishermen are setting their lines deeper to avoid the areas where the turtles can dive and eat their bait. This means the fishermen catch less fish but they also catch less turtles! Sometimes it’s hard to be a fisherman.
What’s Happening with the Fishery?

Disappearing Swordfish
Thick, meaty swordfish steak was once a popular menu item in expensive restaurants. That's changed, though, as swordfish continue to disappear due to overfishing. Many swordfish were once caught off the Atlantic coast of the U.S., but they're now considered overfished, and many restaurants no longer serve them. In 1982, swordfish made up 60 percent of all the open-ocean fish caught by U.S. fishers in the Atlantic, but the swordfish population has almost disappeared because of continued overfishing.

The Pacific Fishery
When the Atlantic fishery for swordfish collapsed, the fishing fleet moved to the Pacific. Japan and the U.S. bring in most of the Pacific swordfish, and swordfish is now the second biggest U.S. fishery there, much of this coming from Hawaii. But the total catch in the Pacific has declined each year since 1993 due to overfishing. All countries fishing for swordfish need to cooperate to protect the population. In 1995, the United Nations produced a treaty to protect fish, like swordfish, that cross the coastal zones of two or more countries or migrate through international waters. The treaty will only take effect, though, once 45 nations have agreed to it.

Setting Limits
The amount of fishing that can occur while still leaving enough animals to reproduce is called the maximum sustainable yield (MSY). In 1999, the international group responsible for swordfish management estimated that the yearly swordfish catch—the MSY—must not exceed 10,000 metric tons. This would allow the swordfish population to grow despite fishing pressure.

Regulating the Fishery
In 2004 the managing council in Hawaii made a new law that required the longline vessels to change the type of hook they were using from a J hook (on left) to a circle hook (on right). This simple change made it much harder for turtles and birds the get accidentally caught and reduced bycatch significantly.

Scientists are also very concerned about the huge numbers of small, immature swordfish caught unintentionally, thrown back dead, and often not counted. In 2000, the U.S. government decided to make swordfish nursery grounds—where young swordfish develop—"off limits" (closed) during the breeding season, hoping to reduce the number of young swordfish caught.

Enforcing the Law
Rebuilding the fishery is a big job. It all depends on monitoring and enforcing the nursery closures and other regulations. The open ocean is a big place. Can you imagine trying to regulate an area that is five times the size of the United States! Unfortunately, although the U.S. uses observers to monitor and count the discarded bycatch (dead fish thrown back into the sea), some other countries do not. Spain—which catches the most swordfish in the North Atlantic—has no observers on board, and it reported "zero" discards in 1999. Was this true?
Who Depends on Fish
Of the 30 countries most dependent on fish as a protein source, 26 are in the "developing world." People in developing countries such as Haiti depend more on fish as their main source of protein than people in industrial countries such as the U.S. and Japan. But people in industrial countries eat 40 percent of the world's fish!

How Much We Eat
Between 1995 and 1997, people in the U.S. ate an average of 46 pounds of fish per person (per capita) every year. The Japanese, biggest harvesters of fish in the world, ate a hefty 152 pounds per capita. Hawaii’s average is more than three times the U.S. average and is 2nd in the world behind Japan.

What Else Gets Caught
The total worldwide catch of all species of fish and shellfish is about 93 million tons. Approximately one-third of that catch is wasted — thrown back into the sea dead or dying. That's around 30 million tons — as heavy as 525 average-sized cruise ships! These unwanted marine organisms are called by-catch, or incidental take.

Shrinking World Fisheries
From 1950 to 1989, there was a 300-percent increase in the amount of marine fish caught by the world fisheries. Since then, the total catch has been decreasing due to overfishing. Nearly every individual fishery is in decline. The Pacific swordfish fishery is now growing though it may need stricter regulations soon. What would you do that hasn’t already been done??

