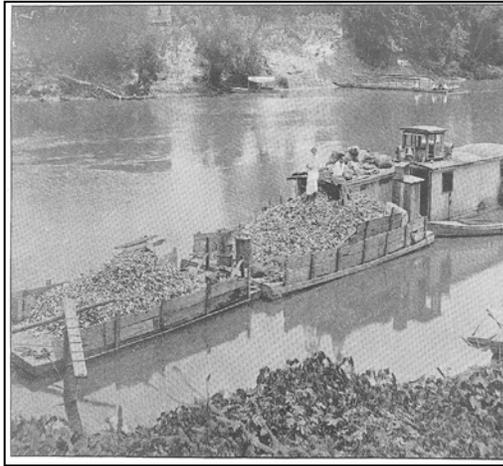


MUSSEL MARKET MYSTERY

OBJECTIVES

Students will be able to:

1. interpret and make inferences about fluctuations in mussel populations from actual data
2. analyze the effects of human use and habitat changes on a mussel population
3. analyze the affect of price fluctuations on mussel harvests



Barge loaded with freshwater mussel shells to be sold as the raw material for making buttons.

METHOD

Students graph and interpret actual Mississippi River mussel harvest data in relation to historical river events or price changes.

BACKGROUND

Data gathered about a wildlife population in a similar manner over a period of time may be useful in detecting trends in that population. The same data may be interpreted by those analyzing it in a variety of ways. Because a mussel population is influenced by many factors, it may be difficult to measure the effect of a single factor. Thus, assumptions must often be made that factors other than the ones being measured are not significantly affecting the population.

When measuring populations of mussels, biologists are seldom able to get a total count. Ideally, biologists would like to have a total count of mussel populations for the period of time they are interested in. However, usually only a sample of the population can be obtained and inferences about the total population must be made from this sample. Errors or inconsistencies in gathering the data over time may

Grade Level: 4 – 12

Subjects: Math, Social Studies, History

Duration: 45 to 60 minutes

Group Size: Any

Setting: Classroom

Key Vocabulary: mussel, harvest

Materials:

- graph paper (or prepared graphs from activity)
- mussel harvest data handout
- price handout
- time line

greatly influence the accuracy of the data. Despite the influence of unknown factors and possible inconsistencies in data gathering, regularly conducted counts or inventories of a population may still be the best information available and decisions must be made from this data.

Unfortunately, there were very few surveys of mussel populations in the past and sampling mussels is a very expensive and time-consuming endeavor. Therefore, it is often necessary for biologists to rely on other types of data to analyze trends in mussel populations. Because of the economic importance of mussels, records of tons harvested as well as the price paid have been kept.

MATERIALS

- graph paper (or prepared graphs)
- mussel harvest data
- price data
- time line

(Note: Examples of graphs are provided. However, you may choose to have students make their own graphs)

PROCEDURE

1. Provide students with the mussel harvest data only (Table 1). Have them graph data from 1894 to 1986. Students should put a legend on their graph. You may want to make an overhead of the graph provided (Fig. 1) for students to check against and for class discussion. A bar chart is more appropriate because the data is not continuous.
2. When they have completed graphing their mussel harvest, have them divide into groups and give each group a copy of the time line.
3. Have each group look for correlations between historic events and changes in harvest.

Comparison of historic harvest and price/ ton

(Students may use mussel harvest graph from previous activity.)

1. Hand out price per ton data (Table 2.)
2. Next they need to add a second Y-axis for price/ton or they may draw a second graph using data on this page to compare the harvest data to (Fig. 2).
3. Have them look for correlations between price and tons harvested.

ASSESSMENT

1. In what year were the greatest tons of mussels harvested? *1914.*
2. Look at the time line of historic events. What were most of the shells were used during the year of greatest mussel harvest? *Pearl Buttons.*
3. What happened between 1900 and 1910 that may partially explain the drastic decline of mussels harvested? *Six-foot channel project (dredging changed habitat and covered up mussel beds; construction of additional closing dams closed off flow into side channels).*
4. What two decades had the lowest harvest? *1940 and 1950.*
5. What explanations are there for these low harvests? *The main reasons the low harvest were the invention of plastic and its use in button making and construction of the locks and dams dramatically changed habitats on the River. However, pollution and its affects on mussels also contributed to lower mussel populations.*
6. Why did harvest of mussels increase in the 1960's? *Development of a market for mussel shells to be used as nuclei (seeds) for cultured pearls.*
7. What harvest technique resulted in a greater harvest in 1966? *Scuba diving.*

EXTENSION

The color and strength of the shell were important to the button industry. Current clammers choose species based on the thickness of the shells. Do some background research to determine which species of mussels have the thickest shells and see if they are harvested for use in the cultured pearl industry.

