Aquaculture as Sustainable Agriculture

National Council for Agricultural Education
Aquaculture as Sustainable Agriculture

L. U. Hatch
M. E. Swisher
A. Todd-Bockarie

T. Hanson
M. Masser
T. Popma

Agricultural Education Mission Statement
The mission of Agricultural Education is to prepare and support individuals for careers, build awareness and develop leadership for the food, fiber and natural resource systems.

National Council for Agricultural Education Mission Statement
The National Council for Agricultural Education provides leadership, coordination and support for the continuous improvement of agricultural education.

© Copyright 1996 by the National Council for Agricultural Education
About These Materials

What Do These Materials Do and How Do I Use Them?
This series, *Aquaculture as Sustainable Agriculture*, explores how aquaculture can contribute to the overall goals and objectives of sustainable agriculture. It uses the definition of sustainable agriculture provided by the U.S. Congress as the basis for defining and discussing what sustainability means and how aquaculture can help achieve sustainable food production systems. There are four units in the series:

Unit I. Is Aquaculture Sustainable?
Unit II. Making Aquaculture Pay
Unit III. Aquaculture and the Environment
Unit IV. Approaches to Resource Management

These units may be used individually, the entire series can be used, or you can select individual lessons from the units.

These materials are designed to be used as *supplemental classroom teaching materials* for teachers who have aquaculture facilities. They are not meant as a substitute for materials that cover the fundamentals of aquaculture production. Rather, they lead students to explore different aspects of aquaculture, such as the impact of aquacultural production on water quality or alternatives to resolving conflicts over resource use.

We also hope that other teachers, both agricultural science teachers and social and natural science teachers, who do not have aquacultural production facilities will also be able to use these materials. While we have provided several *Extensions* that incorporate aquacultural production facilities, we have tried to avoid depending on the presence of such facilities completely to be able to use the materials.

These materials build upon the existing materials developed by the National Council for Agricultural Education. The existing materials provide excellent coverage of the fundamentals of aquaculture production (the Core Materials) and specific, detailed information for individual species (see NCAE’s individual species production guides). If you are just starting an aquaculture program at your school, these materials can be used to build student interest prior to completion of your system.

These materials incorporate a participatory approach to learning. Students are encouraged to engage in hands-on activities and to search for additional information from a variety of sources, including the World Wide Web. The lessons focus on developing problem solving and critical thinking skills. They are designed for use with students in grades 9 to 12.

What Do the Units Contain?
Each unit consists of one or more lessons. Each lesson focuses on one or more of the seven goals of sustainable agriculture defined by the U.S. Congress and listed on the first page of Unit I.

Each lesson contains several different components. First, it includes a lesson plan. The plan includes an “Introduction,” which explains the overall structure and emphasis of the lesson. The section entitled “Getting Ready” provides you with suggestions for developing student interest in the material. “Doing the Activity” provides a step-by-step guide to conducting the suggested activity. “Key Concepts,” lesson “Purposes,” the “Learning Objectives,” related “Subjects,” and “Extensions” are provided for each lesson in the right hand column. We have included “Quiz Questions,” along with some possible answers and, for most lessons, some Discussion Questions and possible responses.

Each lesson also includes “Background Material.” This is a short reading that provides key information of relevance to the lesson. You can either present the information in these readings to your students yourself (recommended if your students have an 8th grade or lower reading level), or use these pages as assigned reading. We have provided large print graphics to go with these pages that you can use to make overhead transparencies if you decide to present the material yourself.
Finally, each lesson includes one or more Student Pages. These pages contain instructions or materials that the students need to complete the activities suggested in the lesson. You will need to make copies of these pages for your students.

**Want More Information?**
You will also see that each lesson contains a section called “Want More Information?” Teachers told us that they wanted materials that are easy to acquire. We therefore searched the bibliography of the National Agricultural Library to find appropriate written materials. For each item, we provide the original publisher and the NAL Call No. NAL is “viewed as a library of last resort.” This means that you should try to get the publication from the original publisher first, before contacting NAL. For the most part, we have selected publications from organizations such as the Regional Aquaculture Centers that will be easy for you to acquire.

However, if you cannot get a reference from the original source, NAL does provide materials upon request. We quote from the NAL’s home page on the web:

“Through an interagency agreement with the Food and Consumer Service (FCS) of USDA, the National Agricultural Library is able to expand the categories of users eligible for direct loan of books and audiovisuals, free photocopies of journal articles, and comprehensive reference/research services. This expanded group includes persons working for federal government agencies and cooperators with FCS program, such as: ... Elementary and secondary schools and school districts (including teachers...)” [emphasis ours]."

You can acquire NAL documents by submitting an interlibrary loan form through your library. We strongly suggest that you ask your librarian about how to get NAL documents or go to NAL’s web page at:

http://www.nal.usda.gov/dds

...to learn more about how to acquire documents from NAL.

The **Web Sites** included in the lessons were selected on the basis of three major criteria: (1) they are highly relevant to the subject matter, (2) they are interesting and well prepared, and (3) they are the product of large, stable organizations and institutions. The latter is an important consideration because web sites move and disappear over time. Therefore, we tried to select sites that will be stable over a relatively long period of time. Nonetheless, there will be changes. We have provided the name of the organization or institution for each web site. If you cannot find a site, we suggest that you conduct a web search of the organizational or institutional name.

---

For more information about instructional materials pertaining to aquaculture, contact the National Council for Agricultural Education, The Council, P.O. Box 15035, 5632 Mount Vernon Memorial Highway, Alexandria, VA 22309-0035.

The National Council for Agricultural Education affirms the belief in value of all human beings and seeks diversity in its membership, leadership and staff.
The development of this educational material from the National Council for Agricultural Education was supported by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Agreement #94-38816-1251.

Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the U.S. Department of Agriculture.
SERIES CONTENT

Unit I. Is Aquaculture Sustainable?
  Lesson 1. What Does Sustainable Food Production Mean?
  Lesson 2. Living Without Enough Protein
  Lesson 3. Protein from Aquaculture
  Lesson 4. Competing for Protein?

Unit II. Making Aquaculture Pay
  Lesson 1. Integrated Aquaculture Systems
  Lesson 2. Aquaculture Around the World
  Lesson 3. Producing What People Want

Unit III. Aquaculture and the Environment
  Lesson 1. Conserving Water Resources
  Lesson 2. Water Quality
  Lesson 3. Who’s Eating the Fish?

Unit IV. Approaches to Managing Resources
  Lesson 1. Managing Aquaculture Resources
Introduction

Sustainability means different things to different people. For example, some people believe that any food production system that depends on non-renewable resources, such as oil, is not sustainable. Other people argue that this is not an important aspect of sustainable food production because they believe that we will find alternative energy sources as oil becomes scarcer. Despite the problems in agreeing about what sustainability means, the U.S. Congress has defined the term in the 1990 Food, Agriculture, and Trade Act. According to their definition, there are seven key features of sustainable food production systems. Sustainable food production systems:

- Will meet human needs for food now and far into the future;
- Integrate plant and animal production;
- Rely as much as possible on natural processes and cycles;
- Are designed specifically to fit the biological, social, and economic conditions of specific places (are site specific);
- Provide a liveable income for the farm family;
- Protect natural resources; and
- Enhance the quality of life for farmers and for society as a whole.

The lessons included in this series will examine aquaculture production systems in terms of how well they meet Congress’ definition of sustainable agriculture.

Getting Ready

Your students may know little about aquaculture. The Background Material on Aquaculture in the USA (pages 6-9) describes the production, sales, imports, and exports of major and emerging aquaculture species in the U.S. For students with a 9th grade or higher reading level you can assign these pages as a homework assignment. For students with an 8th grade or lower reading level, we suggest that you explain the ideas in the readings to your students yourself. You can make overhead transparencies of the tables and figures on pages 10-16 to discuss the concepts included in the reading.

- Make several copies of the world map on page 17. For each of the species discussed in the reading (or as many as you want), tape two maps on the blackboard. Write “imports” over one map and “exports” over the other. Make several copies of the map of the United States to point out the states that produce and consume the species in question.
States on page 18. For the same species, tape a U.S. map on the blackboard. Cut out the names of the aquaculture species on pages 19-20. Have students stick the name of the different species (1) on the states where they are produced, (2) on the countries that export the species to the U.S., and (3) on the countries that import the species from the U.S.

**Doing the Activity**  
**Time: 15 to 30 minutes**

Use the word puzzle to introduce the idea of sustainability as defined by the U.S. Congress. Tell the students that they are going to figure out the seven key things that the U.S. Congress thinks that we should consider when we raise food. There are several ways you can use this exercise, depending on your class size and the time available. (1) Use brainstorming involving the entire class for large classes with little time (10 to 15 minutes). (2) For smaller classes with up to 30 minutes of time, divide the students into two teams. Have them compete to see which team can fill in the most blanks. Have the team discuss each answer before giving it to encourage teamwork.

- Write the word “SUSTAINABLE” in large letters on the chalkboard, drawing in lines as in the example below to show where the words will fit, or use the large print example on page 21 to make an overhead transparency.

```
1  2  3  4  5  6
S U S T A I N A B L E
```

- Read the clues we have provided to the students, adding your own clues as needed. The students should fill the blanks.

1. Keep on going  
2. Right, fair  
3. Bring together, combine  
4. Opposite of manmade or artificial  
5. Something you must earn to pay for what you buy  
6. Keep, protect  
7. Right around here

The completed puzzle is shown on the next page.

**Extensions**

*Are Worldwide Fisheries Collapsing?*

Some suggest that overfishing threatens some fish species that we consume regularly. Have students explore the impacts of fishing on one or more of these species. To get an overview of the problem, students can read the National Oceanographic and Aeronautic Administration’s discussion of NOAA’s sustainable fisheries at:

http://www.noaa.gov/sustainable_fisheries.html

Then they can visit the Fishery Observer Program at:

http://gopher.wh.whoi.edu/library/sos94/fishobs/fishobs.html

This site describes a worldwide effort to monitor catches and reproductive success of many commercially important species.

Have students visit a local supermarket and see if they can find the species either in a fresh or processed form. Remind them to look at the labels on frozen fish products to see what kind of fish are included in the product.
 Discuss each answer with the students. Explain the idea that each word represents:

1. **Last** -- food production systems that meet food needs now and far into the future
2. **Just** -- food production systems that enhance the quality of life for example, by preserving clean water
3. **Integrate** -- systems that integrate plant and animal production such as integrated fish-plant systems
4. **Natural** -- systems that use natural processes and cycles, such as relying on natural predators instead of pesticides
5. **Money** -- systems that earn a fair income for farm families
6. **Save** -- systems that preserve natural resources, such as systems that reduce the use of fossil fuels
7. **Local** -- systems designed specifically for a given place to maximize use of local resources

**Discussion Questions**

**Time: 15 minutes**

Discuss the following questions with your students to make sure that they understand the key ideas of sustainability.

- Why do you think Congress included these seven things in their definition of sustainable farming?

Point out that these factors include environmental, economic, and social aspects of sustainability. All are important. If we rely on food production systems that are not environmentally sound, we may destroy the natural resources needed to produce food. If food production systems are not economically viable, farmers will go broke and their farms will cease to exist. If the systems are not socially sound, they will not meet the needs of our citizens.

- Are there any other factors that you would want to add to the list? How could you tell Congress about the ideas you have?

Use this opportunity to encourage students to understand the importance of the government in U.S. farming and to think about how they can communicate with elected officials. Point out that federal legislation, usually called the “farm bill” sets policies that have major effects on U.S. farmers. The 1990 farm bill, for example, included the definition of...
sustainable agriculture used here. It also established the “Conservation Reserve Program,” which encouraged farmers to remove marginal (hilly, rocky, etc.) land from production. As a result, millions of acres were taken out of production of basic grains such as corn and soybeans, key components in the diets of many aquaculture species.

**Want More Information?**


University of Alaska, Sea Grant Marine Advisory Program. *Salmon Farming: Boom or Bust?* Videocassette. University of Alaska, Anchorage, AK. NAL Call No. Videocassette No. 796.

**On the Web:**
For an excellent overview of aquaculture, visit LaDon Swann’s Web site at:
http://info.utas.edu.au/docs/aquaculture/Pages/Swann.html#100
You’ll get a good history of fish farming in the U.S. and worldwide.