*A loggerhead turtle that was accidentally caught by a longline vessel. The turtle swallowed the bait hook and all! Doctors had to surgically remove the hook.*
What's Known about It?

How They Feed
Maybe the most amazing fact about tuna is that they're **endothermic**, which means they have a rapid metabolism and can keep their body temperatures warmer than the surrounding ocean. Swordfish and some sharks are the same way. This adaptation allows them to swim faster and longer than most fish, and to hunt at greater, colder depths than many predators. This is a major advantage in the open ocean and one reason tuna are so successful.

The Different Kinds
Many species of tuna are caught for food, including bigeye, yellowfin, bluefin, albacore, and skipjack. In Hawaii the most often caught are yellowfin (ahi), bigeye (ahi), and skipjack (aku). These tunas each look a little different and may eat different things including each other. Often their name gives away their defining characteristic (yellowfin tuna have yellowfins). This card will concentrate mostly on yellowfin and bigeye, the two most abundant species in Hawaii.

What They Look Like
Like squids and many other marine organisms, tuna use *countershade coloration* to be less visible in the water from both above and below. They have darker backs and silvery bellies; some may have white spots or stripes on their bellies. The largest of the tunas, bluefin may weigh up to 1,400 lbs and measure over 10 feet long. Yellowfin may grow up to 6 feet long and weigh 400 pounds.

Where They Hang Out
Tuna are social fish, forming large schools. Aku are often spotted at the surface feeding while bigeye tuna may dive to depths of a thousand feet to find food. Tuna often hang around floating objects (as do many other pelagic fish). We're not sure why the tuna do this (to meet up with other fish? to hide from predators?), but fishers take advantage of this behavior to lure tuna under floating objects and catch them.

How Long They Live
Bluefin may live up to 20 years. Yellowfins live at least 5 years, but researchers don't know exactly how old they can really get.

Reproduction
Yellowfin tuna mature enough to *spawn* (lay eggs) at between 2 and 3 years old, when they're about 3 feet long. They do their spawning in warm tropical waters like Hawaii in the summertime, which is why there are many more yellowfin caught in the summer. Bigeye tuna don’t spawn until they’re at least 3.5 feet long and it is unknown where exactly they spawn.

Other TunaFishey Facts
• The scientific name for yellowfin tuna is Thunnus albacares, from the Latin words for "tuna" and "white."
• Because tuna migrate over long distances and travel from one country's coastline to another, it's very difficult to estimate the world's tuna population. Bluefin have been known to swim across the Pacific!
• Tuna are one of the fastest families of fish in the world. Bluefin has been clocked at 45 miles per hour.
What's For Dinner?

What They Eat
Tuna are opportunistic feeders, which means they will munch on anything tasty that they come across. A study done in Hawaii on yellowfin diet found that in yellowfin stomachs 66% of the diet was fish, 28% was crustaceans (like crabs and shrimps), and 6% was squids. This study also found that the tuna that hung around floating objects ate almost only shrimp (maybe that’s all that was around). Bigeye tuna can dive deeper and eat more squid.

What Eats Them
As for tuna’s predators, well...a 157-pound yellowfin was found inside a 1,500-pound black marlin! Tuna are also eaten by other, larger tuna and are particularly vulnerable when they are young. Sharks and some marine mammals (like pilot whales) also eat tuna. People are the largest consumers of tuna in the world. People in the U.S. eat more canned tuna (including yellowfin and juvenile bigeye) than any other seafood. Japan consumes the most sashimi out of any other country in the world.

What We Eat
Tuna fishers often encircle (set their nets around) dolphins to catch the tuna that like to swim underneath. When the nets are hauled in, the dolphins are trapped inside along with the tuna, and may drown or be killed in the equipment. The death of these intelligent marine mammals is a terrible waste. The three leading U.S. tuna canners—StarKist, Bumblebee, and Chicken of the Sea, have said they’ll sell only tuna caught without dolphin encirclement. However, next time you’re at a supermarket or grocery store, check a few tuna fish cans. Are they still all labeled “Dolphin-Safe”.

