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THE MASSACHUSETTS MARINE ECONOMY

Economic Development

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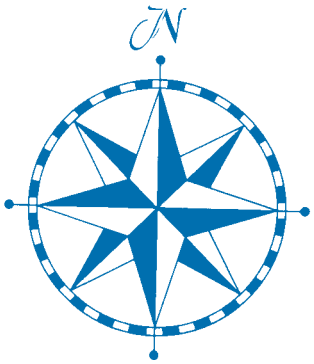
Contents



Executive Summary
Findings and Recommendations

This report summarizes employment and earnings, and identifies important characteristics and trends within various sectors of the Massachusetts marine economy in 1997.

The marine economy includes commercial seafood industries; marine transportation, tourism, and recreation; marine technology and education; and coastal construction and real estate.

Employment and Earnings for Major Sectors of the Marine Economy

Sector	Employment	Earnings	Average Earnings
		(in millions)	
Commercial Seafood Industry			
Commercial Fishing	3,086	$93	$30,136
Commercial Fishing Supplies and Services	1,073	$25	$23,299
Marine Aquaculture	232	$4	$15,000
Processing and Wholesaling Employment	5,219	$181	$34,681
Retail and Food Service Sales	27,975	$356	$12,726
Commercial Seafood Industry Total	37,585	$659	$17,520
Marine Transportation, Tourism, and Recreation			
Transportation and Shipbuilding	2,469	$81	$32,807
Tourism and Recreation	28,002	$548	$19,570
Marine Transportation, Tourism, and Recreation Total	30,471	$629	$26,188
Marine Technology and Education			
Instrumentation	4,627	$239	$51,653
Environmental Services	1,967	$63	$32,027
Research and Education	2,646	$118	$44,596
Marine Technology and Education Total	9,240	$420	$42,758
Coastal Construction and Real Estate	4,512	$177	$39,229
Total	81,808	$1,885	$23,036

ECONOMIC IMPACTS

In 1997, the Massachusetts marine economy generated 81,808 jobs and nearly $1.9 billion in earnings (wages and salaries). The average annual wage or salary was about $23,000, significantly less than the commonwealth's overall average wage of $36,000. Like most sectors of the Massachusetts economy, the marine industry has high-paying jobs — mostly in marine technology and education — and low-paying jobs in food services and tourism, the industry's major employers.

Although the quantity and value of seafood landed in Massachusetts has declined, the commercial seafood industry, which includes processing and retail sales, grew slightly more than the Massachusetts economy in number of jobs and earnings between 1988 and 1997.

Seafood industries employed about one-half of the people working in the marine economy (about 40,000 jobs) but paid only about one-third of total earnings (about $660 million). Employment in commercial seafood industries increased about one percent per year between 1989 and 1997. This increase was slightly more than the growth of employment in the overall Massachusetts economy. Earnings increased by four percent per year, which was also slightly more than the growth of wages and salaries in the Massachusetts economy.

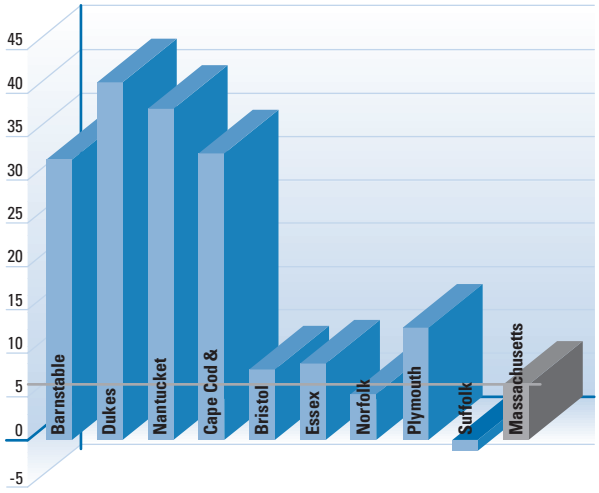
Marine tourism and recreation continue to be major economic activities.

Combined with marine transportation, this sector of the economy employed about 30,000 people, who earned roughly $630 million, accounting for one-third of the marine economy in both employment and earnings. This was second only to commercial seafood industries

In 1996 nearly 1 million people paid $21 million to firms offering whale watching, mostly in Plymouth and Provincetown. This estimate does not include spending for travel, overnight stays, and other expenses. About one-half of total employment and earnings from coastal tourism was on Cape Cod, Martha's Vineyard, and Nantucket; tourists visiting Cape Cod and the islands generated 11,750 jobs with a payroll of over $200 million.

The most recent National Survey of Fishing, Hunting, and Wildlife Associated Recreation, conducted by the U.S. Fish and Wildlife Service, estimates that 429,000 saltwater anglers spent roughly 4 million days fishing in Massachusetts in 1996, spending $222 million. The National Marine Manufacturing Association (NMMA) estimates that recreational boaters in Massachusetts spent $120 million in 1996 on boats, motors, trailers, and accessories. The authors estimate that retail and service expenditures for boating totaled approximately $300 million.

Percent Population Growth by County, 1980 – 1997



Growing population, housing starts, and income levels in coastal areas contribute to the marine economy.

Coastal communities (excluding Boston) grew by 10 percent between 1980 and 1997. From 1980 to 1997, median household income grew by 21 percent in coastal counties, compared to 14 percent in non-coastal counties.

The authors estimate that 2,315 permits issued in 1997 for $329 million worth of single-family houses can be attributed to demand for coastal living. Total Massachusetts employment in the construction of these houses was 4,212 jobs, with total earnings of $166 million. The housing activity also contributes to higher employment and earnings for real estate agents.

Over the past 15 years, commercial fishing and fish processing have declined significantly in the commonwealth. The collapse of many stocks and government efforts to restrict fishing to preserve those stocks have reduced fish landings by more than one-third since 1982.