For a lot of good information on international trends in aquaculture, go to the Food and Agriculture Organization at:
http://www.fao.org/waicent/fishery.htm

Or try the American Tilapia Association at:
http://ag.arizona.edu/azaqua/ata.html
Background Material on Aquaculture in the USA

The world harvest of fish and shellfish reached 109.6 million metric tons (mt) in 1994 (FAO, 1996). Wild-caught seafood dominates production from the ocean. However, aquaculture is a major source of commercial fish and seafood production in fresh and brackish water. Compared to 1993, inland aquaculture production increased 1.7 million metric tons in 1994, with almost all of the increase in production occurring in Asia (FAO, 1996). Since 1989, China has been the largest fish and shellfish producing nation. Its total production increased 3.2 million metric tons in 1994, with over 1 million tons of the new production coming from aquaculture (FAO, 1996).

For U.S. aquaculture to continue to grow there must be an expanding demand for its products (Fig. 1) and U.S. aquaculture producers must be able to offer products to consumers at competitive prices. Consumers say that they believe that seafood is a healthy product. Nonetheless, seafood consumption has declined recently. Most aquaculture products tend to be in the middle to high end of the price range for seafood products. Therefore, the state of the economy plays a large role in their demand. Figure 2 shows the value of some cultured fish in the U.S.

Major Species

Catfish. Catfish is the number one aquaculture species in the United States. The top ten catfish producing states, in order, are: Mississippi, Alabama, Arkansas, Louisiana, California, Missouri, North Carolina, Kentucky, South Carolina and Texas (Table 1). Dramatic growth has occurred in the last two decades (Fig. 3).

In 1991, there were 1,851 catfish farms and in 1993 there were 1,404 farms, averaging 87 acres and 108 acres per farm, respectively. Total catfish acreage was approximately 149,440 in July 1993, down 6 percent and 10 percent from 1992 and 1991 levels. However, since yields increased, actual production has increased by 15 percent over these last two years.

Increasing exports of aquaculture products is important for the U.S. because we import a large quantity of shrimp and tuna, adding to our trade deficit. Exports of catfish products have been seen as a source of future market growth for the catfish industry. The Catfish Institute has used grants from the U.S. Department of Agriculture’s (USDA) Foreign Agricultural Service to determine how best to promote catfish in places like the European Community and Japan. In 1992, U.S. exports of catfish products totaled 245,000 pounds and were valued at $561,000. Currently, the United Kingdom is the largest buyer of U.S. catfish products. Small amounts go to other European countries, Japan, and Singapore.

Imports of catfish peaked in 1980 at 15 million pounds and have declined steadily as a percentage of domestic production. Catfish imports fell 44 percent from 1991 to 1992 to 2.9 million pounds, the lowest in 13 years. The drop in 1992 imports can be attributed to the low farm prices in the U.S. Imports of catfish were up in 1993, aided by higher catfish prices at the farm and processor levels. Brazil was again the largest supplier of catfish imports, accounting for 90 percent. Mexico has been the second largest supplier of catfish to the U.S. The net value of trade in major and emerging fish and seafood species are shown in Table 2.

Trout. The growth of trout culture has remained steady over the last five years, averaging 56 million pounds worth $65 million. The primary states
involved with trout production are Idaho, Utah, North Carolina, California and Pennsylvania. Idaho is responsible for the majority of trout production in the U.S., comprising 72 percent of the market. Trout farming requires colder water and flowing water with a high oxygen content (more than 5 ppm). The most common trout species raised is the rainbow trout, which is considered a harder species compared to other species such as brown and cutthroat trout.

**Salmon.** Estimates of farm-raised Atlantic salmon production in the U.S. were 22 million pounds live-weight in 1992 and 26 million pounds in 1993. Total commercial landings, which includes wild caught salmon, are shown in Figure 4. Virtually all U.S. production is in Maine or Washington. In Maine, the contribution of farm-raised Atlantic salmon to the value of the state’s seafood industry is second only to wild-caught lobsters. This is remarkable considering that the industry barely existed six years ago. Salmon consumption in the U.S. could expand due to year-round availability (Table 3).

While the domestic farm-raised salmon industry is expected to expand, its rate of growth in coming years will likely be much slower due to the lack of high quality sites and the cost of obtaining new farming permits. Almost all of the increase in production in the last several years has been at existing sites, not through additional sites. Another major factor in the slowdown is increasing foreign competition in the salmon market. Canada is currently the largest supplier of farm-raised salmon, but imports from Chile have also expanded rapidly during the last three years. While Norway is not a large supplier in the fresh U.S. market, it remains the world’s leading producer of farmed Atlantic salmon. Production in Norway has not been growing rapidly, but innovations in production practices promise to lower production costs. Production in Chile has expanded very rapidly over the last several years so that Chile is now probably the lowest cost salmon producer.

In 1993, U.S. salmon exports (wild-caught Pacific salmon plus farm-raised Atlantic salmon) were estimated at 372 million pounds valued at $697 million. This total includes 4 million pounds of fresh cultured Atlantic salmon valued at $11 million.

The majority of salmon exports were frozen Pacific salmon, 257 million pounds worth $484 million.

**Shrimp.** In 1993, U.S. culture of shrimp was approximately 6.6 million pounds, which is about 2 percent of the U.S. wild-caught shrimp quantity. Texas and South Carolina are important producers. Imports of shrimp were estimated at 601 million pounds in 1993 and valued at $2.2 billion. Approximately 60 percent of the imported shrimp are thought to be farm-raised. Expansion of U.S. shrimp aquaculture is limited because of the low cost of production in foreign countries and the large U.S. wild catch. Asian and Central and South American countries, such as China, Thailand, Indonesia, India, Vietnam, the Philippines, Ecuador and Mexico, that produce farm-raised shrimp have developed Western markets through the steady supply of consistently high quality and uniformly-sized shrimp at competitive prices.

** Emerging Species **

**Mollusks.** Culture of oysters, mussels and clams is small compared to the wild catch, but aquaculture of these species is growing because of reduction in available oyster and clam stocks and aquaculture’s ability to supply a steady, high quality product that can command a premium price. U.S. production data for most mollusks are not available on any comprehensive basis that separates the species or distinguishes between wild and cultured. California, Alaska, Washington and Maine all produce mollusks. In 1993, total oyster sales in the U.S. were about 32 million pounds, worth $98 million. Mollusk imports ranged from 4 to 10 million pounds from 1989 to 1993 and value ranged from $52 to $64 million. Canada, Korea, Japan, Thailand, China, New Zealand and Indonesia are all mollusk exporting nations. Mollusk exports averaged approximately 4.4 million pounds, valued at about $11 million during the 1990-1993 period.

The outlook for mollusk culture is mixed. Advances continue in efficient culturing methods for some species such as abalone and oysters, while for other species such as soft clams, surf clams and scallops, culture techniques are still in the experimental stages. The two greatest constraints to expansion of mollusk culture are the limited number of suitable
sites and food safety related to consumption of raw mollusks, especially oysters and clams.

**Tilapia.** The outlook for tilapia production in the U.S. is good for several reasons. First, tilapia can be polycultured (grown in the same pond with other fish species) with few adverse effects. Second, it can eat many types of feed. Of special importance is its ability to be grown profitably using less expensive vegetable protein and fertilizers. Third, it can be bred easily and quickly, although too much reproduction crowds fish and stunts fish growth. Lastly, the flesh is mild and can be substituted for a number of other traditional seafood species. However, there are limitations to U.S. culture of tilapia, foremost being the species' intolerance to water temperatures below 45 degrees Fahrenheit. Geothermal water sources and recirculating systems using heated water are being used to circumvent the temperature constraint. Tilapia production is not concentrated in one region or area and is presently being undertaken in Arizona, California, Florida, Idaho, New Jersey and Texas.

Promotional efforts to make consumers more aware of the product and its quality are attempting to expand the market for tilapia. Consumers prefer the lighter color of the golden hybrid over the darker color of the more common tilapia strain. Consumer tests also indicate a preference for a larger size, such as the fillet from a 3/4 pound fish.

Future growth of the industry will require expansion of the market, lower production costs to be competitive with other fish species, and development of cost-efficient water recycling production systems. According to the International Center for Aquaculture and Aquatic Environments (1996: 22), "... 6,000 metric tons of tilapia were raised in the U.S. in 1994, up approximately 42% from 1992." They also indicate that "In 1994, the U.S. imported over 14,500 metric tons of fresh and frozen tilapia." According to the Center, Taiwan is by far the most important exporter of tilapia to the U.S., exporting over 25 million pounds of fresh and frozen tilapia to the U.S. in 1994. Costa Rica (Central America) ranked second with slightly more than 1.5 million pounds. China, Thailand, and Indonesia were third, fourth, and fifth, respectively, but all exported less than 1 million pounds to the U.S.

**Ornamental Fish (Tropical Fish).** The ornamental fish industry is centered in Florida, in the Tampa and Miami areas. These products are considered luxury items which may decline during recessions. This happened in 1992 when imports fell by 12 percent. Currently, producers are concerned about the Food and Drug Administration applying the same rules for therapeutic chemical use in food fish production to the ornamental fish industry.

The forecast for U.S. exports of ornamental fish indicates continued expansion, but net trade will continue to be negative. Export markets to the European Community (EC) are increasing, but American producers must compete with Asian producers for this market. There are concerns about recent EC directives covering the importation of fish, which require exports to the EC from the U.S. to be certified by a U.S. agency that the product complies with EC regulations. U.S. imports of ornamental fish have ranged from $36 to $45 million over the past five years, while exports have ranged from $8.6 to $17.3 million over the same period. The major exporters of tropical ornamental fish are Singapore, Thailand, the Philippines, Hong Kong, Indonesia and Colombia.

**Crawfish.** Crawfish culture is probably the freshwater species most heavily affected by wild production of the same species. Wild production occurs during the same season as aquaculture production. Wild harvests are dependent on water temperature and the volume of water moving through the swamp areas of Louisiana, the most important producer. Because of the variability of these factors, wild crawfish production has experienced wide year-to-year swings, from 18 million pounds in 1991 to 69 million pounds in 1993. This supply fluctuation is a serious limitation to crawfish market development because the food industry wants a product that is in constant supply, has good quality and has a relatively stable price. Crawfish are not generally available year round which makes it difficult to build a steady market. Seasonal harvesting patterns, along with a considerable wild-catch means there are huge swings in prices throughout the season.

The advantages of crawfish culture are the relatively low fixed costs of production, natural reproduction and ability to be double-cropped with rice. U.S.
consumer demand is still relatively restricted to the states where it is found naturally and those areas where it is farmed. Large crawfish are exported to Sweden at a premium price, medium crawfish are sold to restaurants and small crawfish are peeled for tail meat. Recent imports from China, during the off-season for U.S. crawfish production, may allow for a more continuous year-round supply. U.S. culture may actually expand as a result.