PREY

pelagic red crab
5 inches long

Shrimp 1-3 inches long

Squid 7-10 inches long

PREDATORS

marlin 14 feet long

other tuna 6-10 feet long
TUNA

Where in the World?

Where They’re Caught
Most tuna caught around Hawaii come from the longline boats that launch from Oahu. In 2004, Hawaii’s fishermen caught 13.5 million pounds of tuna. Most of this tuna gets eaten in Hawaii or goes to Japan for the sashimi market. The map on the right below shows where the tuna by species are caught around Hawaii.

Who Catches Them
The U.S. and Mexico catch most of the tuna landed (caught and brought to shore) in the entire Pacific. Others include the Philippines, China, France, Venezuela, and many South Pacific islands. In the eastern tropical Pacific, Mexico takes the most tuna. In the central western Pacific, the U.S., Japan, Korea, and Taiwan take the most.

Table 1: This Table shows the total amount of all kinds of tuna landed (in pounds) from 1987. Notice the large increase over the years.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>POUNDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>10,120,000</td>
</tr>
<tr>
<td>1988</td>
<td>11,200,000</td>
</tr>
<tr>
<td>1989</td>
<td>11,180,000</td>
</tr>
<tr>
<td>1990</td>
<td>9,720,000</td>
</tr>
<tr>
<td>1991</td>
<td>10,790,000</td>
</tr>
<tr>
<td>1992</td>
<td>9,460,000</td>
</tr>
<tr>
<td>1993</td>
<td>12,420,000</td>
</tr>
<tr>
<td>1994</td>
<td>11,310,000</td>
</tr>
<tr>
<td>1995</td>
<td>13,820,000</td>
</tr>
<tr>
<td>1996</td>
<td>13,690,000</td>
</tr>
<tr>
<td>1997</td>
<td>16,810,000</td>
</tr>
<tr>
<td>1998</td>
<td>15,560,000</td>
</tr>
<tr>
<td>1999</td>
<td>16,150,000</td>
</tr>
<tr>
<td>2000</td>
<td>14,460,000</td>
</tr>
<tr>
<td>2001</td>
<td>14,950,000</td>
</tr>
<tr>
<td>2002</td>
<td>16,490,000</td>
</tr>
<tr>
<td>2003</td>
<td>14,770,000</td>
</tr>
<tr>
<td>2004</td>
<td>16,340,000</td>
</tr>
</tbody>
</table>

Table 2: This Table shows the total tuna catch by species for Hawaii. □ = albacore, ■ = bigeye, □ = bluefin, □ = skipjack, □ = others, □ = yellowfin. The Big Island is in the center. Notice the change in the dominant species from bigeye to skipjack as you move south. Why might that happen?
How Are They Caught?

The Fishing Method
Throughout the Pacific, the two major methods of catching tuna are longlining and purse-seining, where a fishing boat encircles a school of tuna with a large net and then pulls a rope at the bottom called a purse string. The purse string closes the bottom of the net and catches everything inside. However, this method is rarely used in Hawaii. In the Hawaii, tuna are caught mostly by longlining. Each longline has up to 3,000 shorter lines attached to it, each with a baited hook at the end. A set of longline gear from a single 130-foot boat can stretch up to 80 miles across the ocean! Longline vessels travel far offshore, fishing for several months at a time, day and night.

What Else Gets Caught
Both longlining and purse-seining have a lot of bycatch, or animals that are not intended targets. For longlining sea turtles and albatross (large seabirds) are attracted to the bait and get caught before the hooks can sink below the surface. Yellowfin tuna often swim under dolphins to hunt together or gather under floating objects like logs or buoys. Purse-seiners take advantage of this behavior by using a chaser boat to herd dolphins into their nets to catch the tuna swimming underneath. The dolphins may be trapped inside when the nets are hauled in, and are injured or drown. They may become wasted bycatch.