INDUSTRY CHARACTERISTICS AND TRENDS

The seafood industry is a vital commercial and cultural component of many coastal towns and cities.

Composed of commercial fishing, suppliers that service commercial fishing, marine aquaculture, fish processing and wholesaling, and retail and food service sales, the seafood industry covers many activities in the commonwealth's coastal cities and towns. The seafood industry accounts for less than two percent of the commonwealth's labor force, but is an important component of coastal communities such as New Bedford, Gloucester, and some of the towns on Cape Cod. Fishing was the state's first industry, and it retains important links to tourism and the appeal of coastal life.

Over the past 15 years, commercial fishing and fish processing have declined significantly in the commonwealth. The collapse of many stocks and government efforts to restrict fishing to preserve those stocks have reduced fish landings by more than one-third since 1982 in both pounds and real value. This decline in catch has forced processors, wholesalers, retailers and ultimately consumers to buy more imported fish or products from other parts of the United States. It has also adversely affected businesses that service the fleet of fishing vessels.

The recent success of aquaculture in commercial production of catfish, oysters, and salmon in other parts of the United States hasn't been felt in Massachusetts. This is due mainly to more valuable uses of the commonwealth's seacoast for other activities. According to the highest estimate of production, aquaculture supplies less than three percent of the catch in Massachusetts. Aquaculture supplies seed for quahogs and bay scallops in many coastal towns, but in general, aquacultured seed and fish fry have had little effect in increasing native stocks of other species.

Like most new industries, there have been more failures than successes in the commonwealth's aquaculture. Marine aquaculture may be financially successful in the future, at least where demand for competing uses are low, and if land tenancy and other problems can be resolved.

Massachusetts leads the nation in marine research, which is mostly located in and around Woods Hole.

The commonwealth's reputation for excellence in research and education includes work in the marine environment.

Massachusetts leads the nation in marine research, which is mostly located in and around Woods Hole. The National Marine Fisheries Service, Woods Hole Oceanographic Institution, U.S. Geological Survey's Coastal and Marine Geology Program, and the Woods Hole Research Center are located in Falmouth. Other public and private marine research, education, and policy organizations dot the Massachusetts coastline.

Marine education services and organizations in Massachusetts are many and varied. Museums, centers, and aquariums throughout the commonwealth provide education and information on marine and coastal topics, such as marine wildlife, maritime history, whaling and fishing, and coastal ecology.

Massachusetts is also a leader in marine technology.

Of the 75 manufacturers listed in a recent study of marine instrumentation, 16 were located in the commonwealth. Some of these businesses are represented by the Massachusetts Ocean Technology Network (MOTN), a trade association founded in 1994 to share information and marketing costs among its members.

Increasing popular and legal interests in conserving and regenerating the environment stimulate a growing marine environmental service industry. These activities include managing wetlands, fisheries, and other coastal resources; preserving coastal resources; and reducing pollutants.

In 1999 MOTN received the Export Achievement Award from the Alliance for the Commonwealth and the Massachusetts Port Authority for promoting trade and international marketing.

Increasing popular and legal interests in conserving and regenerating the environment stimulate a growing marine environmental service industry. These activities include managing wetlands, fisheries, and other coastal resources; preserving coastal resources; and reducing pollutants. Government agencies, nonprofit corporations, and private companies provide environmental services in Massachusetts.

RECOMMENDATIONS

Stocks continue to decline, but new policies show promise.

The individual vessel days at sea (DAS) system allocates fewer fishing days to vessel owners (approximately half), but vessel owners or captains may choose the days. The DAS system allows vessel owners to fish when demand and prices are high, because fishing days are too valuable to use when prices are low.

Rotating areas to fish in order to allow stocks to rebuild, also shows promise. In 1999, large stocks of mature scallops were discovered in areas on Georges Bank that had been closed to scallop and groundfishing vessels since 1994, so the area was opened to scallop vessels. Due to high prices and increased landings, the value of the catch rebounded. After six months the areas were closed again because catch limits were reached. The success of the plan has led to proposals to rotate other areas fished.

Recreational boaters are a potential source of tourism dollars.

Thousands of recreational boats are moored in dozens of harbors along the Massachusetts coastline. Dockside support services including ship repair, marine supplies, engine repair, and other businesses are flourishing. An increase in expendable income has generated demand for all sizes of recreational vessels, including large pleasure craft. Gloucester, Boston, and New Bedford have deepwater ports near city centers to moor and service these vessels. Easy access to downtown attractions should be improved to entice boaters ashore.

There is real growth potential in marine technology and education.

Massachusetts remains among the world leaders in marine instrumentation, research, and education. The author's conservative estimate is that 10,000 people earning almost $500 million worked in this sector in 1997. This is the only sector of the marine economy with average yearly salaries significantly above the state average.

Marine technology has received little attention from state policymakers. The size and scope of this sector is poorly defined, and even the definition of marine technology has not been resolved. The Ocean Resources Branch of Hawaii's Department of Business would be a useful model for promoting and developing marine technology in Massachusetts. This organization publishes industry reports and distributes a directory of ocean research and development businesses, organizations, academic institutions, and government agencies in the state.

A Historical Overview

"After long beatings at sea they fell with that land which is called Cape Cod; that which being made and certainly known to be it, they were not a little joyful … A word or two by the way of this Cape. It was thus first named by Captain Gosnold and his company, Anno 1602, because they took much of that fish there."

WILLIAM BRADFORD, *Of Plymouth Plantation*

COMMERCIAL FISHERIES

"Pestered by cod"

In 1602, Bartholomew Gosnold of England explored Cape Cod and the nearby islands. He was probably not the first European to visit Massachusetts. British, French, Portuguese, and Basque fishermen had used the shores of the New World to dry, salt, and prepare cod and other fish prior to shipment back to Europe. Most of their voyages were farther north, to the Grand Banks off Newfoundland, but some had probably visited the rich fishing grounds of Georges Bank. Before them, Norsemen and others, including Native Americans, had sailed and explored the coastal areas of New England's shores.