References


<table>
<thead>
<tr>
<th>Species</th>
<th>1988</th>
<th></th>
<th>1993</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>000 lbs.</td>
<td>%</td>
<td>000 lbs.</td>
<td>%</td>
</tr>
<tr>
<td>Catfish</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alabama</td>
<td>24,276</td>
<td>7</td>
<td>57,609</td>
<td>12</td>
</tr>
<tr>
<td>Arkansas</td>
<td>24,895</td>
<td>8</td>
<td>42,217</td>
<td>9</td>
</tr>
<tr>
<td>Florida</td>
<td>730</td>
<td>0</td>
<td>200</td>
<td>0</td>
</tr>
<tr>
<td>Louisiana</td>
<td>12,530</td>
<td>4</td>
<td>25,250</td>
<td>5</td>
</tr>
<tr>
<td>Mississippi</td>
<td>254,104</td>
<td>78</td>
<td>358,307</td>
<td>72</td>
</tr>
<tr>
<td>No. Carolina</td>
<td>255</td>
<td>0</td>
<td>2,029</td>
<td>0</td>
</tr>
<tr>
<td>So. Carolina</td>
<td>--</td>
<td>0</td>
<td>782</td>
<td>0</td>
</tr>
<tr>
<td>California</td>
<td>3,423</td>
<td>1</td>
<td>3,786</td>
<td>1</td>
</tr>
<tr>
<td>Missouri</td>
<td>1,122</td>
<td>0</td>
<td>2,448</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>861</td>
<td>0</td>
<td>567</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>325,729</td>
<td></td>
<td>495,758</td>
<td></td>
</tr>
<tr>
<td>Trout</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>California</td>
<td>2,460</td>
<td>4</td>
<td>2,955</td>
<td>5</td>
</tr>
<tr>
<td>Colorado</td>
<td>415</td>
<td>1</td>
<td>349</td>
<td>1</td>
</tr>
<tr>
<td>Georgia</td>
<td>459</td>
<td>1</td>
<td>--</td>
<td>0</td>
</tr>
<tr>
<td>Idaho</td>
<td>40,000</td>
<td>71</td>
<td>40,000</td>
<td>73</td>
</tr>
<tr>
<td>Michigan</td>
<td>400</td>
<td>1</td>
<td>570</td>
<td>1</td>
</tr>
<tr>
<td>Missouri</td>
<td>807</td>
<td>1</td>
<td>613</td>
<td>1</td>
</tr>
<tr>
<td>No. Carolina</td>
<td>3,295</td>
<td>6</td>
<td>4,244</td>
<td>8</td>
</tr>
<tr>
<td>Oregon</td>
<td>800</td>
<td>1</td>
<td>335</td>
<td>1</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>1,259</td>
<td>2</td>
<td>1,417</td>
<td>3</td>
</tr>
<tr>
<td>Tennessee</td>
<td>272</td>
<td>0</td>
<td>--</td>
<td>0</td>
</tr>
<tr>
<td>Utah</td>
<td>3,967</td>
<td>7</td>
<td>1,869</td>
<td>3</td>
</tr>
<tr>
<td>Virginia</td>
<td>1,008</td>
<td>2</td>
<td>951</td>
<td>2</td>
</tr>
<tr>
<td>Washington</td>
<td>387</td>
<td>1</td>
<td>277</td>
<td>1</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>406</td>
<td>1</td>
<td>509</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>--</td>
<td>0</td>
<td>439</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>56,032</td>
<td></td>
<td>54,642</td>
<td></td>
</tr>
<tr>
<td>Salmon</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maine</td>
<td>1,000</td>
<td>100</td>
<td>15,606</td>
<td>60</td>
</tr>
<tr>
<td>Washington</td>
<td>0</td>
<td>0</td>
<td>10,428</td>
<td>40</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,000</td>
<td></td>
<td>26,034</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Net Value of U.S. Imports and Exports in Major and Emerging Fish and Seafood Species that Are Also Cultured Millions of U.S. Dollars

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Species</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salmon</td>
<td>729</td>
<td>581</td>
<td>501</td>
<td>309</td>
<td>664</td>
</tr>
<tr>
<td>Shrimp</td>
<td>-1,669</td>
<td>-1,632</td>
<td>-1,504</td>
<td>-1,748</td>
<td>-1,901</td>
</tr>
<tr>
<td>Catfish</td>
<td>-4</td>
<td>-5</td>
<td>-3</td>
<td>-3</td>
<td>-0</td>
</tr>
<tr>
<td>Emerging</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mollusks</td>
<td>--</td>
<td>-64</td>
<td>-43</td>
<td>-47</td>
<td>-49</td>
</tr>
<tr>
<td>Crawfish</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Ornamental</td>
<td>--</td>
<td>-30</td>
<td>-29</td>
<td>-23</td>
<td>-24</td>
</tr>
<tr>
<td>Tilapia</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>-</td>
<td>-13</td>
</tr>
</tbody>
</table>

Negative means net import; positive means net export.

Table 3. Potential Increased Consumption of Fresh Salmon Due to Year-Round Availability, United States, 1989

<table>
<thead>
<tr>
<th></th>
<th>Number of Salmon Meals per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Retail Salmon</td>
</tr>
<tr>
<td>Total Salmon Consumption per Annum</td>
<td>12,300</td>
</tr>
<tr>
<td>Possible Increase in Consumption of Salmon Due to Year-Round Availability</td>
<td>8,500</td>
</tr>
<tr>
<td>Increase Over Base Total</td>
<td>40%</td>
</tr>
</tbody>
</table>

Fig. 1. Total U.S. Fish and Shellfish Consumption

Fig. 2. Value of Some Food-Size Aquaculture Fish in U.S.

Fig. 3. Weight of Farm Sales of All Food-Size Catfish in U.S.

Fig. 4. Commercial Landings of Shrimp and Salmon in U.S.

<table>
<thead>
<tr>
<th>Tilapia</th>
<th>Tilapia</th>
<th>Ornamental</th>
<th>Crayfish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tilapia</td>
<td>Tilapia</td>
<td>Ornamental</td>
<td>Crayfish</td>
</tr>
<tr>
<td>Tilapia</td>
<td>Tilapia</td>
<td>Ornamental</td>
<td>Crayfish</td>
</tr>
<tr>
<td>Tilapia</td>
<td>Tilapia</td>
<td>Ornamental</td>
<td>Crayfish</td>
</tr>
<tr>
<td>Tilapia</td>
<td>Tilapia</td>
<td>Ornamental</td>
<td>Crayfish</td>
</tr>
<tr>
<td>Tilapia</td>
<td>Tilapia</td>
<td>Ornamental</td>
<td>Crayfish</td>
</tr>
<tr>
<td>Tilapia</td>
<td>Tilapia</td>
<td>Ornamental</td>
<td>Crayfish</td>
</tr>
</tbody>
</table>

Lesson 1: What Does Sustainable Food Production Mean?
Unit I. Is Aquaculture Sustainable?
Living without Enough Protein

Introduction
One of the key features of sustainable food production systems, as defined by the U.S. Congress, is that they meet food needs today and far into the future. In this lesson, we will learn about a basic human food need -- protein. Lessons 3 and 4 will examine whether aquaculture can help meet this food need. Explain the purpose and key concept of this lesson to your students.

Getting Ready
Read the Background Material on Hunger Diseases (pages 4-5). This material will provide you with information that you can share with your students about protein needs and deficiencies.

- Show the transparencies Death from Hunger (page 6) and Malnutrition (page 7).

- Briefly describe the dietary diseases that result from or are related to protein deficiency.

- Tape the large print, brief descriptions of kwashiorkor, marasmus, and beriberi (pages 8-10) to different parts of the chalkboard or on large white flip chart papers around the room. Ask students to write a short phrase describing something they have seen on television, read about in a newspaper or magazine, or seen in some other information source that relates to hunger and malnutrition. Use the students’ comments to discuss the prevalence and importance of protein deficiency related disease and death worldwide.

Doing the Activity
You can either conduct the entire activity in class or you can use making the maps (see below) as homework assignments. Students can either work in groups or individually. One good approach, in class or as a homework assignment, is to have different groups of students fill in the maps for the different continents.

- Students should prepare two maps (copy the outline map of the world on page 11 of this lesson).

(1) The first map should show dietary status for the world’s nations. For this exercise, the best alternative is to show average daily protein consumption, but you can also use average daily caloric intake. This information is available in many atlases. Have students use a
commonly agreed upon scale for (1) very low, (2) low, and (3) adequate protein or caloric intake. For caloric intake, for example, students could use under 2,000 as very low, 2000 to 2500 as low, and 2500 or more as adequate. Have students color very low countries red, low countries yellow, and adequate countries green.

(2) The second map should show some economic indicator of national standard of living. Average annual income or per capita GNP would both be good choices, for example. Students should decide on a common scale for this map, too. For per capita GNP (Gross National Product), for example, $1500 or less might be very low, $1500 to $10,000 low, and $10,000 or more adequate. Use the same colors for very low, low, and adequate that were used on the first map.

- Have the students compare the finished maps. Use the discussion questions below to teach students that there is a strong relationship between poverty and inadequate nutrition.

**Discussion Questions**

**Time: 15 minutes**

- Which continent appears to have the greatest number of countries with both very low nutrition and very low wealth?

Many African nations will be very low on both indicators. Point out that the word “kwashiorkor” comes from Africa and refer students back to the meaning of this word.

- Look at your examples of things you have heard about malnutrition. Do any of these examples refer to this continent or nations in this continent? Give an example.

Encourage students to think about what they read and see on television about severe food shortage, environmental degradation, and poverty. Point out that these three factors often go together.

- Can you find an example of a nation that ranks very low for wealth but low or adequate for nutrition? How can you explain this?

Examples might include China, Indonesia, and Thailand. Use this example to discuss the fact that people still raise their own food in many parts of the world. Where it is possible for large numbers of people to raise adequate amounts and quality of foods, poverty and malnutrition are not as closely related as they are in most nations. However, many very poor nations have also experienced severe environmental degradation, which reduces people’s ability to raise food. Most nations in the Sahel of Africa, for example, are both very poor and have had very serious environmental problems such as recurring drought, growing deserts, and deforestation. Therefore, their people cannot raise enough food to eat, even though most of the population lives on farms.

**Materials**

Overhead transparency of Death from Hunger (page 6) and Malnutrition (page 7)

Large print descriptions of kwashiorkor (page 8), marasmus (page 9), and beriberi (page 10)

Copies of world map (page 11)

Red, yellow, and green markers or colored pencils

**Extensions**

Have students prepare a third map of the world showing infant mortality rates. Discuss the relationship between infant mortality and protein levels in the diet.

Have students select a country and look up more information to help explain what they find about dietary levels and income or wealth. Students could prepare a short presentation for class.

**Non-Formal Assessment**

Non-formal assessments are used to make sure students understand the major concepts presented.

Ask students to work in small groups of five or six. Each group should list two reasons why food production systems must meet human food needs today and far into the future in order to be called “sustainable.”
• How could aquaculture help solve nutrition problems?

Aquaculture products are a good source of protein. Aquaculture systems can be small, simple systems that people can use on their own farms to produce protein. They may require less room and fewer purchased inputs than some other kinds of livestock production systems. Producing cattle, for example, usually requires more room than producing fish. People in poor nations could use aquaculture to help increase the amount of protein in their diet.

Quiz Questions Time: 10 minutes
• List two of the three hunger diseases that often happen because of low protein intake.

Answers: Kwashiorkor, marasmus, beriberi

• True or false: Since most people in Africa raise their own food they have very few problems with malnutrition.

Answer: False

• What is one of the most important things about sustainable food production systems?

Best Answer: They provide food today and far into the future.

• True or false: Less than a million people die from starvation each year.

Answer: False; 13,000,000 to 18,000,000 die from starvation.

Want More Information?
Neat Web site that explains all about nutrition -- including how you can actually be overweight and malnourished!
http://www2.uu.se/insts/nutrition/malnutrition/

For an optimistic view on our ability to feed the world, see:
http://oneworld.org/patp/vol4_energy.html
Background Material on Hunger Diseases

The following information is from W.A. Dando and C.Z. Dando, 1991, *A Reference Guide to World Hunger*, Enslow Publishers, Hillside, NJ. The authors provide the following definitions of hunger terms.

**Undernutrition.** An unhealthy condition caused by a person not getting enough food for normal body maintenance and development. Humans require a highly complex mixture of chemical substances, along with water and oxygen, to exist and reproduce. Also, humans vary in specific nutritional needs depending on their health, size, sex, age, and genetic background; nutritional needs vary for active and inactive people, for the geographic location where they live (tropic versus arctic), and for pregnant or lactating women. If a human does not eat enough food, he or she will lose body weight and may starve to death. Starvation is extreme undernutrition. Nutrition experts have distinguished between undernutrition and malnutrition, although the two terms are interrelated. Undernutrition relates to quantity of a diet; malnutrition relates to the quality of a diet. (Page 93.)

**Malnutrition.** An unhealthy condition caused by an inadequate intake of essential nutrients and the body’s inability to process these nutrients properly. Malnutrition is characterized by extreme malaise (uneasiness or vague body discomfort), weakness, lack of growth, and, in severe cases, anemia -- a blood condition in which there is a decrease in red blood cells or hemoglobin or both. These conditions cause a person’s natural immune system to weaken and be less able to resist infectious diseases. There are basically two types: 1) *primary malnutrition* is caused by an inadequate intake of nutrients for normal body development because of food shortages, or because of the inability to purchase adequate quality food; 2) *secondary malnutrition* can be caused by a variety of diseases such as anorexia nervosa, alcoholism, gastrointestinal tract disorders (gastritis, ulcers, or colitis), and cancers. Large segments of the population practicing subsistence agriculture in underdeveloped countries or living in urban shantytowns are malnourished; one-half to two-thirds of the world’s population suffers from undernutrition. Age groups most affected are infants, preschool children, adolescents, and pregnant women -- those experiencing the most rapid growth. (Pages 69-70).