Reducing Bycatch
For decades, thousands and thousands of dolphins were being trapped and killed each year along with the tuna. In 1990, though, the United States stopped buying tuna caught with those fishing methods. All tuna in U.S. stores from 1990 to 1998 were caught by other methods, with far less bycatch. Soon all tuna fishers in the Pacific had to change their fishing methods if they wanted to sell their catch to the U.S. They agreed to place a government observer on every tuna boat, and to use a technique called backing down to release dolphins from the nets. By the late 1990s, the number of dolphins killed had dropped by 97 percent. Tuna caught with dolphin-saving techniques began to be sold in cans labeled "Dolphin Safe."

A Step Backward?
Congress has been considering less-strict standards for the "Dolphin Safe" label. The government is thinking of allowing tuna cans to display the label even if the tuna was caught using dolphin-encircling methods—as long as shipboard observers don't actually see dolphins killed or injured. Supporters of this change believe it would allow more manufacturers to use the "Dolphin Safe" label while still making sure dolphins aren't harmed. Opponents argue that dolphins will still die or be harmed as they're chased over miles of open ocean and encircled in nets up to a mile long. In 2000, a federal judge ruled that more studies and review of the data need to be done. What do you think?
FISHERY INFORMATION CARD

What’s Happening With the Fishery?

The Kind of Tuna We Buy
The U.S. eats the most canned tuna in the world. Albacore is the highest quality of canned tuna, and is labeled "white meat tuna"; yellowfin is canned as "chunk light tuna." Most bigeye tuna is sold fresh as sashimi in Japan. Many restaurants in Hawaii now only serve tuna that is caught by trolling or other fishing methods that are less harmful to the open ocean environment. Most of the seafood eaten in Hawaii is fresh or frozen.

Setting Limits
The amount of fishing that can occur while still leaving enough animals to reproduce is called the maximum sustainable yield (MSY). The MSY for yellowfin tuna in the eastern tropical Pacific is about 280,000 metric tons. But in 1999 the average catch of yellowfin for the eastern tropical Pacific was 296,392 metric tons. It appears that yellowfin is being fished above the level it can sustain. Bigeye tuna in the Pacific Ocean is also subject to overfishing according to the Western Pacific Fishery Council. In Hawaii the bigeye catch has risen from 1.8 million pounds in 1987 to 9.5 million pounds in 2004.

Managing the Fishery
Most worldwide tuna populations have declined due to overfishing. Even if the number of boats fishing for tuna were kept at a constant level, the fishing capabilities of the fleet are increasing as fishing gear and techniques become more and more efficient. No overall management plan covers the tuna fishery in international waters—or even in all U.S. waters. Instead, a number of separate organizations and treaties, with limited power over limited areas, try to manage the fishery. Two new international agreements (the United Nations Highly Migratory Fish Stocks and the Code of Conduct for Responsible Fishing) may help protect the tuna. In Hawaii the overall catch of tuna has been going up for the past twenty years and may be approaching a limit.
What’s the Big Deal?

Who Depends on Fish
Of the 30 countries most dependent on fish as a protein source, 26 are in the "developing world." People in developing countries such as Haiti and Lesotho depend more on fish as their main source of protein than people in industrial countries such as the U.S. and Japan. But people in industrial countries eat 40 percent of the world's fish! In Hawaii the tuna fishery was worth 38 million dollars in 2004. That’s a lot of money for the State.

How Much We Eat
Between 1995 and 1997, people in the U.S. ate an average of 46 pounds of fish per person (per capita) per year. The Japanese, biggest harvesters of fish in the world, ate a hefty 152 pounds per capita. Hawaii eats more seafood per capita than any other state. Hawaii’s average is more than three times the U.S. average and is 2nd in the world behind Japan.