Have each student illustrate an event from the timeline and put their illustrations together in a book format.



TIME LINE OF HISTORIC EVENTS

1875-85 - Dumping of sawdust and wood waste creates major concern in Mpls/St.Paul

1878 - 4.5 ft channel project

1889 - First big pearl strike in Mississippi River Valley

1890 - Passenger pigeon virtually eliminated from upper Mississippi River

1891 - Beginning of pearl button industry

1897 - Crow foot drag bar (brail) invented; over 300 hundred clambers between Burlington and Clinton IA

1898-16 - Boom years of mussel harvest and Button industry

1899 - Congress passes Rivers & Harbors Act (authority of Corps of Engineers to regulate the dumping of pollutants in navigable streams)

1900-20 - Growing awareness of negative effect of direct discharge of municipal and industrial waste directly into the upper Mississippi River

1901 - Button making automated

1907 - 6 ft channel project

1907-10 - Investigation of artificial propagation of mussels

1914 - Hydroelectric dam built blocking the migration of skipjack which were essential to the development of mussel glochidia

1915 - Clamming with dredge outlawed in WI

1916 - End of boom years for button industry

1924 - Upper Mississippi River National Wildlife & Fish Refuge established by Congress

1928-30 - Natural reproduction of mussels on the Mississippi River was recognized as essentially nonexistent

1930 - Locks and dams built to create a 9-foot deep channel for navigation, this resulted in a change from a free flowing river to a series of pools that occupy the river floodplain; severe pollution in Mississippi River

1943 - Water analysis in limited areas show some contamination

1946 - No shelling below Muscatine, IA

1950's - Development of synthetic buttons

1960 - Development of market for mussel shells to be used as seeds in cultured pearls

1965 - Flood on upper Mississippi River

1966 - Harvest of mussels using scuba gear begins

1973 - Flood

1975 - US Food and Drug Administration stop shipment of common carp from Lake Pepin due to high PCB concentrations

1976 - Drought

1978 - *Lampsilis higgensi* mussel becomes first mussel to be on state and federal endangered species lists

1987-90 - Submerged aquatic plants diminish in upper pools of Mississippi River

1988 - Wilderness Society lists Upper Mississippi River National Wildlife and Fish Refuge as among the 10 most endangered in the United States

1987-89 - Drought

1989 - 10 additional mussels added to state's endangered species list; 7 to threatened list

1991 - First zebra mussel documented in upper Mississippi River

1993 - Major flood of entire Mississippi River basin

Table 1. HISTORIC HARVEST DATA

(all species of mussels harvested combined)

YEAR	TONS HARVESTED
1894	97.75
1899	8000.00
1914	8539.00
1920	933.29
1921	521.95
1922	501.18
1923	712.47
1924	582.83
1925	572.34
1926	1029.31
1927	444.49
1928	1211.45
1929	510.24
1930	741.34
1931	429.17
1932	149.59
1934	217.63
1935	162.17
1936	64.25
1937	96.22
1938	133.22
1939	74.33
1940	148.37
1941	112.98
1942	182.93
1948	14.34
1949	7.10
1950	9.87
1964	87.00
1965	500.00
1966	690.00
1967	124.00
1975	72.51
1976	264.78
1977	306.00
1978	124.00
1979	91.75
1982	177.95
1983	28.83
1984	131.25
1985	583.71
1986	387.40
1987	1016.96
1988	852.44
1989	934.09
1990	1194.26
1991	614.26

(all species of mussels harvested combined)

YEAR	PRICE/TON
1914	\$17.40
1919	\$40.00
1920	\$58.18
1921	\$25.16
1922	\$33.54
1923	\$43.74
1924	\$37.12
1925	\$79.38
1926	\$61.83
1927	\$70.12
1928	\$51.04
1929	\$42.03
1930	\$30.77
1931	\$25.16
1932	\$15.46
1934	\$22.11
1935	\$22.19
1936	\$18.12
1937	\$33.90
1938	\$31.74
1939	\$23.06
1940	\$20.70
1941	\$32.38
1942	\$45.44
1948	\$36.64
1949	\$29.63
1950	\$38.00
1964	\$60.11
1965	\$40.00
1966	\$60.00
1975	\$89.40
1976	\$111.52
1977	\$121.47
1978	\$140.00
1979	\$161.03
1982	\$152.48
1983	\$148.54
1984	\$200.00
1985	\$264.71
1986	\$400.10
1987	\$659.81
1988	\$852.85
1989	\$1070.56
1990	\$1816.81
1991	\$2109.84