Gosnold and his crew found the land inhabited by native people who had settled the area thousands and perhaps tens of thousands of years before. Few lived on or near the coast year-round because the coast lacked shelter. Some established summer camps on the shore, however, fishing and gathering shellfish before moving farther inland for better protection from the harsh coastal weather during winter months. These tribes had established their own marine economy mixed with enjoyment of summer life on the seacoast. They fished, stored what they could for later, and collected shells and other items for trade with interior groups.

Captain Gosnold was searching for sassafras, highly prized as a medicine, when he landed on Cape Cod, and when he returned to England, he reported that he had been "pestered" by cod. His reports encouraged several profitable expeditions to New England shores by English fishing boats, including a voyage by Captain John Smith in 1614, when he named both Massachusetts and New England. When English colonists, who had little experience in either farming or fishing, landed here, coastal Indian tribes showed them how to gather shellfish and fish in coastal waters.

The permanent settlements established by religious dissidents in 1620 at Plymouth and in 1630 at Boston changed life along the coastal areas of Massachusetts. After a difficult start, when they depended upon Native Americans for food and sustenance, the Pilgrims in Plymouth and the more populous Puritans in Boston established a subsistence and trading economy based on the resources they found near the shore. Within a few years of their arrival, colonists were fishing for cod and other species from boats they had built, salting them for preservation, and shipping them with furs and other goods to England.

During the early twentieth century, consumers demanded processed food for easier home preparation. In Gloucester, Clarence Birdseye experimented with freezing fish and vegetables, and he founded General Seafood Company, which later became General Foods.

The industry is marked by a century of success…

During the nineteenth and early twentieth centuries, Provincetown and Gloucester were home ports for the schooner fleets that fished for cod from dories using long hooked lines on Canada's Grand Banks. Trips lasted two or three months until the hold was filled with salted cod. Smaller vessels fished offshore and on Georges Bank from other Massachusetts ports for herring, halibut, and haddock. These trips were shorter, from one to three days, and the catch was brought back fresh for immediate use. Around the turn of the century, larger vessels, mostly from Boston, used otter trawls and beam trawls, large nets dragged from the side or stern, to catch large quantities of cod and haddock for Boston's fresh fish market. Increasingly, these vessels used gasoline and later diesel engines to drag nets and power vessels in treacherous weather amid the dangerous shoals off Nantucket and on Georges Bank.

During the early twentieth century, consumers demanded processed food for easier home preparation. In Gloucester, Clarence Birdseye experimented with freezing fish and vegetables, and he founded General Seafood Company, which later became General Foods. In Boston and later in New Bedford, onshore processors filleted the local catch of groundfish (cod, haddock, and flounder) for easier consumer preparation. The Boston Fish Pier was built in 1913 as a state-of-the-art fish unloading, processing, and storage center. The fresh fish business in Boston reached its peak during the 1930s when 300 million pounds of fresh fish were landed per year on the Fish Pier.

The Fishery Conservation and Management Act of 1976 established fishery management councils responsible for management plans that were "necessary to prevent overfishing, to rebuild over fished stocks, to ensure conservation, to facilitate long-term protection of essential fish habitats, and to realize the full potential of the Nation's fishery resources."

…followed by an alarming drop in landings.

World War II interrupted fishing in the Northwest Atlantic. After the war, the industry revitalized, and Massachusetts landed its record catch of 650 million pounds in 1948. The success of the New England fishing industry attracted foreign fleets looking for cheap protein. Spanish, Polish, and Russian fleets fished Georges Bank like combines harvesting wheat. Between 1960 and 1972, the commonwealth's catch dropped by half, from 500 million pounds to 250 million pounds. Haddock landings, the major moneymaker for the local fleet, declined by over 90 percent. Fishing families watched their earnings drop and blamed the foreign fleets for reduced catches, claiming they were fishing out stocks that had long supported local fishing communities.

The federal government began to assume a more important role in the management of fisheries. The Fishery Conservation and Management Act was passed in 1976. This law designated up to 200 miles offshore as an extended fishing zone where foreign vessels could not fish, except on those stocks that were not caught by U.S. vessels. The act claimed these waters as U.S. territory and gave the federal government the responsibility "to provide for the conservation and management of the fisheries." The act established fishery management councils responsible for management plans "necessary to prevent overfishing, to rebuild over fished stocks, to ensure conservation, to facilitate long-term protection of essential fish habitats, and to realize the full potential of the Nation's fishery resources."

The elimination of foreign boats from some of the richest fishing grounds in the world and exclusive ownership by U.S. fishermen caused large-scale investment in fishing vessels and in industries associated with fishing. A gold rush took over fishing communities as fish landings increased sharply and fishermen and capital flowed into the major and minor ports throughout the commonwealth. The boom extended to shoreside businesses. More welders, electricians, ship's carpenters, and other related craftspeople were needed on the docks. Lumping, ship supply, boat repair, and other marine services thrived. Processing plants called for more fish cutters, packers, floor men, and other processing workers.

The boom ended almost as quickly as it had begun. By the early 1980s, the catch of most commercial species had begun to decline. By 1991, the commercial catch fell below what it had been before the 200-mile limit, and it continued to fall until 1994. This depletion of most of the valuable fish stocks in New England waters caused the New England Fishery Management Council to pass management plans limiting catches of most commercial species through quotas. When this failed,

the Management Council tried to limit the catch by restricting fishing gear and eventually restricting the number of days per year boats can fish.

WATER TRANSPORTATION AND SHIPBUILDING

By 1700, Massachusetts had about 500 seagoing vessels, which traded mostly with the West Indies and Europe. Merchants around the world thought that Salem, Marblehead, Newburyport, New Bedford, and Boston were separate countries because so many merchant ships hailed from these ports.