What Else Gets Caught
The total worldwide catch of all species of fish and shellfish is about 93 million tons. Approximately one-third of that catch is wasted—thrown back into the sea dead or dying. That's around 30 million tons—as heavy as 525 average-sized cruise ships! These unwanted marine organisms are called bycatch, or incidental take.

Shrinking World Fisheries
From 1950 to 1989, there was a 300-percent increase in the amount of marine fish caught by the world fisheries. Since then, the total catch has been decreasing due to overfishing. Nearly every individual fishery is in decline. What will happen to the fishermen if there are no more fish?

This picture shows the world record tuna catch. Picture courtesy of the IFGA.
Where They Hang Out
Whales are found worldwide in Arctic seas (cold), temperate seas (which never get very hot or very cold), and in the tropics (where seas are always warm). Whales travel in groups or alone depending on the species. All whales need to breathe air so they must return to the surface depending on their dive time. Sperm whales are the longest divers, may descend up to 10,000ft and stay underwater for two hours on one breath.

What They Look Like
Whales come in a variety of shapes and sizes. The blue whale is the largest living animal, at up to 94ft long and 180 tons. The smallest whale is the dwarf sperm whale, which only grows to about 9ft long. Baleen whales have two blowholes while toothed whales only have one. Baleen whales have a skull shaped to house their baleen plates and a large cavity in their mouths to gulp water when they feed. Toothed whales have a larger skull built to receive sound (echolocation) and mouth designed to grab and chew prey. All whales have a dorsal fin for stability, two pectoral (side) fins for steering, and flukes (tail fin) for power.

How They Feed
There are two types of whales; The toothed whales, which have teeth and the baleen whales, which have long, thin plates (baleen) in their mouth. Baleen whales feed by using their baleen to filter small organisms out of the water. Most baleen whales will take in large gulps of seawater and then spit out the water through their baleen. The food gets trapped on the inside of the filter. The whale then licks the food off the inside. Toothed whales capture their prey using a variety of techniques. They often hunt in groups to surround their prey. Toothed whales have the unique ability of echolocation, a type of sonar, which they use to locate prey and avoid predators.

How Long They Live
Whales have differing life spans. One bowhead whale was reported to have been 130 years old when it died! Whales are difficult to age because they live so long. There are very few records of whales that have been tracked from birth to death. One way that humpback whales are aged is by looking at layers in their earwax. Humpback whales are estimated to live between 50 to 80 years old.

Reproduction
Whales are mammals and therefore give birth to live young instead of laying eggs like many fish. Most whales don’t start reproducing until they are 7 to 10 years old. Whales give birth to one calf (baby whale) at a time. There has never been a documented case of twins. The calf will then nurse or drink its mother’s milk for up to one year. This allows the calf to grow very quickly to avoid predators and keep up with the other whales. Gaining enough strength to swim for long periods is especially important for humpback whales, which migrate with their mothers a few months after they are born for thousands of miles.
What’s For Dinner?

What They Eat
Baleen whales eat zooplankton such as krill, small shrimp, and small fish. Blue whales will eat as much as 9,000 pounds of plankton every day. Toothed whales eat a variety of different foods depending on their size. Smaller toothed whales eat fish and small squid. The largest toothed whale, the sperm whale, eats giant squid that may grow to be 30 ft long. Many baleen whales will migrate from colder nutrient-rich waters where they feed to warmer waters where they reproduce. While in Hawaii, humpback whales don’t eat any food. This is because there less zooplankton in nutrient-poor tropical waters. That’s why our ocean is so clear because it’s low on nutrients!

What Eats Them
Large sharks such as great whites, tigers, and makos as well as killer whales (orca) eat whales. Killer whales are actually in the dolphin family. The most dangerous predator for whales in Hawaii is the tiger shark, which preys on sick or baby humpbacks. Larger whales such as the blue whale and sperm whale have very few natural predators. Humans are the major predator of whales. Humans are responsible for the collapse of many of the world’s whale populations. Currently there are six species of whales that are still caught commercially.