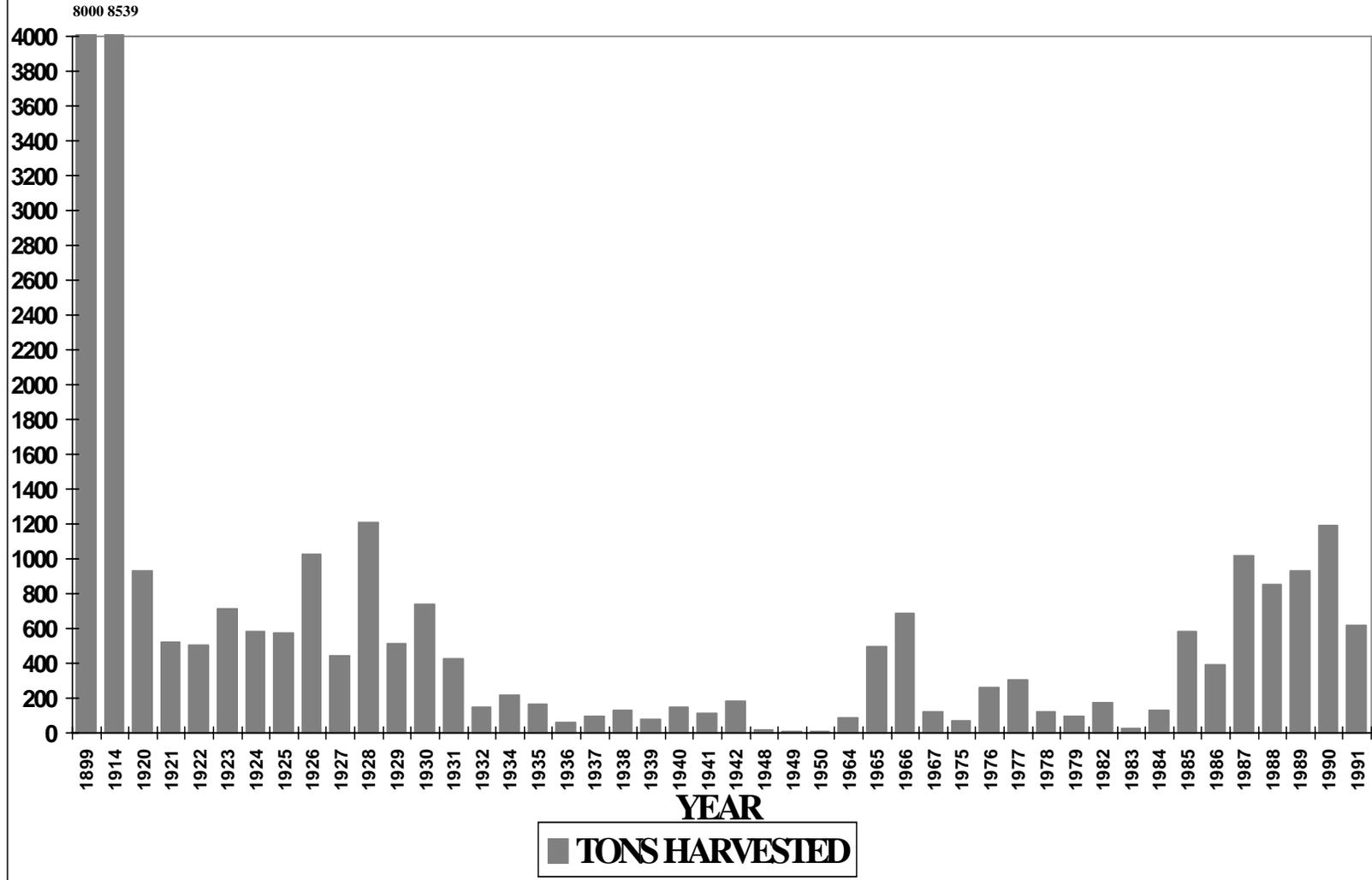
*Data in these tables were obtained from the Iowa DNR.
 Note: Years on harvest and price data may not always match up.