Water transportation and shipbuilding, especially for the seafaring merchant trade, were the second and third pillars of the Massachusetts colonial marine economy. During the Colonial era, ships leaving Massachusetts with salt fish returned with salt, iron, foodstuffs, molasses, and wine. By 1700, Massachusetts had about 500 seagoing vessels, which traded mostly with the West Indies and Europe. In 1710, Long Wharf was built 2,000 feet into the deep water of Boston Harbor. Merchandise for trade was gathered from the cities and towns along the rivers, canals, and tidal basins that fed the port cities of Boston, Salem, Marblehead, New Bedford, and others.

Trade declined after the Revolutionary War, when England, Spain, and France restricted American trade in the West Indies and points south. The commonwealth recovered quickly, however, and sought other ports for trade. Merchants around the world thought that Salem, Marblehead, Newburyport, New Bedford, and Boston were separate countries because so many merchant ships hailed from these ports.

New York surpassed Massachusetts in shipping in 1850 because New York City was growing so fast. Tonnage shipped declined in Massachusetts, especially during the Great Depression and after World War II. New York now ships more than 15 times the cargo shipped in and out of Boston, which basically supplies the local area.

During the mid-nineteenth century, shipyards in Massachusetts built clipper ships that dominated maritime shipping. Built mostly for the East Coast–West Coast trade around Cape Horn, a trip of 15,000 miles, these ships were the largest and fastest sailing ships ever built.

Shipbuilding becomes a leading industry.

Soon after they landed and established themselves, they began building boats. In 1631, they built their first ship, Blessing of the Bay. By 1660, aided by the English Navigation Act that restricted colonial shipping to English and colonial-built vessels, shipbuilding became the leading industry in Boston and most other seaside settlements. Throughout the seventeenth and eighteenth centuries, Massachusetts was the primary supplier of ships and boats for the colonies. During the mid-nineteenth century, shipyards in Massachusetts built clipper ships that dominated maritime shipping. Built mostly for the East Coast–West Coast trade around Cape Horn, a trip of 15,000 miles, these ships were the largest and fastest sailing ships ever built.

Clipper ships were not the cheapest way to carry freight, though, and Massachusetts delayed the transition to steam and steel, favored by New York merchants. During the glorious decades of the clipper ship era, New York passed Massachusetts for the lead among states in shipping. Foreign ships were also carrying more freight. As early as 1880, only one-sixth of U.S. exports and imports were carried on U.S. ships, down from over two-thirds before the Civil War. Shipbuilding followed the merchant trade out of Massachusetts to New York and foreign countries.

A short-term boom-and-bust cycle operated within the general decline of shipbuilding in the commonwealth. World Wars I and II revived shipbuilding in the United States, and the oil crisis of the 1970s led to construction of large tankers to carry liquefied natural gas.

Quincy shipyard, the largest in Massachusetts, was built in 1884 in the same location where boats had been built since the 1600s. During World War II, it employed 32,000 people, including James Kilroy, an inspector who signed ship parts and other equipment "Kilroy was here," which became a slogan during World War II and again during the counterculture of the 1960s and 1970s. The yard almost closed in 1963, but General Dynamics bought it for $5 million. Foreign competition eliminated commercial shipbuilding, which the shipyard replaced with Defense Department contracts. When General Dynamics couldn't secure enough naval contracts, it closed the shipyard in 1985, and more than 6,000 employees were laid off. The most recent effort to revive the shipyard was in 1997 when a group of MIT professors and graduates projected higher demand for new ships and proposed more automated production there.

Even during the decline of shipbuilding in the twentieth century, Massachusetts firms continued to build small commercial fishing boats and recre-

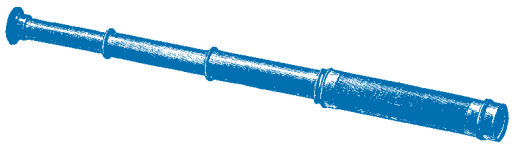
ational vessels. During the 1980s, however, boat building followed other manufacturing out of the commonwealth. Boston Whaler left Massachusetts in the early 1990s for Florida, where demand for recreational boats was higher and production costs probably cheaper.

Some organizations and businesses within these sectors, especially the research institutions in Woods Hole, have become world leaders in marine research and technology.

NEW SECTORS OF THE MARINE ECONOMY

New sectors of the marine economy include marine research, technology, and education; coastal tourism; marine recreation; and marine environmental services. Some organizations and businesses within these sectors, especially the research institutions in Woods Hole, have become world leaders in marine research and technology.

When Spencer Baird established the U.S. Commission of Fish and Fisheries in 1871 and later became its first director, he established a laboratory in Woods Hole to study fish stocks. The commission became the National Marine Fisheries Service, which still operates that laboratory. In 1888, the Marine Biological Laboratory, a nonprofit institution established by a group of scientists to study molecular biology, joined the government marine laboratory in Woods Hole. In 1930, Woods Hole Oceanographic Institution (WHOI), another private, non-profit organization, was established to study deepwater oceanography and other aspects of the marine ecosystem. In 1962, the U.S. Geological Survey (USGS) established a field office in Woods Hole, which became the Coastal and Marine Geology Program in 1974. The program investigates underwater terrain, geophysics, and global climate change and history of the coastal areas of the Atlantic, the Gulf of Mexico, and Caribbean areas. The Woods Hole Research Center, another private, nonprofit institution, was established in 1985 to study and advise on global warming and other issues concerning the global environment.