**Kwashiorkor.** [Pronounced kwash-ee-or-core.] A protein deficiency disease mainly found in infants and young children between one and five years of age. *Kwashiorkor* is a West African word meaning “the disease the child gets when another baby is born.” The disease occurs soon after a child has been weaned and is still too young to thrive on the food the adults consume, which is usually low in protein. Kwashiorkor is found primarily in underdeveloped countries and is the most widespread and significant dietary disease in the world, according to the World Health Organization (WHO). Symptoms include poor health and development, a bloated abdomen caused by weak muscles and water retention (edema), a skin rash, dyspigmentation or loss of color of the skin and hair, and apathy and irritability. If the condition is not treated, it results in slowed or halted physical development, greater susceptibility to infection, and high infant deaths. Nutritionists have made progress in discovering how to supply the needed protein to these families’ diets and to teach them about improved feeding and care of children. (Page 63.)

**Marasmus.** A condition caused by a protein-deficient diet. Marasmus is common in infants who have been taken off their mother’s milk too early in life and placed on low-calorie, low protein substitutes. The infants develop persistent diarrhea, which creates a severe mineral imbalance in their bodies. Their physical growth becomes stunted, and if unhalted, brain damage and death follow. (Pages 70-71.)

**Beriberi.** A nutritional disease caused by severe lack of thiamine or vitamin B-1. Symptoms of the disease include cracked skin, painful swollen legs, and cardiovascular changes. Three major forms are: *wet beriberi*, characterized by fluid retention, causing visible swelling and heart failure; *dry beriberi*, in which the peripheral nerves are affected, causing weakness of the limbs; and *infantile beriberi*, the
leading cause of death among infants between two and five months of age in rice-eating rural areas. Beriberi may be found in areas of the world where diets are low in protein but high in refined foods such as white rice, white flour, or processed cornmeal or starchy tropical roots like cassava. (Page 27.)

Reference
Death from Hunger

One child dies every two seconds from diseases caused by malnutrition in poor nations.

More than 35,000 people starve to death every day.

One out of every four children in poor countries will die before the age of five from diseases related to malnutrition.

Malnutrition

People feel bad, are weak, and do not grow well because they do not get enough of the right kinds of food. This general weakness makes people get sick from many diseases very easily.

One-half to two-thirds of the people in the world suffer from malnutrition.

Babies, children, and pregnant women suffer the most from the effects of malnutrition.

Lack of protein in the diet causes people to get three hunger diseases.

Kwashiorkor

The word is from Africa and means "the disease the child gets when another baby is born." Children get kwashiorkor soon after they quit getting their mother’s milk, which is rich in protein, if they are too young to live on the other kinds of food that they can get. In poor countries, the other foods are often very low in protein. Kwashiorkor causes poor health and slow growth. Children with this hunger disease often have big stomachs. They get rashes and their skin and hair lose their color. They have very little energy and are apt to be grouchy. Children with this disease grow slowly, get infections very easily, and often die.

Marasmus

This is another hunger disease that happens to babies who are taken off their mother’s milk too soon and given a low protein diet. They first become stunted. If they cannot get a good source of protein, brain damage and death follow.

Beriberi

The main cause of beriberi is a lack of vitamin B-1. But it is more common when babies have a low protein diet with lots of very starchy foods.

Introduction

Time: 15 minutes

In Lesson 2 we saw that one of the key features of sustainable food production systems, as defined by the U.S. Congress, is that they meet food needs today and far into the future. This includes providing a nutritionally adequate diet for the world’s population. Explain that we will examine whether aquaculture can help meet world protein needs in this lesson. To do so we will compare fish to other sources of animal protein.

Read the Background Material on Protein from Aquaculture (pages 6-7). This reading explains some of the advantages of aquaculture for producing protein. For students with a 9th grade or higher reading level you can assign these pages as a homework assignment. You may want to have these students answer the discussion questions at the end of the reading (page 7) in writing as part of their homework assignment. For students with an 8th grade or lower reading level, we suggest that you explain the ideas in the readings to your students yourself. You can make an overhead transparency of the graphs on pages 8 and 9 to discuss the concepts of dressing percentage and percentage of lean meat, fat, and refuse with your students. Table 1 (page 10) shows how much these values can vary.

Getting Ready

Time: 15 minutes

- Show one or more of the transparencies (tuna, whole milk, or luncheon meat) "What’s on a Nutrition Label?" (pages 11-13). Point out that many fast food restaurants now display nutrition information, often near the cash register. For your reference, see Nutrition Information for Some Sources of Animal Protein (pages 14-15) and Nutrition Information for Fast Foods (page 16). Have students compare the grams of protein, fat and total calories for the tuna on the transparency to the salami in their handout (Student Page 20).

- Show the transparency of a completed Food Diary (page 17). Explain that students are to write down all the meat, fish, eggs, and dairy products that they eat, the number of servings, and examine the nutrition label to find grams of protein and grams of fat. Make copies of Student Page 21 for all students.

- Tell students that they should divide total protein and fat consumption by two to get their average consumption. Ask students why it is important to get an average rather than a single day’s consumption.

- Show a transparency of the completed My Percentages (page 18). Provide each student with a copy of Student Page 22 to use in calculating percentages. Students should make a bar graph showing

Purpose

To compare aquaculture with other animal production systems in terms of its ability to provide a healthy source of protein.

Key Concepts

Sustainable food production includes meeting human nutritional requirements. Protein is a critical component in the human diet.

Learning Objectives

Students will be able to:

- Explain why fish use less energy to make protein than many land-based animals;

- Compare fish with other sources of animal protein;

- Calculate, diagram, and interpret the sources of animal protein they consume.

Subjects

Nutrition
Social Studies
Mathematics
Science
the percentage of protein that they get from fish, chicken, beef, pork, other meats, eggs, and dairy products. You can use the overhead of a bar graph that we have prepared (page 19) to show students an example of the kind of graph they should make.

**Doing the Activity**  
**Time: 30 minutes**

- Students should display their completed bar graphs.

- Ask the students to examine the bar graphs and find three students with a high consumption of fish and other aquaculture products and three students with a low consumption of these products. Ask these students to tell the class what their total fat consumption was. Discuss the relationship between consumption of aquaculture products and fat consumption. You will probably want to make a table on the blackboard showing percent protein from fish in one column and total fat consumption in the other.

- Refer students to the discussion questions on the Student Page What Protein Do You Eat? (page 19). Discuss these questions in a large group.

- Bring closure to the lesson by discussing the questions in the Background Material (page 7). Students may either hand in their answers to the discussion questions, or you may choose to call upon students to share their answers in class.

**Key Points for the Discussion Questions**

- What are some reasons why aquaculture production could be more sustainable than other kinds of animal production?

**Possible Answers.** Fish are very efficient at producing protein compared with land-based animals. In addition, we consume a larger percentage of the fish carcass than other animals. However, it is worth pointing out to your students that many non-animal sources of protein, such as soybeans, are even more efficient protein producers than fish. Most nutritionists recommend, however, that animal protein be consumed to achieve proper protein balance in the human diet. Getting the right combination of plant proteins to acquire the various amino acids that humans need to build protein is complicated and requires a thorough understanding of dietary amino acid requirements.

- What kinds of animal protein sources produce the least waste products per pound of protein that you eat?

There is no simple correct answer to this question. Have students review the figure “Lean, Fat and Refuse.” Point out that fish differ widely in the amount of waste produced per pound of edible animal protein. Compare the amount of refuse in tilapia and catfish to illustrate this wide variability.

---

**Materials**
- Student Pages 20-22
- Pencil
- Graph paper
- Calculator
- Transparencies of pages 8-19.

**Extensions**

*Have We Changed What We Eat?*

Students can graph changes in U.S. total protein consumption, recommended consumption levels, and sources of protein over the last 20 years.

*Find Out the Dress-Out Percentage of Your Aquaculture Product*

Have students find the dress-out percentage of your aquaculture product, using a common form of dressing out the organisms (e.g., gutted and gilled, gutted and gilled with head off, etc.). This activity is designed to get students to explore how a scientifically valid experiment is performed. Let students develop their own experimental design. First, students should select a sample of organisms to perform the experiment. Before selecting the sample, have student discuss how many organisms they need to use to get a reliable result. Use this opportunity to discuss concepts such as the mean, variation from the mean, and other important aspects of...
The following question is most appropriate for advanced students.

- What are some of the potential disadvantages of fish and seafood as a source of animal protein for the world’s population?

**Possible Answers.** (1) People have strong dietary preferences. For example, many people in the United States have a strong preference for beef. Changing these kinds of preferences is often difficult. Even if more protein were available from aquaculture products, many people might not want to eat them.

(2) Aquaculture products are only one source of fish and seafood products. Many of the fish and seafoods that we eat are harvested from wild stocks. Some species, such as halibut, herring, and haddock, have been overfished to the point where they are *commercially extinct*. That is, they are now so rare that it is no longer pays to hunt them. “The U.S. National Fish and Wildlife Foundation says that 14 major fish species in U.S. waters yielding one-fifth of the world’s catch, are so depleted that even if all fishing stopped immediately, stocks would take up to 20 years to recover” (G. Lean and D. Hinrichsen, 1992, *WWF Atlas of the Environment*, Harper Perennial, New York, p. 157).

(3) Finally, some aquaculture production depends on catching wild fingerlings, or small fish, to stock aquaculture ponds. This can cause depletion of the fingerlings in their natural environments, reducing the number of animals available to grow to adult size and reproduce themselves. Over time, this practice can endanger not only the aquaculture production system that depends on wild fingerlings, but also the natural population of the species, at least locally.

**Quiz Questions**

- List at least two reasons why fish make protein for less energy than many land-based animals.

**Possible answers:** First, fish do not have to maintain a constant body temperature like humans and cows do. Second, they do not have to spend as much energy as birds or other land animals to move around because they live in water. Third, they are more efficient at converting what they eat into protein.

- What protein sources would you recommend to a friend who wants to eat a diet lower in fat and why?

**Possible answers:** Fish, chicken, or turkey because they are low in fat. Also, plant sources such as beans are a good source of low fat protein, if you know how to combine sources properly to get the correct balance of amino acids in the diet. Point out that the trade-offs between consuming animal and plant protein will be discussed in greater detail in Lesson 4. However, do point out that considerable knowledge of the amino acid developing a valid statistic. Then have students decide how they are going to select a random sample. Discuss issues such as bias in sampling.

Weigh the organisms before and after dressing to find the dress-out percentage. Compare your results to those in Table 1 on page 10. Close the exercise by encouraging students to discuss whether they think their procedure was scientifically valid and how they could improve the procedure.

If you do not have a production facility, you can perform this experiment by purchasing some whole fish or shellfish and using them for the experiment.

**Non-Formal Assessment**

Have students look up per capita animal protein consumption levels and sources in three countries. Ask them to determine whether consumption levels meet the National Academy of Science recommendations. If they do, which country has the most “sustainable” animal protein consumption pattern? Why? If not, how could the country potentially increase its animal protein production?
content of different foods is needed to ensure an adequate diet based solely on vegetable protein sources.

- List three ways that aquaculture helps to meet world animal protein needs.

**Possible answers:** Fish are more efficient at converting what they eat into weight gain; we eat more of a fish carcass than for many other animals, they make high quality protein efficiently.

**Want More Information?**


**Web Sites:**

Send your students to interactive versions of the food label and food pyramid on the Food and Drug Administration’s Web site. Click on food label or nutrition information at:

http://vm.cfsan.fda.gov/label.html

For a discussion of nutrition specifically for teens, including a discussion of vegetarianism, send your students to the FDA at:

http://www.fda.gov/opacom/catalog/ots_nutr.html

The National Agriculture Library also has a good Web site on human nutrition:

http://www.nal.usda.gov/fnic/dga/dg95/variety.html
Protein is essential in the human diet. Dando and Dando (1991:78) say the following about protein:

"Protein. After water, the second most plentiful substance in the human body, comprising roughly one-fifth of its total weight. Proteins are made up largely of carbon, hydrogen, oxygen, and nitrogen. Their molecules comprise a class of complex organic compounds made up of amino acids. They provide the materials within our bodies to form hair, tendons, muscle, skin, and cartilage. Proteins also make up many hormones such as insulin and the growth hormones, along with all of the enzymes, chromosomes, hemoglobin, cytochromes, and viruses.

Because proteins serve such important functions in our bodies, nutritionally they are essential in our diets. The most common dietary sources of protein are meats, such as beef, pork, and poultry; fish and seafood; eggs and dairy products; and grains and legumes such as beans and peas. Protein from animal sources is generally of higher quality than from plant sources because it contains all the essential amino acids."