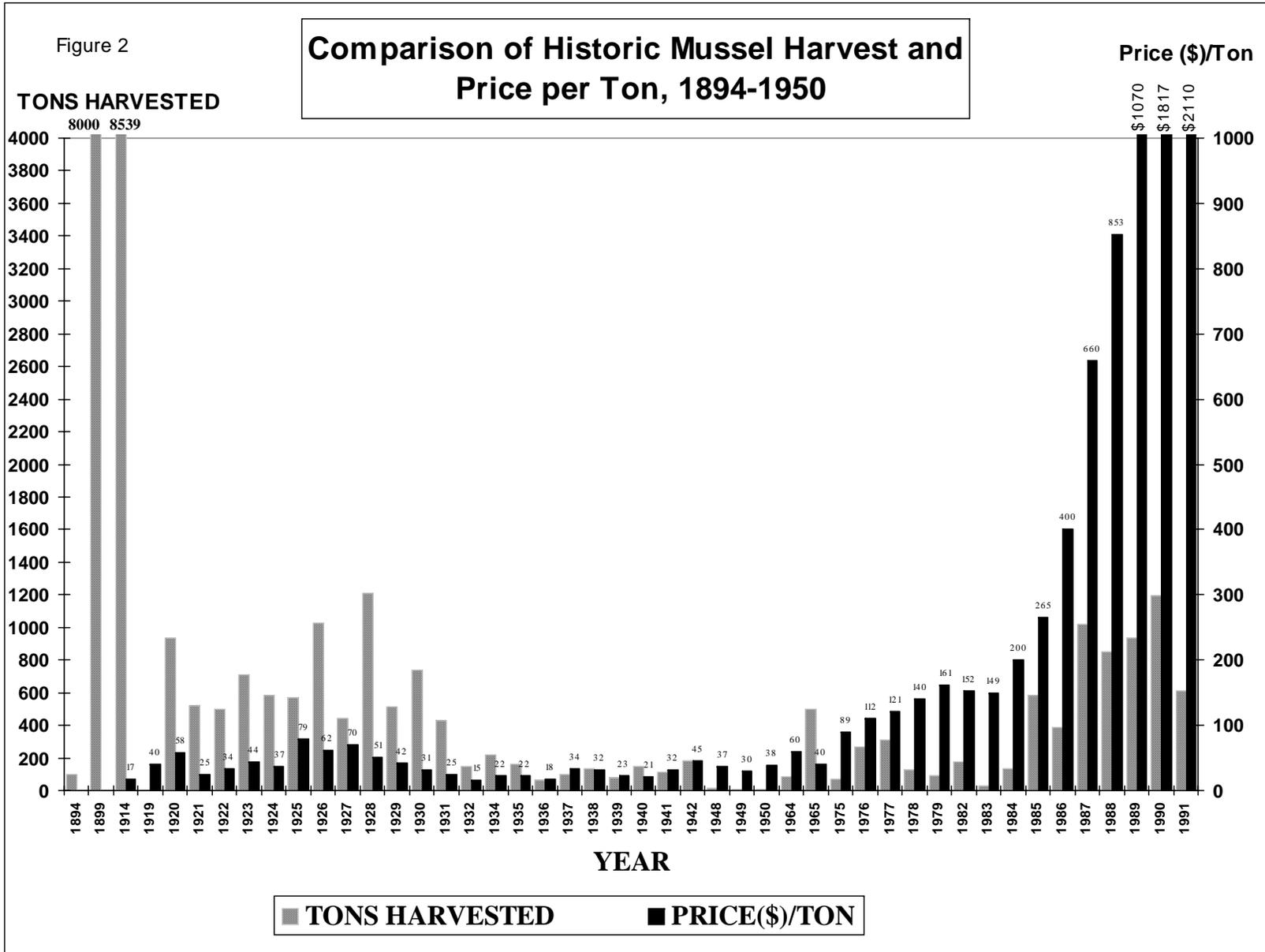
Table 2. HISTORIC PRICE PER TON DATA

Figure 1

Comparison of Historic Mussel Harvest, 1899-1991

TONS HARVESTED





MUSSEL MARKET MYSTERY: The Saga Continues



Washboard Mussel

OBJECTIVES

Students will be able to:

1. Interpret and make inferences about fluctuations in mussel populations from actual data
2. Analyze the effects of human use on a population of freshwater mussels
3. Analyze the affect of supply and demand

METHOD

Students graph actual Mississippi River mussel harvest data from 1986 – 1997. Students interpret relationships between harvest levels and price per pound.