Methodology

The marine economy is composed of commercial activities related to the sea. Massachusetts has about 2,000 miles of coastline, depending on how much its coastal inlets and rivers are considered coastline. Fall River, for example, is considered a coastal city because it lies along the Taunton River, a tidal river that empties into Narragansett Bay. For this study, coastal areas include the counties of Barnstable, Bristol, Dukes, Essex, Nantucket, Norfolk, Plymouth, and Suffolk because these counties border the coastline. When data permits, coastal areas are further defined to include only the coastal towns and cities within these counties. In a few instances, we exclude coastal cities from this measure of coastal areas. Coastal areas are listed in Appendix A and are shown on the inside back cover of this publication.

The marine economy is divided into the following sectors with their associated subsectors, roughly based on Standard Industrial Classification (SIC) divisions.

Seafood Industry
- Commercial Fishing
- Commercial Fishing Supplies
- Marine Aquaculture
- Seafood Processing and Wholesaling
- Retail and Food Service Seafood Sales

Water Transportation, Tourism, and Recreation
- Transportation and Shipbuilding
- Coastal Tourism
- Recreational Fishing
- Recreational Boating

Marine Technology and Education
- Instrumentation
- Environmental Services
- Research
- Education
  - College and University Marine Degree Programs
  - K-12 Marine Educational Programs
  - Other Marine Educational Institutions

Coastal Population and Construction Growth

Although most marine activities are located in coastal communities, the marine economy of Massachusetts extends beyond coastal areas. For example, households across the commonwealth order seafood in restaurants and buy seafood in supermarkets. Data limitation, which is explained later in the text, restricted some employment analysis for coastal areas.

This report estimates employment and earnings in the various sectors of the marine economy in 1997, identifies important characteristics and trends within each marine industry, and summa-

To estimate the size of the marine economy, the authors summarized employment and earnings (wages and salaries) rather than sales or product revenue. This eliminated double counting that would result, for example, from adding wholesale seafood sales to retail seafood sales, which would count the wholesale value twice.

rizes employment, earnings, and trends for the entire marine economy of Massachusetts. In most cases, employment data report the number of jobs and do not differentiate between full-time and part-time jobs. Nor do the data indicate the number of people employed, because many people hold more than one job. For this reason, earnings (that is, wages and salaries) are a better measure of the marine economy than employment. The year 1997 is studied because it was the most recent year for which data in all sectors of the marine economy are available. Data for later years are not considered, except to observe trends.

Finding accurate data on employment and earnings in the various sectors of the marine economy provided many challenges. The Massachusetts Divisions of Employment and Training (DET) data on employment and earnings by SIC code provided primary data. In many cases, however, DET categories included businesses outside the marine economy, and data on marine activities were inextricably combined with non-marine data. This was especially troublesome in marine instrumentation. The Guidance Systems category, SIC 381, for example, covers aeronautical as well as nautical systems. Using DET employment and earnings data, therefore, would lead to overestimates of the marine economy. Data from iMarket supply employment estimates based upon finer categories than 4-digit SIC codes, but they do not estimate earnings. For many sectors, iMarket data were used for employment, and DET data were used to estimate earnings. Data from other government agencies and primary data from firms and organizations were used occasionally.

To estimate the size of the marine economy, the authors summarized employment and earnings (wages and salaries) rather than sales or product revenue. This eliminated double counting that would result, for example, from adding wholesale seafood sales to retail seafood sales, which would count the wholesale value twice. Multipliers were not considered, nor were the effects from purchases of marine goods and services and marine earnings on other sectors of the economy. There was no justification for a single multiplier for the marine economy, and using multipliers for each category of transaction would prove too complicated and increase the probability for error. Secondary effects were considered when they were contained within the marine economy. For example, the purchase of fishing gear by vessel owners was included; the production of steel to manufacture that gear was not.

Activities are divided into primary and secondary activities in many commercial or industrial studies. In the marine economy, commercial fishing would be considered a primary activity, and businesses that service commercial fishing (e.g., boat repair) would constitute secondary activities. This approach was rejected because it complicated the organization of the study without improving the analysis. Furthermore, the choice of primary or secondary marine activity is often arbitrary.

Overview of Employment and Earnings

The marine economy of Massachusetts employed more than 80,000 people and generated almost $2 billion in payroll in 1997.

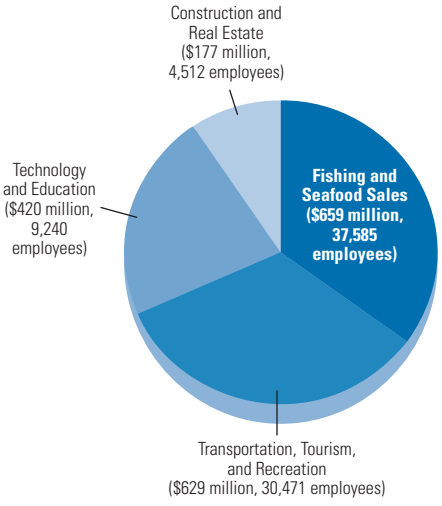
While the commonwealth's marine economy has declined in importance over the long run, employment and payroll remain substantial. It employed more than 80,000 people and generated almost $2 billion in payroll in 1997, accounting for about 3 percent of the 3 million jobs in the commonwealth and about 2 percent of the $100 billion in total earnings in 1997. Average annual earnings in the marine economy were $23,000 per person, significantly lower than the average for the commonwealth, which was $35,000. Much of this difference was due to low earnings in food services and tourism, the major employers in the marine economy.

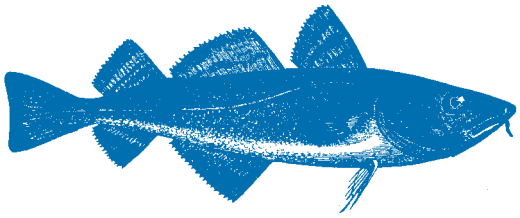
The largest sector in the marine economy, commercial seafood, employed almost 40,000 people, who earned $659 million. Marine transportation, tourism, and recreation employed about 30,000 people, with a total payroll of $629 million. Average wages and salaries were higher in transportation, tourism, and recreation than in commercial seafood industries. Marine technology and education employed over 9,000 people, who earned about $420 million. Average wages and salaries in technology and education were almost $50,000 per year, more than double those in the other sectors.