Prey

- Krill 1-3 inches
- Fish all sizes
- Squid all sizes

Predators

- Tiger Shark 12-16 ft
- Killer Whale 15-20 ft
FISHERY INFORMATION CARD

Whales

Where in the World?

Where They’re Caught
Whales are found throughout the world in arctic seas (which are always cold), temperate seas (which never get very hot or very cold), and in the tropics (where seas are always warm). The major fisheries occur in the western Pacific and in the northern Atlantic Oceans. Several countries have outlawed whaling in their exclusive economic zones, which extend 200 miles out from the shoreline. Along with these countries there are two major established sanctuaries against commercial whaling in both the southern (Antarctic Ocean) and the Indian Ocean.

This map shows the dark areas as the whale sanctuaries (www.iwcoffice.org)

Who Catches Them
Norway, Iceland, and Canada to some degree are the only countries that openly engage in commercial whaling, which is strictly for profit. Japan takes five different species of whales under “scientific permits.” Aboriginal peoples in the United States, Canada, the Faroe Islands, Indonesia, Russia, Greenland, and St Vincent and the Grenadines take several species of whales in limited amounts for subsistence, which is only to survive. Indonesia, the Philippines, and New Zealand may also take an undocumented amount of whales for subsistence.

<table>
<thead>
<tr>
<th>Country</th>
<th>Sperm</th>
<th>Sei</th>
<th>Brydes</th>
<th>Minke</th>
<th>Fin</th>
<th>Bowhead</th>
<th>Gray</th>
<th>Humpback</th>
<th>Beluga</th>
<th>Pilot</th>
<th>Narwhal</th>
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</thead>
<tbody>
<tr>
<td>Canada</td>
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<td>Norway</td>
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<tr>
<td>Japan</td>
<td></td>
<td>10</td>
<td>100</td>
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<td>50</td>
<td>1078</td>
<td>50</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Iceland</td>
<td></td>
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<td>U.S.</td>
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<tr>
<td>Russia</td>
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<tr>
<td>Greenland</td>
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<tr>
<td>St. Vincent</td>
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<tr>
<td>Grenadines</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faroes</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>TOTALS</td>
<td>10</td>
<td>100</td>
<td>50</td>
<td>1942</td>
<td>69</td>
<td>58</td>
<td>140</td>
<td>54</td>
<td>800</td>
<td>1250</td>
<td>350</td>
</tr>
</tbody>
</table>

This table shows the total catch of each species per country for 2006. These numbers are approximate values and are only as accurate as the reporting of each country. Total documented world catch of whales is approximately 4823.
How Are They Caught?

**The Fishing Method**
Whales are caught by many different methods. Most commercial whalers use explosive harpoons to kill whales at sea. These harpoons puncture the skin of a whale and then explode inside its body. Indigenous people such as the Alaskan Inuits hunt according with tradition: hunters use skin-covered or wooden whaleboats to harpoon, spear, or shoot the whales and tow them back to shore to be flensed and shared among community members. Some species of whales such as bowhead and Narwhal whales are harpooned in the winter when they come up through holes in the ice to breathe. Faroe islanders use a fleet of boats to herd pilot whales into shallow lagoons where they are beached and are killed with long knives.