BACKGROUND

The market for freshwater mussel shells is the same as it is for any business, supply and demand are interdependent. For example, if the price for mussel shells (the product) is high, then the demand for the shell is great and many people are harvesting them. However, if the number of shells harvested (supply) is great, then the price of shell usually drops.

Due to the demand for freshwater mussels, a size limit was placed on commercial freshwater mussels in the 1980's based on the management concept of sustainable yield. Sustainable yield management of mussel populations is based on the assumption that mussel size limits are sufficient to protect enough adults to reproduce numbers equal to what is being harvested.

The data provided in this activity was looked at by biologists as one method of monitoring the populations of washboard and threeridge mussels to determine if over-harvesting of their populations was occurring. What they saw was decreasing harvest of washboards even though the price per pound continued to rise. Additionally, when they noticed that the tons harvested of threeridge continued to rise, they theorized that this was due to clammers switching from the more preferred washboard to the less sought after threeridge due to a decline in washboard populations. This indicated to biologists that the size limit set may have been too low to protect the washboard population.

Grade Level: 4 - 12

Subjects: Math, Social Studies, History

Duration: 30 to 45 minutes

Group Size: Any

Setting: Classroom

Key Vocabulary: mussel, harvest, over harvest, supply, demand

Materials:

- graph paper (or prepared graphs from activity)
- handout of table 1

A detailed biological survey was conducted in the mid-1990's which verified the biologists' concern, the size limit was inadequate to maintain sustainable yield. Over-harvest was having a severe impact on the populations of washboard mussels along Wisconsin's portion of the Mississippi River (Figure 1). The decline was so severe in some areas that surveys were documenting more endangered Higgins' Eye Pearly mussels than the commercial washboard. The season for washboard mussels in Wisconsin's portion of the Mississippi was closed based on the market data presented in this activity and the biological surveys.



Divers surveying mussel populations

Over harvest was not the only factor contributing to the decline in washboards. An exotic species, the zebra mussel, was first documented in the Upper Mississippi River in 1990. Zebra mussels attach themselves to hard surfaces, including freshwater mussels. By 1996, many areas of the Mississippi River were heavily infested by zebra mussels, which attached themselves to native mussels and made clamming much more difficult. The clambers could not easily identify species underwater and had to spend a lot of time cleaning off the zebra mussels before taking the shells to market. Some of the washboards that were not being harvested were dying a slow death as they eventually became encrusted with zebra mussel. Once encrusted by zebra mussels, the native mussel cannot feed or get oxygen. This eventually leads to death.

MATERIALS

- graph paper (or prepared graphs)
- Table 1

(Note: Examples of graphs are provided. However, you may choose to have students make their own graphs)

PROCEDURE

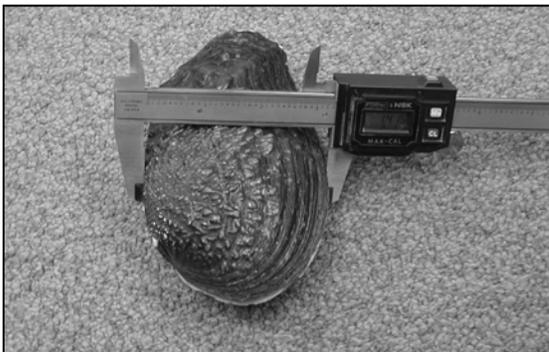
Using the information provided in Table 1, have the students do a comparison of harvest and price for two species commercially harvested from 1986-1997.

1. In this activity students can make several different types of graphs.
 - a) They may want to make two, two-line graphs, one with a comparison of the number of washboard vs. threeridges harvested (Fig. 2) and one comparing the price/pound of threeridge vs. washboard (Fig. 3).