The National Research Council of the National Academy of Sciences generally recommends a daily intake of 45 grams of protein for males ages 11 to 14 and 59 grams for males ages 15 to 18. For females, the recommendations are 46 grams for ages 11 to 14 and 44 grams for ages 15 to 18. A more precise recommendation is 0.8 grams of protein per kilogram of body weight.

As we saw in Lesson 2, many people in the world suffer from protein deficiency. One way to evaluate the sustainability of a food production system, then, is to see how efficiently it produces protein.

Let's compare fish with other farm animals.

The major advantage of fish over other animals is that they use less energy to make protein. There are three main reasons for this. First, fish do not have to maintain a constant body temperature like humans, beef cattle and poultry do. Second, they do not have to spend as much energy as birds or other land animals to move around because they live in water. Think about how weightless you feel when you swim. Third, fish use less energy to get rid of waste. For example, channel catfish gained 47 g of protein for each megacalorie of energy that they ate. Chickens gained 23 g and cattle gained only 6 g (Lovell, 1989).

Fish are also more efficient than other animals at changing what they eat into body tissue. Catfish raised on farms gained about 0.84 g of weight for each gram of food that they ate. Chickens gained about 0.43 g and beef cattle only 0.13 g of weight for each gram they ate.

Fish can also provide more lean meat, as a percent of the animal after slaughter, than most other animals. Figure 1 (page 7) shows that pork and chicken have a higher marketable percentage, the part of the animal that can be sold after slaughter, than do channel catfish or beef. This includes both the lean meat sold for human consumption and other parts of the animal, such as fat and refuse. Pork and chicken each have about 72 percent marketable percentage. Channel catfish and beef have only about 60 percent marketable percentage.

However, channel catfish has a much higher percentage of lean meat than any of the other animals, about 81 percent compared to 60 percent for beef, 54 percent for pork, and 65 percent for chicken (Fig. 2, page 8). Catfish and chicken also have much less fat than beef and pork. They have only about 5 percent. Beef and pork have about 25 percent fat.

Finally, catfish have a relatively small amount of refuse, or material that is not used as human food (it may be used as animal feed, in fertilizer, etc., however). Catfish has 14 percent refuse and beef 15 percent. Pork has about 21 percent and chicken has about 30 percent.

These figures vary widely for different kinds of fish, however. Table 1 (page 9) shows the dress-out percentages for some aquaculture species. Gutted
and gilled hybrid striped bass have a dress out percentage of 77 to 82 percent, quite high. Trout and salmon at 72 to 78 percent are nearly equal. Catfish is intermediate at 62 to 64 percent dress-out while tilapia has a dress-out percentage of only 51 to 53 percent. Furthermore, the form in which the fish is consumed is also important. Striped bass drop from a dress-out percentage of 77 to 82 to a percentage of only 40-45 when consumed as a fillet, for example. When making comparisons of waste, refuse, and lean meat, it is important to specify the kind of fish that you are talking about. Some compare well to beef, pork, and chicken. Others do not.

Discussion Questions
- What are some reasons why aquaculture production could be more sustainable than other kinds of animal production?
- What kinds of animal protein sources produce the least waste products per pound of protein that you eat?
- What are some of the potential disadvantages to increased consumption of fish and seafood as a source of animal protein?

References


Fig. 1. Marketable Percentage of the Animal after Slaughter

Marketable Percentage = All of the animal that can be sold after slaughter. Includes lean meat, fat, and refuse.

Fig. 2. Lean, Fat and Refuse

Refuse
Catfish and Chicken: Bones Only
Beef and Pork: Bones, Trim Fat, Tendons

Table 1. Dress-Out Percentages for Select Aquaculture Species

<table>
<thead>
<tr>
<th>Species</th>
<th>Fillet</th>
<th>Gutted and Gilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid Striped Bass</td>
<td>40-43 (skin off)</td>
<td>77-82 (headed, gutted and skinned)</td>
</tr>
<tr>
<td></td>
<td>42-45 (skin on)</td>
<td></td>
</tr>
<tr>
<td>Channel Catfish</td>
<td>42-46</td>
<td>62-64</td>
</tr>
<tr>
<td>Trout</td>
<td>50-54</td>
<td>72-78 (head on)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>65 (head off)</td>
</tr>
<tr>
<td>Salmon</td>
<td>52-58</td>
<td>72-78 (head on)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>65 (head off)</td>
</tr>
<tr>
<td>Tilapia</td>
<td>32-33</td>
<td>51-53 (headed, skinned and gutted)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>53-55 (skin on, headed and gutted)</td>
</tr>
</tbody>
</table>

What's on a Nutrition Label?

**Nutrition Facts**

Serving Size 2 oz. Drained  
(56 g - about 1/4 cup)

Servings about 2.5

Amount per serving

<table>
<thead>
<tr>
<th>Calories 70</th>
<th>Fat Cal 10</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>% Daily Value</th>
</tr>
</thead>
</table>

Total Fat 1g  
Saturated Fat 0g

Cholesterol 25 mg

Sodium 250 mg

Total Carb 0g

Protein 15g

Calcium 4%  
Iron 8%

Vitamin A 0%  
Vitamin C 0%

Tuna in Water
What's on a Nutrition Label?

<table>
<thead>
<tr>
<th>Nutrition Facts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serving Size</td>
</tr>
<tr>
<td>Servings per container</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Amount per serving</th>
<th>Calories 170</th>
<th>% Daily Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fat Cal 140</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Fat</th>
<th>16g</th>
<th>25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated Fat</td>
<td>6g</td>
<td>30%</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>40 mg</td>
<td>13%</td>
</tr>
<tr>
<td>Sodium</td>
<td>750 mg</td>
<td>31%</td>
</tr>
<tr>
<td>Total Carb</td>
<td>0g</td>
<td>0%</td>
</tr>
<tr>
<td>Protein</td>
<td>7g</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>Vitamin A</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Vitamin C</td>
<td>0%</td>
<td></td>
</tr>
</tbody>
</table>

Luncheon Meat
## What's on a Nutrition Label?

<table>
<thead>
<tr>
<th>Nutrition Facts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serving Size</td>
</tr>
<tr>
<td>Servings</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Amount per serving</th>
<th>Calories 15</th>
<th>Fat Cal 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Daily Value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Fat</td>
<td>8g</td>
<td>12%</td>
</tr>
<tr>
<td>Saturated Fat</td>
<td>5g</td>
<td>25%</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>35 mg</td>
<td>12%</td>
</tr>
<tr>
<td>Sodium</td>
<td>110 mg</td>
<td>5%</td>
</tr>
<tr>
<td>Total Carb</td>
<td>11g</td>
<td>4%</td>
</tr>
<tr>
<td>Protein</td>
<td>8g</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>30%</td>
<td>Iron</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>6%</td>
<td>Vitamin C</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>25%</td>
<td>4%</td>
</tr>
</tbody>
</table>

Whole Milk (1/2 gallon)
<table>
<thead>
<tr>
<th>Item</th>
<th>Serving Size</th>
<th>Serving (g)</th>
<th>Kcal</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bass</td>
<td>3 oz.</td>
<td>85</td>
<td>82</td>
<td>15.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Bacon</td>
<td>3 slices</td>
<td>68</td>
<td>378</td>
<td>5.9</td>
<td>39.1</td>
</tr>
<tr>
<td>Bologna (beef)</td>
<td>1 slice</td>
<td>23</td>
<td>72</td>
<td>2.8</td>
<td>6.5</td>
</tr>
<tr>
<td>Bison</td>
<td>3.5 oz.</td>
<td>100</td>
<td>143</td>
<td>28.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Catfish (breaded &amp; fried)</td>
<td>3 oz.</td>
<td>85</td>
<td>194</td>
<td>15.5</td>
<td>11.3</td>
</tr>
<tr>
<td>Cheese (American)</td>
<td>1 oz.</td>
<td>28</td>
<td>106</td>
<td>6.3</td>
<td>8.9</td>
</tr>
<tr>
<td>Cheese (cheddar)</td>
<td>1 oz.</td>
<td>28</td>
<td>114</td>
<td>7.1</td>
<td>9.4</td>
</tr>
<tr>
<td>Chicken (fried, with skin)</td>
<td>3.5 oz.</td>
<td>100</td>
<td>289</td>
<td>22.5</td>
<td>17.4</td>
</tr>
<tr>
<td>Chicken (roasted, with skin)</td>
<td>3.5 oz.</td>
<td>100</td>
<td>239</td>
<td>27.3</td>
<td>13.6</td>
</tr>
<tr>
<td>Chicken (roasted, without skin)</td>
<td>9 sm.</td>
<td>85</td>
<td>171</td>
<td>12.1</td>
<td>9.5</td>
</tr>
<tr>
<td>Clams (breaded and fried)</td>
<td>5 oz.</td>
<td>142</td>
<td>290</td>
<td>20.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Cod (frozen, breaded)</td>
<td>1 cake</td>
<td>60</td>
<td>93</td>
<td>12.1</td>
<td>4.5</td>
</tr>
<tr>
<td>Crab cakes</td>
<td>3 oz.</td>
<td>85</td>
<td>97</td>
<td>20.3</td>
<td>1.2</td>
</tr>
<tr>
<td>Crayfish (boiled)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duck (with skin)</td>
<td>3.5 oz.</td>
<td>100</td>
<td>201</td>
<td>23.5</td>
<td>11.2</td>
</tr>
<tr>
<td>Eel (dried)</td>
<td>3 oz.</td>
<td>85</td>
<td>200</td>
<td>20.1</td>
<td>12.7</td>
</tr>
<tr>
<td>Egg (fried)</td>
<td>1 egg</td>
<td>46</td>
<td>91</td>
<td>6.2</td>
<td>6.9</td>
</tr>
<tr>
<td>Fish fillet (frozen, battered)</td>
<td>6 oz.</td>
<td>170</td>
<td>447</td>
<td>15.9</td>
<td>25.8</td>
</tr>
<tr>
<td>Fish sticks (light and crispy)</td>
<td>4 sticks</td>
<td>106</td>
<td>270</td>
<td>10.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Frog Legs (raw)</td>
<td>3.5 oz.</td>
<td>100</td>
<td>73</td>
<td>16.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Goose (without skin)</td>
<td>3.5 oz.</td>
<td>100</td>
<td>238</td>
<td>29.0</td>
<td>12.7</td>
</tr>
<tr>
<td>Haddock (baked)</td>
<td>3 oz.</td>
<td>85</td>
<td>95</td>
<td>20.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Ham</td>
<td>3.5 oz.</td>
<td>100</td>
<td>203</td>
<td>20.2</td>
<td>12.9</td>
</tr>
<tr>
<td>Hamburger (baked)</td>
<td>3.5 oz.</td>
<td>100</td>
<td>287</td>
<td>23.0</td>
<td>20.9</td>
</tr>
<tr>
<td>Hamburger (fried)</td>
<td>3.5 oz.</td>
<td>100</td>
<td>306</td>
<td>23.9</td>
<td>22.6</td>
</tr>
<tr>
<td>Hot Dog (beef)</td>
<td>1</td>
<td>57</td>
<td>180</td>
<td>6.9</td>
<td>16.3</td>
</tr>
<tr>
<td>Ice Cream (low fat)</td>
<td>½ cup</td>
<td>71</td>
<td>130</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Lamb (leg of)</td>
<td>3.5 oz.</td>
<td>100</td>
<td>180</td>
<td>28.2</td>
<td>6.7</td>
</tr>
<tr>
<td>Lobster (raw)</td>
<td>3 oz.</td>
<td>85</td>
<td>77</td>
<td>16.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Milk (1%)</td>
<td>8 oz.</td>
<td>244</td>
<td>102</td>
<td>8.0</td>
<td>2.6</td>
</tr>
<tr>
<td>Item</td>
<td>Serving Size</td>
<td>Serving (g)</td>
<td>Kcal</td>
<td>Protein (g)</td>
<td>Fat (g)</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>--------------</td>
<td>-------------</td>
<td>------</td>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>Oysters (breaded and fried)</td>
<td>6 med.</td>
<td>85</td>
<td>167</td>
<td>7.5</td>
<td>10.7</td>
</tr>
<tr>
<td>Perch (baked)</td>
<td>3 oz.</td>
<td>85</td>
<td>99</td>
<td>21.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Rabbit</td>
<td>3.5 oz.</td>
<td>100</td>
<td>197</td>
<td>29.1</td>
<td>8.1</td>
</tr>
<tr>
<td>Salmon (dry heated)</td>
<td>3 oz.</td>
<td>85</td>
<td>155</td>
<td>21.6</td>
<td>6.9</td>
</tr>
<tr>
<td>Sardines (in soy oil)</td>
<td>2</td>
<td>24</td>
<td>50</td>
<td>5.9</td>
<td>2.8</td>
</tr>
<tr>
<td>Sausage</td>
<td>1 slice</td>
<td>24</td>
<td>79</td>
<td>4.1</td>
<td>6.8</td>
</tr>
<tr>
<td>Shrimp (breaded and fried)</td>
<td>11 lg.</td>
<td>85</td>
<td>206</td>
<td>18.2</td>
<td>10.4</td>
</tr>
<tr>
<td>Shrimp (boiled)</td>
<td>15 lg.</td>
<td>85</td>
<td>84</td>
<td>17.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Snail (raw)</td>
<td>3.5 oz.</td>
<td>100</td>
<td>90</td>
<td>27.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Steak (broiled)</td>
<td>3.5 oz.</td>
<td>100</td>
<td>269</td>
<td>16.1</td>
<td>16.7</td>
</tr>
<tr>
<td>Trout (baked)</td>
<td>3 oz.</td>
<td>85</td>
<td>129</td>
<td>22.4</td>
<td>3.8</td>
</tr>
<tr>
<td>Tuna (in water)</td>
<td>2 oz.</td>
<td>56</td>
<td>7.0</td>
<td>18.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Turkey</td>
<td>3.5 oz.</td>
<td>100</td>
<td>188</td>
<td>27.3</td>
<td>8.5</td>
</tr>
<tr>
<td>Turtle</td>
<td>3.5 oz.</td>
<td>100</td>
<td>106</td>
<td>23.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Veal (leg)</td>
<td>3.5 oz.</td>
<td>100</td>
<td>203</td>
<td>36.7</td>
<td>5.1</td>
</tr>
<tr>
<td>Whale (raw)</td>
<td>3.5 oz.</td>
<td>100</td>
<td>156</td>
<td>20.6</td>
<td>7.5</td>
</tr>
<tr>
<td>Yogurt (vanilla)</td>
<td>6 oz.</td>
<td>170</td>
<td>180</td>
<td>9.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