**What Are They Used For**
Whales are used for much more than food. The meat is eaten, the bones and baleen may be used to build shelters, make knife handles, stiffen collars and ladies’ corsets, build fishing rods, and even used for fertilizer. Ambergris, found in sperm whales, is used for perfume and for luxury soaps. The whale’s blubber (fat) was boiled down for oil. This was used mainly, until the 19th century, for lamps as well as for producing candles and soap. After the discovery of oil and the advent of electricity, whale oil was used in margarine, washing products, shampoo, cooking fat, the production of varnish, paint, printing inks, oilcloth, linoleum, wax, candles, etc. Spermaceti (the oil found in the sperm whale's brain) was also used for tanning leather and as part of the production of luxury candles, cosmetics, beauty creams, lipstick, and shaving cream. When filtered, it is used as a lubricant for engines and precision mechanisms. The skin may used to cover houses, boats, make baskets, even for glue. Their tendons used to make the strings for tennis rackets or for surgical thread. Indigenous people still make use of almost every part of the whale, however many whale products that were produced at the height of the industry in the 19th and early 20th century are not made today.

**History of the Fishery**
The earliest record of whaling is found from Korea in 6000 BC. Traditionally whales were hunted from the shore. However, in the 16th century men began to hunt whales from large ocean going ships. Whales were hunted extensively in the 1800’s to fuel the industrial age. In 1848 the exploding harpoon was invented and by 1930 80% of large whales were feared to be on the edge of extinction. Public opinion turned against whaling in the 1960’s and 70’s and many whaling nations ceased whaling or scaled back.

This figure shows the carving found in South Korea depicting a whale with a boat to the left.

http://news.bbc.co.uk/2/hi/science/nature/3638853.stm
What’s Happening with the Fishery?

Managing the Fishery
The International Whaling Commission (IWC) is the main organization in charge of managing modern whaling. The IWC was created in 1948 by the world’s fourteen major whaling nations. Full duties of the IWC include

1. Protection of certain species;
2. Designation of specified areas as whale sanctuaries
3. Setting limits on the numbers and size of whales which may be taken
4. Prescribing open and closed seasons and areas for whaling
5. The compilation of catch reports and other statistical and biological records is also required.

In 1986 the IWC stopped commercial whaling. Subsequently Norway, Canada, and Iceland broke away from the IWC and have continued commercial whaling. Japan continues to whale under a scientific permit from the IWC. Many critics of Japan’s whaling program argue that the program is unnecessary and does not accurately report data.

World Debate
The IWC’s policies allow for the resumption of commercial hunting when populations reach a little more than half of their historic numbers. Many experts argue that the IWC bases its historic estimates on unconfirmed and highly inaccurate whaling records dating back to the mid-1800s. Should the IWC allow whaling again when we don’t know exactly how many whales are left?

<table>
<thead>
<tr>
<th>Species</th>
<th>Pre Whaling Estimates</th>
<th>Current Population Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue whale</td>
<td>160,000 - 240,000</td>
<td>9,000</td>
</tr>
<tr>
<td>Bowhead whale</td>
<td>52,000-60,000</td>
<td>8,200</td>
</tr>
<tr>
<td>Bryde's whale</td>
<td>unknown</td>
<td>66,000-86,000</td>
</tr>
<tr>
<td>Fin whale</td>
<td>300,000-650,000</td>
<td>123,000</td>
</tr>
<tr>
<td>Gray whale</td>
<td>15,000-20,000</td>
<td>21,000</td>
</tr>
<tr>
<td>(Eastern Pacific)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gray whale</td>
<td>1,500-10,000</td>
<td>100-200</td>
</tr>
<tr>
<td>(Western Pacific)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humpback whale</td>
<td>150,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Minke whale</td>
<td>unknown, but tens of thousands were killed</td>
<td>850,000</td>
</tr>
<tr>
<td>Sei whale</td>
<td>100,000</td>
<td>55,000</td>
</tr>
<tr>
<td>Southern Right whale</td>
<td>no estimate, but 40,000 were killed from 1785 and 1939</td>
<td>1,500</td>
</tr>
<tr>
<td>Sperm whale</td>
<td>2 to3 million</td>
<td>1 to 2 million</td>
</tr>
<tr>
<td>Beluga</td>
<td>Unknown</td>
<td>40,000-80,000</td>
</tr>
<tr>
<td>Narwhal</td>
<td>Unknown</td>
<td>10,000-45,000</td>
</tr>
</tbody>
</table>