In 1997, about 4,500 people were employed in construction and real estate, due to the high demand for coastal living. They earned about $180 million.

Employment and Earnings in the Marine Economy, 1997

Total employment = 81,808 Total earnings = $1.9 billion





Commercial Seafood Industries

Fishing was the state's first industry, and it retains important links to tourism and the appeal of the commonwealth's coastal life.

The commercial seafood industry covers many activities in the commonwealth's coastal cities and towns, including commercial fishing, suppliers that service commercial fishing, marine aquaculture, fish processing and wholesaling, and retail and food service sales. The seafood industry employs less than 2 percent of the commonwealth's labor force but is an important component of coastal communities like New Bedford, Gloucester, and some of the towns on Cape Cod. Fishing was the state's first industry, and it retains important links to tourism and the appeal of the the state's coastal life.

Most firms in the seafood industry are small and specialize in a single or small set of products or services. Fishing boats are usually owned by individual families, who fish for a particular species or group of species. Fish processing is also highly specialized. Firms process either fresh or frozen seafood products, but not both. Most participants in the industry, however, will cross lines to make a profitable deal. Fishermen will change gear or species, and fish processors will take a chance with a new product.

The collapse of many stocks and government efforts to restrict fishing to preserve those stocks have reduced fish landings by more than one-third since 1982 in both pounds and real value.

Products sometimes flow through many firms before reaching consumers. Cod, haddock, and flounder are caught by Massachusetts fishermen and sold to processors in one of the ports. Processors cut the fish into fillets and sell them to wholesalers, restaurants, and other retailers. Other products take shortcuts. Fishermen or brokers who buy directly from fishermen may sell lobsters and other shellfish directly to consumers. Imported products are sold in supermarkets, sometimes without further processing.

While firms in the industry are keenly competitive and decentralized, they depend on one another to supply their consumers. As in most supply chains, one firm's expenses are another firm's revenues. Dollars flow from retailers to wholesalers, to processors, to vessel owners, to suppliers that service vessels, with wages and salaries generated at each stage. But seafood firms, especially in the fresh fish business, are more interdependent than in most industries. The short time firms have to sell fresh product forces them to work together to quickly find product when they need it and dispose of it when they don't.

A declining industry affects all players.

Over the past 15 years, commercial fishing and fish processing have declined significantly in the commonwealth. The collapse of many stocks, and government efforts to restrict fishing to preserve those stocks have reduced fish landings by more

COMMERCIAL FISHING

Several types of fishing boats currently operate off Massachusetts shores. Draggers pull a net, called an otter trawl, across the ocean floor. Large draggers, from 70 to 100 feet long, fish in federal waters from three to 200 miles offshore, generally on Georges Bank. Smaller draggers fish in state waters, within three miles of shore, and occasionally in federal waters. Scallopers, large vessels from 80 to 120 feet long, pull 14- to 15-foot rakes, called dredges, across the ocean floor. They generally fish far offshore but within the 200-mile limit. Lobster boats, usually smaller vessels, set and retrieve traps on the ocean floor marked by buoys on the surface. Hook boats, similar in design to lobster boats, set lines of hooks rather than lobster traps. A small number of vessels set purse seines and gill nets.

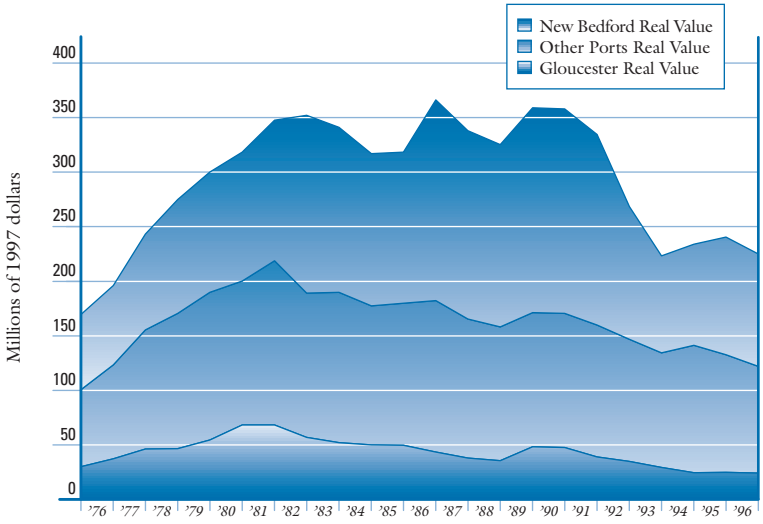
than one-third since 1982 in both pounds and real value. This decline in catch forced processors, wholesalers, retailers, and ultimately consumers to buy more imported fish or products from other parts of the United States. Suppliers that service the fishing fleets have also followed fishing in this downward spiral. Fresh fish processors, who used to depend on local or New England landings, have either left the industry or import seafood products. Frozen fish processors have suffered more losses than fresh fish processors because of falling demand for their products.

There is widespread agreement that current catch is below the long-term potential of the industry, given better management of fish stocks.

The peaks this industry reached in the early 1980s were probably not sustainable, because they depended on a rate of catch that depleted stocks. There is widespread agreement that current catch is below the long-term potential of the industry, given better management of fish stocks.

Nearly 40,000 people were employed in the Massachusetts seafood industry in 1997, and they earned almost $700 million. Retail and food service provided about three-fourths of this employment and about one-half of earnings. Fishing, supplies and services, processing, and wholesaling provided about 10,000 jobs in Massachusetts, which paid roughly $300 million in wages and salaries. Jobs in the retail seafood sector paid less than jobs in other links of the supply chain.