## Nutrition Information for Fast Foods

<table>
<thead>
<tr>
<th>Item</th>
<th>Serving (g)</th>
<th>Kcal</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burger King Broiled Chicken Sandwich</td>
<td>168</td>
<td>379</td>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td>Burger King Whopper</td>
<td>270</td>
<td>614</td>
<td>27</td>
<td>36</td>
</tr>
<tr>
<td>Hardee's Regular Roast Beef Sandwich</td>
<td>114</td>
<td>260</td>
<td>15</td>
<td>31</td>
</tr>
<tr>
<td>Hardee's Fish Sandwich</td>
<td>207</td>
<td>500</td>
<td>23</td>
<td>49</td>
</tr>
<tr>
<td>McDonald's Quarter Pounder</td>
<td>166</td>
<td>410</td>
<td>23.1</td>
<td>20.7</td>
</tr>
<tr>
<td>McDonald's Big MAC</td>
<td>215</td>
<td>566</td>
<td>25.2</td>
<td>32.6</td>
</tr>
<tr>
<td>Pizza Hut Pepperoni Pizza (2 slices)</td>
<td>211</td>
<td>540</td>
<td>29</td>
<td>22</td>
</tr>
<tr>
<td>Wendy's Big Classic</td>
<td>277</td>
<td>570</td>
<td>27</td>
<td>33</td>
</tr>
<tr>
<td>Taco Bell Taco</td>
<td>78</td>
<td>183</td>
<td>10</td>
<td>11</td>
</tr>
</tbody>
</table>

Restaurant's published values.
## FOOD DIARY

### Day 1: What I Ate

<table>
<thead>
<tr>
<th>Animal Protein Source</th>
<th>Servings</th>
<th>Serving Size (g)</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>1</td>
<td>46</td>
<td>6.2</td>
<td>6.9</td>
</tr>
<tr>
<td>American Cheese</td>
<td>1 slice</td>
<td>28</td>
<td>6.3</td>
<td>8.9</td>
</tr>
<tr>
<td>Milk (low fat)</td>
<td>1 glass</td>
<td>244</td>
<td>8.0</td>
<td>2.6</td>
</tr>
<tr>
<td>Hot Dog</td>
<td>1</td>
<td>57</td>
<td>6.9</td>
<td>16.3</td>
</tr>
<tr>
<td>Milk (low fat)</td>
<td>1 glass</td>
<td>244</td>
<td>8.0</td>
<td>2.6</td>
</tr>
<tr>
<td>Fried Chicken</td>
<td>2 pieces</td>
<td>200</td>
<td>22.5</td>
<td>17.4</td>
</tr>
<tr>
<td>Milk (low fat)</td>
<td>1 glass</td>
<td>244</td>
<td>8.0</td>
<td>2.6</td>
</tr>
<tr>
<td>Ice Cream</td>
<td>1</td>
<td>142</td>
<td>8.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Milk (low fat)</td>
<td>1 glass</td>
<td>244</td>
<td>8.0</td>
<td>2.6</td>
</tr>
</tbody>
</table>

### Day 1 Total

<table>
<thead>
<tr>
<th>Protein (g)</th>
<th>Fat (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>81.9</td>
<td>65.9</td>
</tr>
</tbody>
</table>

### Day 2: What I Ate

<table>
<thead>
<tr>
<th>Animal Protein Source</th>
<th>Servings</th>
<th>Serving Size (g)</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk on my cereal</td>
<td>1</td>
<td>244</td>
<td>8.0</td>
<td>2.6</td>
</tr>
<tr>
<td>Milk (low fat)</td>
<td>1 glass</td>
<td>244</td>
<td>8.0</td>
<td>2.6</td>
</tr>
<tr>
<td>Yogurt</td>
<td>1</td>
<td>170</td>
<td>9.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Milk (low fat)</td>
<td>1 glass</td>
<td>244</td>
<td>8.0</td>
<td>2.6</td>
</tr>
<tr>
<td>Big Mac</td>
<td>1</td>
<td>214</td>
<td>25.2</td>
<td>32.6</td>
</tr>
<tr>
<td>Pizza</td>
<td>2 slices</td>
<td>422</td>
<td>58.0</td>
<td>44.0</td>
</tr>
</tbody>
</table>

### Day 2 Total

<table>
<thead>
<tr>
<th>Protein (g)</th>
<th>Fat (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>116.2</td>
<td>87.4</td>
</tr>
</tbody>
</table>

**Grand Total Protein and Fat**  
198.1  153.3

**Average Protein and Fat**  
99.0  76.6

*(Grand Total Divided by 2)*  
*(Remember? 1 oz. = 28 g)*
My Percentages

Add up the total grams of protein that you got from each protein source.

<table>
<thead>
<tr>
<th>Fish &amp; Seafood</th>
<th>Beef</th>
<th>Poultry</th>
<th>Pork</th>
<th>Other Meats</th>
<th>Eggs</th>
<th>Dairy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.9</td>
<td>22.5</td>
<td></td>
<td>58</td>
<td>6.2</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>25.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32.1</td>
<td>22.5</td>
<td>0</td>
<td>58</td>
<td>6.2</td>
<td>79.3</td>
</tr>
</tbody>
</table>

Divide the total for each kind of protein source (fish and seafood, beef, etc.) by your total protein from the previous page to get the percentage of protein from each kind of protein source.

- **Fish and Seafood**: 0 = 0%  
  Total Protein 198.1
- **Eggs**: 6.2 = 3%  
  Total Protein 198.1
- **Beef**: 32.1 = 16%  
  Total Protein 198.1
- **Dairy**: 79.3 = 40%  
  Total Protein 198.1
- **Poultry**: 22.5 = 11%  
  Make a bar graph showing the percentage of protein from each source.
- **Pork**: 0 = 0%  
  Total Protein 198.1
- **Other Meats**: 58.0 = 29%  
  (Remember? 1 oz. = 28 g)
What Protein Do You Eat?

Nutrition facts are everywhere these days -- at restaurants, at the grocery store, and even at school. When was the last time that you read a nutrition label? Unfortunately, most of us ignore them. Let's look at a nutrition information label from a package of salami. How many grams of protein are there in a serving of salami? How much fat is there? Calories? Look at the nutrition label on a fish product. Compare the protein, fat, and calories to this salami label.

According to the National Research Council, males from 11 to 14 should eat 45 g of protein and females from 11 to 14 should eat 46 g. Males between 15 and 18 need 59 g and females between 15 and 18 need 44 g. How much of your protein do you usually get from (1) meat and fish, (2) eggs, and (3) dairy products? On the Food Diary on the next page, record what animal protein sources you eat for the next two days. Write down how many grams of protein and fat you got from each type of product. Now add them together and fill out the line: Grand Total Protein and Fat. Get your average daily consumption of each by dividing by two. Compare this with the recommendation. Are you eating too little protein? Too much? Too little or too much fat?

Finally, let's look at where you get your animal protein. Fill out My Percentages. Make a bar graph like the one at the left that shows the percentage of protein that you got from (1) fish and seafood, (2) beef, (3) poultry, (4) pork, (5) other meats, (6) eggs, and (7) dairy products.

Discussion Questions

How could you change your diet to include more energy efficient protein sources? What would happen if most Americans changed their diet to eat more aquaculture products?

---

**Nutrition Facts**

<table>
<thead>
<tr>
<th>Amount Per Serving</th>
<th>% Daily Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calories</strong> 110</td>
<td></td>
</tr>
<tr>
<td><strong>Fat Cal 90</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total Fat</strong> 9g</td>
<td>14%</td>
</tr>
<tr>
<td><strong>Saturated Fat</strong> 4g</td>
<td>20%</td>
</tr>
<tr>
<td><strong>Cholesterol</strong> 35 mg</td>
<td>12%</td>
</tr>
<tr>
<td><strong>Sodium</strong> 500 mg</td>
<td>21%</td>
</tr>
<tr>
<td><strong>Total Carb</strong> 0g</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Protein</strong> 6g</td>
<td></td>
</tr>
<tr>
<td><strong>Calcium</strong> 4%</td>
<td>Iron 8%</td>
</tr>
</tbody>
</table>

**Salami**

---

**My Protein Sources**

![Bar graph showing protein sources: Beef, Dairy, Chicken, Fish]
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Servings</td>
<td>Servings</td>
</tr>
<tr>
<td></td>
<td>Serving Size (g)</td>
<td>Serving Size (g)</td>
</tr>
<tr>
<td></td>
<td>Protein (g)</td>
<td>Protein (g)</td>
</tr>
<tr>
<td></td>
<td>Fat (g)</td>
<td>Fat (g)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 1 Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 2 Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Grand Total Protein and Fat**

**Average Protein and Fat**

*(Grand Total Divided by 2)*

(Remember! 1 oz. = 28 g)
My Percentages

Add up the total grams of protein that you got from each kind of protein source.

<table>
<thead>
<tr>
<th>Fish &amp; Seafood</th>
<th>Beef</th>
<th>Poultry</th>
<th>Pork</th>
<th>Other Meats</th>
<th>Eggs</th>
<th>Dairy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Divide the total for each kind of protein source (fish and seafood, beef, etc.) by your total protein from the previous page to get the percentage of protein from each kind of protein source.

Fish and Seafood ______ = ____%  Eggs ______ ______ = ____%  
Total Protein  

Beef ______ = ____%  Dairy ______ ______ = ____%  
Total Protein  

Poultry ______ = ____%  
Total Protein  

Pork ______ = ____%  
Total Protein  

Other Meats ______ = ____%  
Total Protein

Make a bar graph showing the percentage of protein from each source.
Introduction

In previous lessons we have examined ways that aquaculture can help meet the goal of sustainable food production systems to meet human food needs today and far into the future. We have stressed the advantages of aquaculture for providing protein for the human diet. Explain to your students that there are also some disadvantages to aquaculture as a source of human protein. This lesson will focus on some of these disadvantages, especially the potential for aquacultural use of high protein feed to compete with direct human consumption of plant protein.

Read the Background Material on Competing for Protein (pages 5-7). This reading explains some of the disadvantages of aquaculture as a source of protein for the world’s population. For students with a 9th grade or higher reading level, you can assign these pages as a homework assignment. You may want to have these students answer the discussion questions at the end of the reading (page 6) in writing as part of their homework. For students with an 8th grade or lower reading level, we suggest that you explain the ideas in the readings to your students yourself. You may want to make a transparency of Table 1 (page 8) to use.