This Table shows the approximate numbers of whales prior to heavy whaling based mostly off whaler’s records in the 1800’s. Current population estimates are made from ship, shore, and aerial sightings.
**What’s the Big Deal?**

**Who Depends on Whales**
Many Indigenous people are dependant on whales for their survival. Residents of these often small and isolated coastal communities around the world subsist wholly or in part on the small-scale harvest of whales. Whaling feeds their families, their communities, their economies, and their cultures. For many, centuries of reliance on the products of the hunt have created a vital nutritional, cultural, spiritual and ecological link between whaling peoples and whales. Commercial whaling has decimated the populations of several species of whales in the past. Today commercial whaling is continuing in several countries but is it really necessary? Some of these countries do depend on whale products for a source of food and income. What happens if these countries stop whaling; are they really taking enough whales to hurt the populations?

**Intelligent Animals**
Many people, particularly in the West, believe that whales are highly intelligent animals. Supporters of whale intelligence point to the social behavior of whales and their organized communication as evidence of a sophisticated intellect. This belief has become one of the central arguments against commercial whaling and the killing of an “intelligent animal”. Watching these intelligent social creatures has become an industry that brings in an estimated one billion dollars every year. Whale watching generates far more income than whaling ever has. A whale alive may be worth more than one dead. However, some countries support the cultural and traditional right to catch whales.

**Growing Fisheries**
The majority of whale populations are making recoveries. Many whaling nations are beginning to start whaling more. In 2005 Japan applied to take 50 endangered fin whales. At an IWC meeting in 2006, a resolution calling for the eventual return of commercial whaling was passed by a majority of just one vote. This motion was spearheaded by Japan. Japan plans to take 50 endangered humpback whales in 2007.

**Hawaii’s Whales**
Hawaii is most famous for its humpback whales which come here to conceive and give birth from October to April. Along with an estimated 4,000 to 5,000 humpbacks, Hawaii is home to several other transient and resident species including sperm whales, fin whales, melon-headed whales, false killer whales, short-finned pilot whales, and two species of beaked whales. Hawaii was also once a critical stopover for many whaling ships. Hawaii whale watching was estimated to bring in 27 million dollars in 1999. Will increased whaling in the Pacific affect whales that visit Hawaiian waters?
Fishery Presentations Notes

We handed out the assessment questions and had the students grade their own group’s performance. Answers to the questions varied greatly according to student’s level of understanding although we had a very limited timeframe? Presentations took an average of 15min but could be as long as 25 to allow for questions, stressing the main points (make sure the rest of the class is learning about all the fisheries), or interaction. Should allow two science periods per class for presentation.

What was the main problem with your fishery and your potential solution??

How are you going to know if your solution was working??

What did you learn from this project??

What was the hardest thing about the project??

Other Notes!
Main point of Conclusion (Problem: solution: Assessment) should be stressed much more! Redo project outline to scaffold a bit more and provide some examples (maybe the teacher should give a sample presentation on a fishery to show how its done) and standardize the fishery cards. Presentations could be made more interactive and good presentation techniques should be stressed. Breaking students into roles worked fairly well. The structure of the presentations in terms of general information, fishing, conservation was also pretty good. Good solutions and note that the students thought of tags as pollution (seems as if the marine debris worksheet was successful). We should have tag and release exercise (tag people and send them in the dark). Tagging was a common technique. Also cameras were common (need to teach how data (numbers) can translate into seeing what the fish are doing)! Main solution is to take less fish, management solutions and possibly limit solutions so they have to allow the same amount of fishing (we need to make the connection between these fisheries and our dinner table!!!!!). The fish adaptation exercise was also memorable.

A lot of reading with the presentations. Need to stress originality. If you don’t understand the information you should not present it!!!! Read through info before cutting and pasting.

Common questions from students. (How big does it get?,