Value of Landings by Port, 1976 – 1997



Employment in commercial seafood industries increased about one percent per year between 1989 (the benchmark from the author's previous study, Hogan, et al, 1991) and 1997. This increase was slightly more than the growth of employment in the overall Massachusetts economy. Earnings increased by four percent per year, which was also slightly more than the growth of wages and salaries in the Massachusetts economy.

New Bedford (which includes Fairhaven), the commonwealth's leading port, has benefited the most from the 200-mile limit. New Bedford lies closest to the rich scallop and yellowtail flounder fishing grounds on Georges Bank and to the south. Considerable public funds were invested in the port before the 200-mile limit was established. A seawall was built to protect the harbor; fish piers were remodeled; and new processing plants, each with its own dock space, were built within a few minutes' steam from fish piers. From

The New England Fishery Management Council responded with severe restrictions in days at sea (DAS) for vessels fishing for groundfish and scallops. For the typical large dragger, DAS declined from unlimited in 1993, to 190 days in 1994, to 88 days in 1997.

1983 to 1991, New Bedford was the leading port in the United States in value of the catch, mostly due to scallop landings. The value of the catch has since declined in New Bedford, but it remains about 50 percent higher than it was in 1977, the first year of the 200-mile limit.

Gloucester (which includes Rockport) has suffered the most from the recent decline in the commercial catch. The value of Gloucester's catch has declined about 50 percent from its peak in 1986. A decline in Boston landings began with World War II and has not been reversed by the 200-mile limit. Haddock landings, once the port's major product, dropped from more than 100 million pounds per year as recently as the 1950s to less than 1 million pounds per year during the 1990s. Boston no longer ranks among the top 60 ports in the United States and can be considered only a minor port, even within the region.

Other Massachusetts ports have shown the least decline in landings. Smaller boats from these ports bring in fresh product daily because they are closer to fishing grounds. The 1990s saw a resurgence of hook fishing for cod, especially from Cape Cod ports, due to low capital entry costs, improved port facilities, and high prices at the dock for hooked cod, which is generally fresher than netted fish.

The lobster fishery has not followed the same pattern of decline as other commercial fisheries in the commonwealth, probably because lobster traps are more selective than other fishing gear in releasing juveniles alive.

Declines in landings call for regulations.

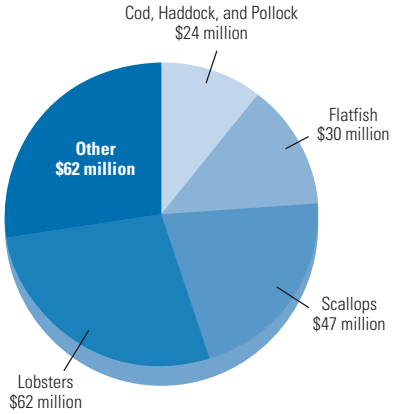
These overall declines in landings and values were caused by the sharp decline in fish stocks, as well as management efforts by the federal government to reduce fishing. In 1991, the Conservation Law Foundation sued the federal government over its failure to maintain fish stocks. The New England Fishery Management Council responded with severe restrictions in days at sea (DAS) for vessels fishing for groundfish and scallops. For the typical large dragger, DAS declined from unlimited in 1993, to 190 days in 1994, to 88 days in 1997.

The U.S. Department of Commerce initiated a program to buy and destroy fishing vessels in 1997. The program spent about $25 million between 1997 and 1999, buying and scrapping 55 large Massachusetts draggers, which had caught 20 percent of the groundfish catch in 1996. The resulting reduction in total catch for subsequent years was probably less, because some of this capital and the fishermen associated with these boats moved to other vessels. In 1998, a similar program was proposed for scallop vessels, but has not been enacted.

Fishing fewer days for depleted stocks led vessel owners, especially those in New Bedford, to switch to other, less utilized species, such as monkfish (anglerfish), skate, and dogfish. Markets have existed in the Orient and Europe for products from these species, but fishermen had not taken advantage of them. Even though the catch of these species rose sharply, prices on the dock increased as other products became increasingly difficult to supply to demanding customers. These products brought significant revenues to New England fishermen. Between 1992 and 1997, the total landed value for monkfish, skate, and dogfish averaged around $15 million per year.

Value of Landings by Species, 1997

Total value = $225 million



Currently, a wide assortment of species makes up the commonwealth's commercial catch, which was worth $225 million in 1997. Lobster was the leading species landed in 1997, with a total value of $62 million, followed by scallops, flatfish, groundfish, and other species. The lobster fishery has not followed the same pattern of decline as other commercial fisheries in the commonwealth, probably because lobster traps are more selective than other fishing gear, releasing juveniles alive.

Since 1984, about 15 million pounds have been landed every year in Massachusetts. Due to rising lobster prices, the lobster catch has increased sig-

nificantly both in current value and after accounting for inflation. The number of traps and areas fished have increased sharply, which may lead to higher catches from declining stocks and cause reduced landings in the future.

The authors estimate that 3,100 commercial fishermen fished full time in federal waters in 1997. Four thousand to five thousand other people fish commercially part time in Massachusetts state waters.

Estimated numbers of commercial fishermen vary.

Estimating the number of commercial fishermen in the state is difficult. Thousands of people sell their catches, ranging from those who make an occasional fishing trip in a small boat to those who make their living working year-round on larger boats. The authors estimated the number of full-time or nearly full-time fishermen, because including part-time fishermen would give an inaccurate measure of significance to this industry.

Massachusetts DET reported 1,379 commercial fishermen in Massachusetts in 1997. This figure is low, because self-employed people and independent contractors are not included in DET data. Owners usually skipper their own small commercial fishing boats. Family members and others, who are often considered independent contractors, make up the rest of the crew. Neither skipper nor crewmembers of small boats are usually considered employees in DET data. Furthermore, in mid-1980, scallop crews and vessel owners agreed to designate crewmembers (probably more than 1,000 fishermen) on scallop vessels as self-employed.