Getting Ready

Time: 15 minutes

Explain to your students that we are going to examine how much crop land planted in soybeans was used in 1995 to support the U.S. catfish industry. Then we are going to see how many young people in China could have met their total daily protein requirement by (1) eating the catfish produced and (2) eating the soybeans that were fed to the catfish.

- Give each student a copy of Feeding the Catfish (Student Page 12). Have the students read through the page and discuss key points with them.

Doing the Activity

Time: 20 minutes

We suggest conducting this activity with soybeans because soybeans are used to supply protein for both people and animals. However, you may want to focus on some other component in fish diets. We have provided the basic information that you need to complete the same calculations for corn, wheat and cotton (page 11).

- Give each student a copy of How Many Acres of Soybeans Were Used to Feed Catfish in 1995? (Student Page 13). You may have the students complete the needed calculations individually or in small groups, or you can work through the sheet with the class as a whole. We have provided a completed sheet for you (page 10).
• Give each student a copy of Which Is Best? Feed People Catfish -- or Feed People Soybean Meal? (Student Page 14). Have them work through the problems. The correct answers are:

<table>
<thead>
<tr>
<th></th>
<th>Catfish</th>
<th>Soybean Meal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys ages 11 to 14</td>
<td>874,666,667</td>
<td>1,695,749,333</td>
</tr>
<tr>
<td>Boys ages 15 to 18</td>
<td>667,118,644</td>
<td>1,293,368,136</td>
</tr>
<tr>
<td>Girls ages 11 to 14</td>
<td>855,652,174</td>
<td>1,658,885,217</td>
</tr>
<tr>
<td>Girls ages 15 to 18</td>
<td>894,545,545</td>
<td>1,734,289,091</td>
</tr>
</tbody>
</table>

• Discuss why we cannot just conclude that everyone should eat soybean meal, and not catfish. Make sure that students understand that animal protein is of very high quality for human beings. You may want to share Table 2 (page 9) with them again to point out that animal sources of protein are generally higher in the essential amino acids than are plant sources. You may also want to raise additional points such as the cost of getting U.S. produced soybean meal to China, even if U.S. farmers were willing to give it away, etc.

**Suggestions for the Discussion Question**

The discussion question at the end of the Background Material on Competing for Protein (page 6) asks students to name examples of foods containing wheat, corn, and soybeans. Some examples are:

**Corn:** corn chips, corn bread, many breakfast cereals, corn meal on fried foods  
**Wheat:** cakes, bread, breakfast cereals, crackers  
**Soybeans:** low fat cheese, tofu, filler in sausage and hamburger, cooking oil

**Quiz Questions**

**Time: 10 minutes**

• Why do commercial fish farmers use special fish feeds?

**Possible answers:** The food naturally present in ponds and lakes will not support a very large amount of fish (usually 50 to 300 pounds per acre). It especially does not support many individuals of the more commercially valuable species such as catfish, shrimp, or trout.

• What does the term “complete diet” mean?

**Answer:** A feed that contains all of the ingredients that are essential for good health and maximum growth.

• Why do fish need a diet that is high in protein?

**Answer:** A large percentage of the fish’s body tissue (70 percent by dry weight) is composed of protein. Fish must eat protein to get the amino acids that they need to build their own protein.

**Materials**

Student Pages 12-14.  
Calculator  
Transparencies of pages 8-9.

**Extensions**

**Comparing Protein Levels**

The objective of this extension is for students to examine the impact of protein level on fish/shellfish growth. Students should separate fingerlings into five tanks or aquaria, placing 3 to 5 fingerlings in each tank or aquaria. Feed the organisms (1) 60%, (2) 80%, (3) 100%, (4) 120%, and (5) 140% of recommended protein intake. Measure growth over time, running the experiment an appropriate period for your species. Have students calculate basic descriptive statistics, such as the mean final weight and average weight gain and graph the results. As a closure discussion, have students explain why the highest protein intake did not produce the highest growth rate.

**Non-Formal Evaluation**

"Whip" rapidly back and forth between students. The first student takes a "pro" or "con" position on the value of aquaculture for protein production and the second student must refute the first student’s comment.
• Name at least two potential disadvantages to aquaculture.

Possible answers: (1) Aquaculture can cause pollution if large amounts of water from aquaculture ponds or tanks rich in organic matter are dumped into natural waterways. (2) Some aquaculture farms depend on catching wild fingerlings to stock their ponds. If too many fingerlings are caught, the natural population of the species may decline or even disappear at least locally. (3) Fish require high protein diets and some people argue that people should consume this protein directly, rather than feeding it to the fish and then eating the fish.

Want More Information?


Lovell, R.T. and Li, M. 1991. Are Fish Farmers Feeding Too Much Protein to Catfish? Alabama Agricultural Experiment Station, Vol. 38, No. 4. Auburn University, Auburn, AL. 6 p. NAL Call No. 100 AL1H.


Web Sites:

Want to contact your regional aquaculture center? Go to:
http://aqua.ucdavis.edu/centers.regional.html
They're all listed along with how to contact them.

Need access to publications free of charge? Try these sites:
http://aac.msstate.edu/pubs/
http://hammock.ifas.ufl.edu/
Both have searchable collections of publications that you can print directly from your computer.

The Harbor Branch Oceanographic Institute has a lot of topics of interest, including information on ornamentals, tropical aquaculture, and shellfish:
http://www.hboi.edu/division/aqu.htm
Aquaculture does have many advantages over other livestock production systems for providing protein for the human diet. However, it also shares some negative aspects with other food production systems.

Aquaculture can be a source of pollution. The water drained from aquaculture tanks or ponds, for example, can enter natural waterways and cause pollution because it is high in organic matter such as feces. This increases the biochemical oxygen demand (BOD). Bacteria immediately colonize organic matter. They need oxygen to decompose the organic matter — producing a high biochemical oxygen demand. Organically polluted water rapidly becomes deoxygenated, or low in oxygen. Loss of most invertebrates and fish may follow. A mass of stringy bacteria, including “sewage fungus,” *Sphaerotilus natans* and others, may develop. Sewage fungus can make the stream unsuitable for its natural inhabitants. If the stream bottom happens to be muddy, communities of worms and aquatic fly larvae may also develop.

Some aquaculture production depends on catching wild fingerlings, or small fish, to stock aquaculture ponds. This can cause depletion of the fingerlings in their natural environments. It can reduce the number of animals available to grow to adult size and reproduce themselves. Over time, this practice can endanger the natural population of the species.

Another criticism of aquaculture is that farmers use high quality, protein rich inputs in the feeds used to raise fish. Often, the food that the fish eat contains inputs that could be used to feed people directly or indirectly. In short, aquaculture can compete with human beings for these protein rich inputs. Some argue that it would be better for people to eat these sources of protein themselves, instead of first feeding the protein sources to fish and then eating the fish.

In the early days of aquaculture, farmers depended on natural pond organisms to provide food for the fish being grown. Later, they often increased production by using fertilizers, either natural manures or manufactured fertilizers, to boost the production of the natural pond organisms. However, they did not directly feed the fish.

Under totally natural conditions, the amount of fish that a lake or pond has is limited by the amount of natural food present. The carrying capacity or total quantity of fish that can be supported by the natural foods in the pond is usually between 50 and 300 pounds per acre under totally natural conditions. Some heavily fertilized fish ponds can produce several thousand pounds of fish per acre. However, these fish must be species that feed low on the food chain, such as tilapia or carp.

Many commercially valuable species, such as catfish, shrimp, and trout, feed higher on the food chain; that is, they require diets higher in protein. Neither completely natural ponds nor fertilized ponds will support many individuals of these species. Farmers want to support high densities of these species because they are very valuable. Fish farmers therefore soon began to provide supplemental feeds. That is, they started adding to the amount of feed available in natural systems. These early feeds were usually made from mixtures of plant and animal materials and provided protein and energy. However, they were not complete feeds because they lacked some substances, such as certain amino acids or fatty acids, vitamins, or minerals, that fish need to achieve optimum growth.

Today most commercial aquaculture is intensive agriculture, meaning that the animals being grown are crowded together at high densities in ponds, raceways, or cages. These intensive systems can maintain 6,000 to 8,000 pounds per acre of valuable fish species such as catfish. Farmers rely on scientifically developed complete diets for fish raised in intensive systems. A complete diet has all the essential nutrients for good health and maximum growth.

Fish need lots of protein. Fish meat or muscle is very high in protein — 70% of its dry weight is
protein. Fish therefore need a constant supply of protein in their diet. The first complete fish diets used large amounts of ground fish like Menhaden, a marine fish. Basically, farmers fed ground fish to live fish.

Today, fish feeds are based on scientific research. A typical catfish feed will contain 32 percent protein, compared to 16 percent in most dog food or 10 percent for cat food, for example. Requirements are similar for other species, although some species can use diets with less protein. Tilapia, for example, achieve maximum growth at protein levels of 35 to 50 percent. However, the economically optimum protein level is usually less, 25 to 35 percent (International Center for Aquaculture and Aquatic Environments, 1996: 15).

Since protein is the most expensive part of fish feed, many studies have been conducted to find low cost sources of protein. Typical high-protein items in fish feed include soybean meal (48 percent protein), cottonseed meal (41 percent protein), Menhaden meal (61 percent protein) and meat, bone, or blood meal (65 percent protein).

As Table 1 (page 8) shows, soybean meal, corn and wheat now account for almost 80 percent of a typical catfish feed. The more expensive Menhaden meal, on the other hand, accounts for only 4 percent. These modern complete diets also usually include the vitamins and minerals that fish need. In fact, most complete diets contain enough vitamins and minerals to exceed minimum requirements.

The problem is that people also consume many of the resources used to make fish feed. We commonly eat soybeans, corn, and wheat for example, three ingredients that account for 79 percent of the typical catfish diet. As we have seen in previous lessons, protein deficiency and hunger are serious problems for much of the world’s population. Should we promote aquaculture? Or should we use the soybeans, corn, and wheat that go into fish feed to feed people?

The answer is not an easy one because, as we also learned earlier, animal protein is generally of higher quality for humans than plant protein. Dando and Dando (1991: 22) point this out: “While there are twenty-three amino acids needed to build protein, eight are essential for humans: tryptophan, threonine, methionine, leucine, isoleucine, lysine, valine and phenylalanine. Not able to produce these amino acids on its own, the body must obtain them from foods.” They also say (1991: 78): “Protein from animal sources is generally of higher quality than from plant sources because it contains all the essential amino acids.” Table 2 (page 9) compares the content of the eight essential amino acids in some high-protein vegetable sources and several sources of animal protein.

Fish, shrimp, and terrestrial animals also have amino acid requirements. The International Center for Aquaculture and Aquatic Environments (1996: 15) discusses the amino acid requirements of tilapia, shrimp, and terrestrial animals. They require 10 amino acids. They say:

“Plant protein, in general, is deficient in two of the essential amino acids, methionine and lysine. ... to supplement these deficiencies, feedstuffs of animal origin (fish meal, meat and bone meals, etc.) usually constitute 7 to 15% of economically optimum supplemental rations for commercial production of tilapia.”

In fact, 50 percent of the world’s fish meal production is used in aquaculture (worldwide), especially in shrimp and salmon production. This is true because fish require high protein levels in their diet compared to other domesticated animals.