- b) Or they may want to draw two graphs with two Y-axis each, comparing the price/pound and the number of mussels harvested. They will end up with a graph showing the cost/pound vs. the amount harvested for each species (Figs. 4 & 5).
2. Have students compare how many of each species is harvested, and then compare those numbers to the price/pound.
3. Use the background materials to discuss the concept of sustainable yield, importance of size limits and the survey conducted to document why current regulations were not adequate to protect the washboard population

ASSESSMENT

1. When the harvest of washboard mussels was at its greatest, the price per pound was at its (lowest/highest)? *Lowest.*
2. In general, price/pound increases when there is a (lower/higher) demand for mussels than supply. *Higher.*
3. Why do biologists believe the harvest of washboard mussels was decreasing from the late 1980's to late 1990's even though the price per pound was getting higher? *Washboard mussel populations were being over-harvested to the point that there were fewer and fewer mussels of legal harvest size and fewer adults in the population.*
4. What may have caused a decline in the harvest of both species beginning in 1996? *By 1996 many areas of the Mississippi River were heavily infested by zebra mussels, which attached themselves to native mussels and made clamming much more difficult. The clammers could not easily identify species underwater and had to spend a lot of time cleaning off the zebra mussels before taking the shells to market.*



Measuring the height of a freshwater mussel. The height of a mussel is the measurement used for size



Zebra mussels on freshwater mussel.

Table 1. Two species comparison.

Year	1000's pounds of Threeridge Harvested	\$/pound of Threeridge	1000's pounds of Washboard Harvested	\$/pound of Washboard
1986	168	0.05	802	0.20
1987	55	0.10	563	0.20
1988	56	0.25	862	0.20
1989	575	0.25	516	0.42
1990	1063	0.23	272	1.20
1991	259	0.20	287	1.20
1992	567	0.40	69	1.01
1993	377	0.47	67	1.45
1994	652	0.57	81	1.78
1995	685	1.40	112	2.50
1996	459	0.50	90	1.95
1997	104	0.75	13	2.00

Figure 1. Age frequency of washboard mussels sampled by biologists in 1995-1998. Washboards have the potential to reproduce beginning at 7 years of age, however, only a small percentage are mature enough to do so. As they become older a higher percentage of the individuals of that age are sexually mature. Studies have documented that it is not uncommon for some species of mussels to successfully reproduce only once out of seven or more years. Therefore, when interpreting the graph, one must realize that the sub legal adults may only have one, or at most two, successful reproductive cycles before they are large enough to be harvested.