**Discussion Question**

- Name some of the ways that soybeans, corn, and wheat are used in foods that people eat.
References


International Center for Aquaculture and Aquatic Environments. Department of Fisheries and Allied Aquacultures. 1996. *Worldwide Prospects for Commercial Production of Tilapia*. Auburn University, Auburn, AL.
Table 1. Ingredients in a Typical Catfish Feed

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>% of Fish Feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean meal</td>
<td>36.5</td>
</tr>
<tr>
<td>Cottonseed meal</td>
<td>10.0</td>
</tr>
<tr>
<td>Fish meal</td>
<td>4.0</td>
</tr>
<tr>
<td>Meat/bone/blood meal</td>
<td>4.0</td>
</tr>
<tr>
<td>Corn (ground)</td>
<td>22.9</td>
</tr>
<tr>
<td>Wheat middlings</td>
<td>20.0</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>1.0</td>
</tr>
<tr>
<td>Vitamin mix</td>
<td>0.05</td>
</tr>
<tr>
<td>Mineral mix</td>
<td>0.05</td>
</tr>
<tr>
<td>Catfish oil</td>
<td>1.5</td>
</tr>
<tr>
<td>Food</td>
<td>Serving Size (g)</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Vegetable Foods</td>
<td></td>
</tr>
<tr>
<td>Raw firm tofu (½ c)</td>
<td>126</td>
</tr>
<tr>
<td>Boiled lentils (1 c)</td>
<td>198</td>
</tr>
<tr>
<td>Boiled pinto beans (1 c)</td>
<td>171</td>
</tr>
<tr>
<td>Peanut butter (2 Tb)</td>
<td>32</td>
</tr>
<tr>
<td>Sunflower seeds (1 oz)</td>
<td>28</td>
</tr>
<tr>
<td>Animal Foods</td>
<td></td>
</tr>
<tr>
<td>Ground beef (3.5 oz.)</td>
<td>100</td>
</tr>
<tr>
<td>Pork chop (3.5 oz.)</td>
<td>100</td>
</tr>
<tr>
<td>Fried chicken breast (½)</td>
<td>98</td>
</tr>
<tr>
<td>Atlantic salmon (3 oz.)</td>
<td>85</td>
</tr>
<tr>
<td>Breaded, fried shrimp (11 lg)</td>
<td>85</td>
</tr>
<tr>
<td>Whole milk (8 oz)</td>
<td>244</td>
</tr>
<tr>
<td>Breaded, fried catfish (3 oz)</td>
<td>85</td>
</tr>
<tr>
<td>Tuna in water (3 oz.)</td>
<td>85</td>
</tr>
</tbody>
</table>

TRY = tryptophan
THR = threonine
ISO = isoleucine
LEU = leucine
LYS = lysine
MET = methionine
PHE = phenylalanine
VAL = valine

Recommended daily allowances for adults in mg per kilogram of body weight:
TRY = 3.5
THR = 7
ISO = 10
LEU = 14
LYS = 12
MET (+cystine) = 13
PHE (+tyrosine) = 14
VAL = 10


How many pounds of catfish were produced in 1995?

\[
\text{Number of Acres} \times \text{Pounds of Catfish per Acre} = \text{Total Pounds of Catfish}
\]
\[
150,000 \times 3,200 = 480,000,000
\]

How many pounds of feed did these catfish eat?

\[
\text{Total Pounds of Catfish} \times \text{Feed Conversion Ratio} = \text{Pounds of Feed They Ate}
\]
\[
480,000,000 \times 2 = 960,000,000
\]

Catfish feed is sold in tons? How many tons are there in 960,000,000 pounds?

\[
\text{Pounds of Feed They Ate} + \frac{\text{Pounds per Ton}}{2,000} = \text{Tons of Feed They Ate}
\]
\[
960,000,000 + \frac{2,000}{2,000} = 480,000
\]

How many pounds of soybean meal are in one ton of catfish feed?

\[
\text{Pounds per Ton} \times \text{\% Soybean Meal in Diet} = \text{Pounds of Soybean Meal Per Ton of Catfish Feed}
\]
\[
2,000 \times 0.365 = 730
\]

We use soybean meal, not the whole soybean, in catfish feed. Each pound of soybeans (whole) produces 0.793 pounds of soybean meal. So how many pounds of whole soybeans are needed to make one ton of catfish feed?

\[
\text{Pounds of Soybean Meal per Ton of Feed} \div \text{Conversion Factor (Soybeans to Meal)} = \text{Total Pounds of Soybeans per Ton of Catfish Feed}
\]
\[
730 \div 0.793 = 920
\]

On average, each acre planted in soybeans in the U.S. produces 2,160 pounds (60 bushels) of soybeans. So how many acres of soybeans are needed to produce one ton of catfish feed?

\[
\text{Pounds of Soybeans per Ton of Catfish Feed} \div \text{Pounds of Soybeans Produced per Acre} = \text{Acres per Ton of Catfish Feed}
\]
\[
920 \div 2,160 = 0.426
\]

How many acres of soybeans were used to feed catfish in 1995?

\[
\text{Total Tons of Catfish Feed} \times \text{Acres of Soybeans per Ton} = \text{Total Acres}
\]
\[
480,000 \times 0.426 = 204,480
\]
Corn, Wheat, and Cotton Options

If you want to use another example instead of soybeans that you feel your students would enjoy more, here are values you can use in this exercise. You may want to have your students find out the total acreage in the crop that you use and determine the percentage of all U.S. acreage that goes to catfish feed. This will provide them with a better perspective on the amount of cropland for each crop going to support catfish production.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Corn</th>
<th>Wheat</th>
<th>Cotton</th>
</tr>
</thead>
<tbody>
<tr>
<td>% in Diet</td>
<td>22.9</td>
<td>20.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Lbs. in One Ton of Catfish Feed</td>
<td>458</td>
<td>400</td>
<td>200</td>
</tr>
<tr>
<td>Conversion Factor for Crop to Meal for Cotton</td>
<td>N.A.</td>
<td>N.A.</td>
<td>0.466</td>
</tr>
<tr>
<td>Total Lbs. Of Crop per Ton of Catfish Feed for Cotton</td>
<td>N.A.</td>
<td>N.A.</td>
<td>430</td>
</tr>
<tr>
<td>Pounds of Crop per Acre</td>
<td>6,720</td>
<td>2,160</td>
<td>1,004</td>
</tr>
<tr>
<td>Acres of Crop per Ton of Catfish Feed</td>
<td>0.068</td>
<td>0.185</td>
<td>0.428</td>
</tr>
<tr>
<td>Total Acres of Crop Used to Feed Catfish</td>
<td>32,640</td>
<td>88,800</td>
<td>205,440</td>
</tr>
</tbody>
</table>
Feeding the Catfish

Catfish farming is the largest single aquaculture enterprise in the U.S. In 1996, about 150,000 acres of ponds were used to produce catfish in Alabama, Arkansas, Louisiana, and Mississippi. On average, catfish farmers produce 3,200 pounds of catfish per acre of pond per year. The average feed conversion ratio is 2 to 1. That is, it takes two pounds of catfish feed to produce one pound of catfish.

Catfish diets are made from common farm products. A typical catfish diet will include corn, wheat, soybeans, and cotton (a meal made from cotton seeds). How much of these crops are produced just to feed catfish in the United States? Should we be feeding people the corn, wheat, and soybeans that go into catfish feed?

Let’s look at the example of soybeans. We use soybeans in a lot of human foods, even though we may not know it. Soybeans are used as fillers in sausage and hamburger and for cooking oil, for example. You may have eaten tofu -- it’s made from soybeans, too. And in some countries people eat roasted soybeans, just like we eat roasted peanuts.

Soybeans are very high in protein. The soybean meal that is used in a typical catfish feed contains 48 percent protein. As we learned in earlier lessons, many people in the world do not get enough protein in their diet. As a result they get serious illnesses like kwashiorkor and marasmus. We also talked about how aquaculture could help provide more protein for the world’s population. And we talked about the importance of animal protein in people’s diets. *But would it be better to feed the soybeans that we raise for catfish directly to people instead of feeding them to fish or other animals?*

Let’s find out how much cropland in the United States is used to raise soybeans to feed catfish. Then let’s see how many young people in China could get the protein that they need each day from the catfish and from the soybeans themselves.

Soybeans (*Glycine max*) are legumes, plants that can extract nitrogen from the air and therefore do not need to receive nitrogen fertilizer. Soybeans are native to China. Today, most soybeans are processed for their oils. A large portion is also used in animal feeds, but only a relatively small amount is consumed by humans. However, in China and some other Asian countries soybeans are a major source of protein for people. Tofu or soybean curd and soy sauce are also popular.
How Many Acres of Soybeans Were Used to Feed Catfish in 1995?

How many pounds of catfish were produced in 1995?

\[
\begin{align*}
\text{Number of Acres} & \times \text{Pounds of Catfish per Acre} = \text{Total Pounds of Catfish} \\
150,000 & \times 3,200 = \underline{480,000,000}
\end{align*}
\]

How many pounds of feed did these catfish eat?

\[
\begin{align*}
\text{Total Pounds of Catfish} & \times \text{Feed Conversion Ratio} = \text{Pounds of Feed They Ate} \\
480,000,000 & \times 2 = \underline{960,000,000}
\end{align*}
\]

Catfish feed is sold in tons. How many tons are there in 960,000,000 pounds?

\[
\begin{align*}
\text{Pounds of Feed They Ate} & \div \text{Pounds per Ton} = \text{Tons of Feed They Ate} \\
960,000,000 & \div 2,000 = \underline{480,000}
\end{align*}
\]

How many pounds of soybean meal are in one ton of catfish feed?

\[
\begin{align*}
\text{Pounds per Ton} & \times \% \text{ Soybean Meal in Diet} = \text{Pounds of Soybean Meal Per Ton of Catfish Feed} \\
2,000 & \times 0.365 = \underline{730}
\end{align*}
\]

We use soybean meal, not the whole soybean, in catfish feed. Each pound of soybeans (whole) produces 0.793 pounds of soybean meal. So how many pounds of whole soybeans are needed to make one ton of catfish feed?

\[
\begin{align*}
\text{Pounds of Soybean Meal per Ton of Feed} & \div \text{Conversion Factor (Soybeans to Meal)} = \text{Total Pounds of Soybeans per Ton of Catfish Feed} \\
730 & \div 0.793 = \underline{920}
\end{align*}
\]

On average, each acre planted in soybeans in the U.S. produces 2,160 pounds (60 bushels) of soybeans. So how many acres of soybeans are needed to produce one ton of catfish feed?

\[
\begin{align*}
\text{Pounds of Soybeans per Ton of Catfish Feed} & \div \text{Pounds of Soybeans Produced per Acre} = \text{Acres per Ton of Catfish Feed} \\
920 & \div 0.426 = \underline{2,160}
\end{align*}
\]

How many acres of soybeans were used to feed catfish in 1995?

\[
\begin{align*}
\text{Total Tons of Catfish Feed} & \times \text{Acres of Soybeans per Ton} = \text{Total Acres} \\
480,000 & \times 0.425 = \underline{204,000}
\end{align*}
\]
Which is Best?
Feed People Catfish -- or Feed People Soybean Meal?

Do you remember the recommended daily intake of protein for teenagers? It's in the table on the right, in case you've forgotten.

There are about 1.5 billion (1,500,000,000) people in China. Let's see how many young Chinese people of your age and gender could get the protein that they need each day from the catfish produced in 1995. Each pound of catfish (breaded and fried, with bones) contains about 82 grams of protein. In 1995, 480,000,000 pounds of catfish were produced.

\[
\begin{array}{c|c}
\text{Young Men} & \\
\hline
\text{Age 11 to 14} & 45 \text{ g} \\
\text{Age 15 to 18} & 59 \text{ g} \\
\hline
\text{Young Women} & \\
\hline
\text{Age 11 to 14} & 46 \text{ g} \\
\text{Age 15 to 18} & 44 \text{ g} \\
\end{array}
\]

Pounds of Catfish \times \text{Grams of Protein per Pound} = \text{Total Grams of Protein in Catfish}

\[
480,000,000 \times 82 = 39,960,000,000
\]

\[
\frac{\text{Total Grams of Protein in Catfish}}{\text{Protein Requirement for Chinese People Like Me}} = \text{Chinese People Who Could Get Their Protein from Catfish}
\]

\[
\frac{39,960,000,000}{\text{Chinese People Who Could Get Their Protein from Catfish}}
\]

Now let's see how many of these young Chinese people could get their daily recommended protein from the soybean meal used to feed the catfish. Each pound of soybean meal contains about 218 grams of protein (based on 48 percent protein content). In 1995, 350,040,000 pounds of soybean meal were used to feed catfish (960,000,000 pounds of feed containing 0.365 pounds of soybean meal per pound).

Pounds of Soybean Meal \times \text{Grams of Protein per Pound} = \text{Total Protein in Soybean Meal}

\[
350,040,000 \times 218 = 76,308,720,000
\]

\[
\frac{\text{Total Protein in Soybean Meal}}{\text{Protein Requirement for Chinese People Like Me}} = \text{Chinese People Who Could Get Their Protein from Soybean Meal}
\]

\[
\frac{76,308,720,000}{\text{Chinese People Who Could Get Their Protein from Soybean Meal}}
\]

Why can't we just conclude that it would be best to feed everyone in the world soybean meal instead of catfish?

---

Lesson 4: Competing for Protein?
Unit I. Is Aquaculture Sustainable?