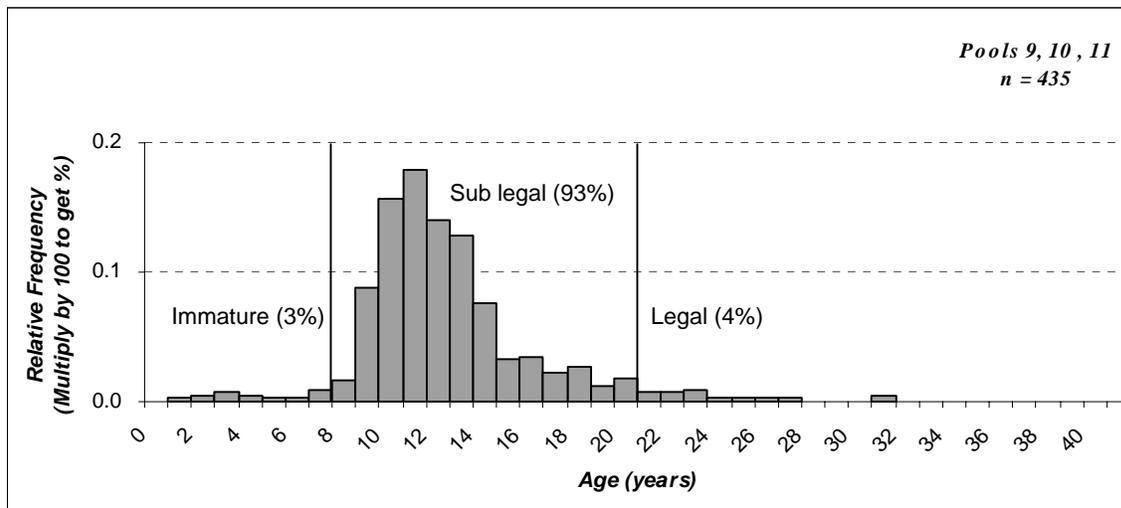


Figure 2. Harvest of Threeridge vs. Washboard

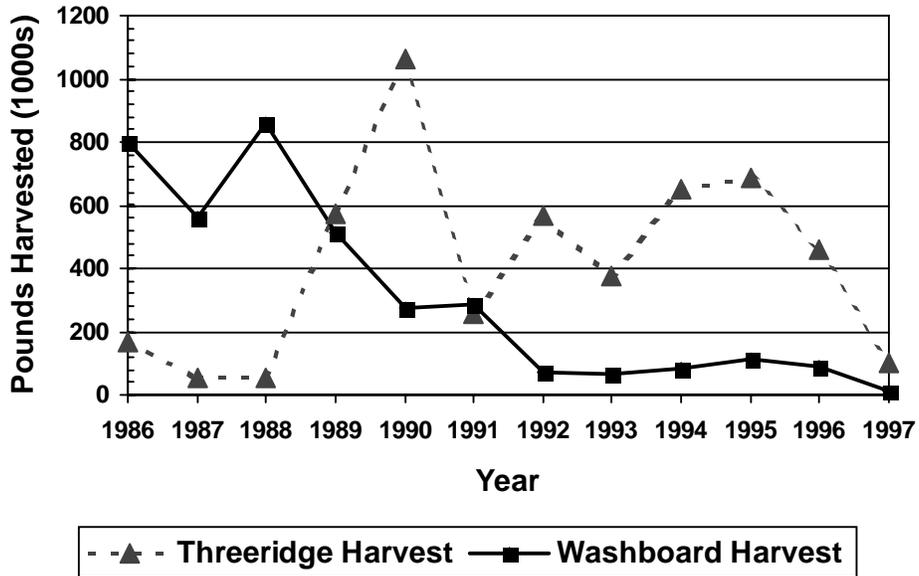
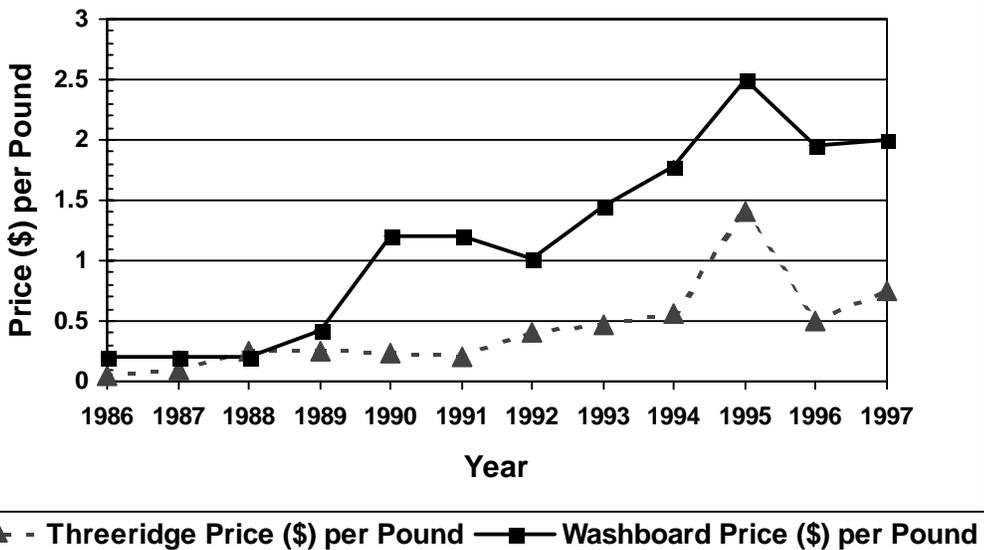
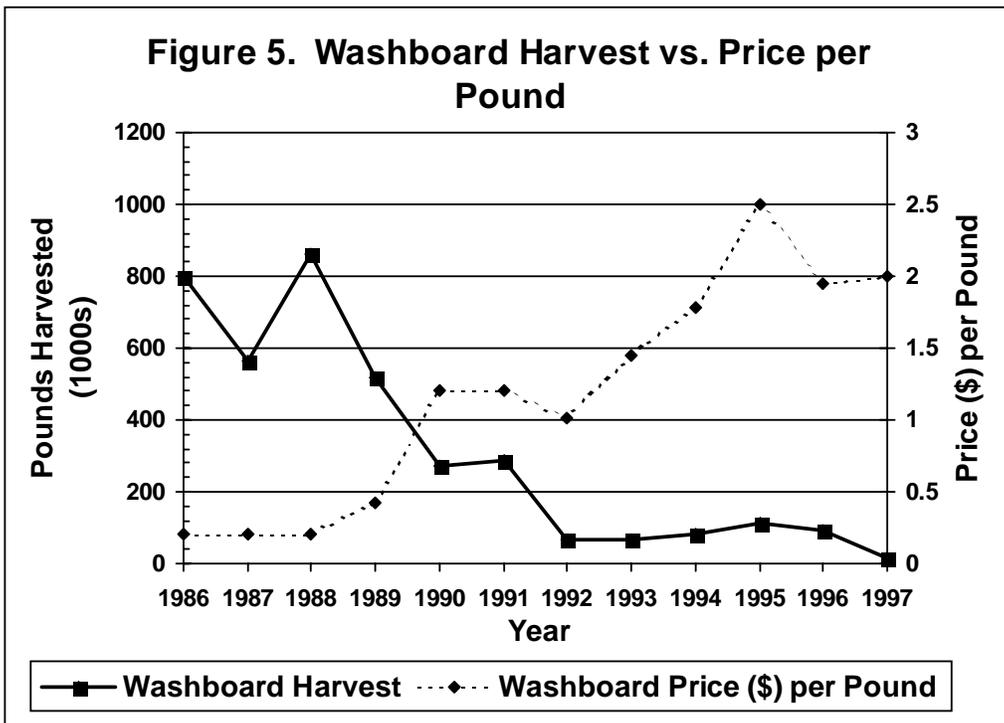
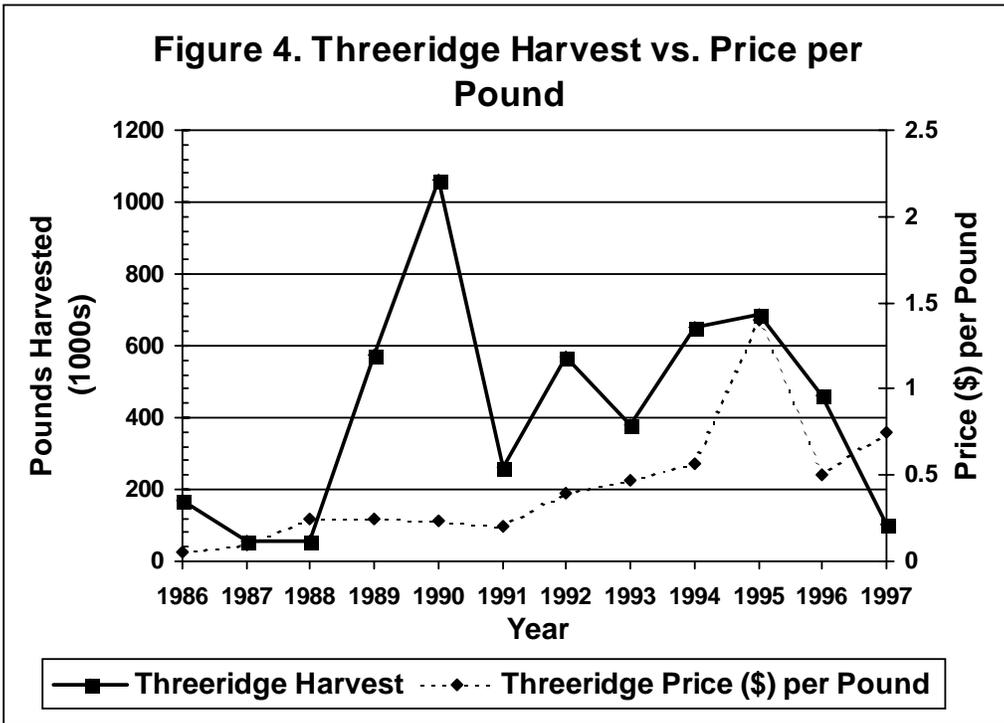


Figure 3. Price per Pound of Threeridge vs. Washboard





CONCEPT MAP – UNIT ASSESSMENT

OBJECTIVE

At the conclusion of the mussel unit, the student will complete a concept map.

METHOD

The class brainstorms information about mussels, in pairs or as individuals, to complete a concept map.

MATERIALS

- Concept map framework (1/student)
(Optional)

PROCEDURE

1. Lead students in a brainstorm session about mussels. Include societal, technological and scientific components.
2. Have students individually or in pairs organize the information about mussels into a concept map. You may provide students with a concept map framework or they may create their own.

ASSESSMENT

Is the concept map accurate and complete?

Are components/concepts arranged in an understandable format?