The authors estimate that 3,100 commercial fishermen fished full time in federal waters in 1997. This estimate was arrived at by using the number of commercial fishing vessels that reported Massachusetts as their home state and that landed their catches in the commonwealth, and by using the average crew size per vessel type recorded by the National Marine Fisheries Service (NMFS). The Massachusetts Division of Marine Fisheries regulates commercial fishing in state waters (three miles offshore).

In 1997, approximately 5,000 fishermen had permits to fish commercially with rod and reel in state waters; 2,000 had permits to use lobster pots in state waters; and another 2,000 had permits to gather shellfish. About half of state lobster-permit holders and a few rod and reel permit holders had federal permits to fish offshore. Some fishermen also had multiple state permits.

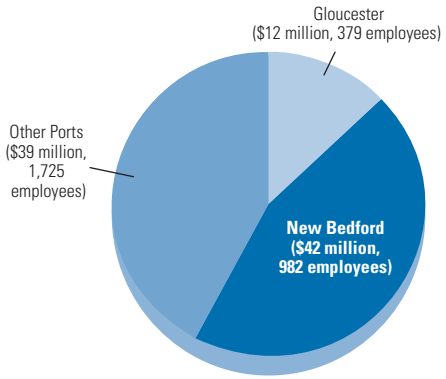
The Massachusetts Division of Marine Fisheries estimates that about two-thirds of the permits were used for commercial fishing. Assuming that 20 percent of these active permits were used full time, we estimate that 1,000 commercial fishermen fished in state waters as their main occupation in 1997. Four thousand to five thousand other people fish commercially part time in Massachusetts state waters.

New Bedford was the leading port in fishing employment in 1997. There are dozens of other ports on Cape Cod and in other coastal areas that harbor anywhere from a few to several dozen small commercial fishing boats, employing fishermen and small cottage industries of net menders, baiters, engine repair mechanics, ship's carpenters, and other services.

The share or lay system, where owner, captain, and crew are paid shares of the catch, has been used for hundreds of years in commercial fishing. There are two types of lay systems: clear lay, where the gross stock (total value of the catch) is split among the owner, captain, and crew before expenses are paid; and broken lay, where expenses are paid from the gross stock (leaving the net stock) before shares are paid. Larger vessels usually operate under a clear lay system and smaller vessels under a broken lay system, but there are exceptions. In New Bedford scallop vessels use a clear lay and draggers use a broken lay system. Few vessels switch between clear and broken lays. The percentage split between boat owner and crew differs by port and type of fishery.

Employment and Earnings of Commercial Fishermen, 1997

Total employment = 3,086 Total earnings = $93 million



New Bedford led Massachusett ports with $42 million paid to skippers and crew. Scalloping is New Bedford's main fishing activity, and this fishery yields the most revenue per vessel.

Recently NMFS has surveyed vessel owners to estimate costs of fishing for draggers, scallopers, and hook vessels. The authors used these cost and revenue figures for scallopers and large draggers in New Bedford, for large draggers in Gloucester, and for hook vessels and small draggers in the other ports to estimate fishermen's earnings after expenses.

New Bedford led Massachusetts ports with $42 million paid to skippers and crew. Scalloping is New Bedford's main fishing activity. Scalloping uses more fuel and requires more repairs to vessels and gear than other types of fishing. It also yields the most revenue per vessel. Crewmembers (including the skipper) pay many of the costs of scalloping, and net about one-third of the value of the catch.

Gloucester fishermen received a total of $12 million, and fishermen in Boston and the other ports received a total of $39 million. On average, crews in these ports earned a larger share of the catch after expenses were paid, but the value of the catch was lower than in New Bedford. Total earnings for fishermen in Massachusetts in 1997 were $93 million. Average income per fisherman was $43,000 in New Bedford, $31,000 in Gloucester, and $23,000 in Boston and the other ports.

Average income in fishing may be misleading because fishermen's incomes vary directly with the quantity and prices paid for the catch. The value of the catch varies widely depending on luck, efficiency of the vessel, the experience of the skipper, and prices that fluctuate daily. Skippers receive from 50 percent to 100 percent more than crewmembers, depending on the fishery. Lobstering yields the largest total revenue in the commonwealth but probably pays little per fisherman or per vessel. There are so many vessels and fishermen that the catch per trap or per vessel is quite low.

COMMERCIAL FISHING SUPPLIES AND SERVICES

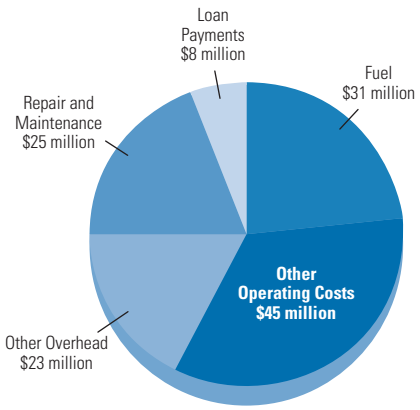
Commercial fishing vessels pay out most of their revenues to fishermen and shore-side suppliers. Under complex arrangements, which vary by port, vessel owners or their crews buy fuel, ice, bait, and food for the trip; repair gear and maintain the engine and equipment; pay insurance premiums; and pay the mortgage and other loans on the vessel and gear. In a typical clear lay, the crewmembers pay for fuel, ice, food, and water from their share, and the vessel owner pays maintenance, insurance, and mortgage from the boat share. While these payments are expenses to vessel owners and crew, they generate revenue and employment for dockside firms that sell these goods and services.

The commercial fishing fleet spent $31 million in 1997 for fuel, which was the largest expenditure other than payments to captains and crews. Other operating expenditures of $45 million included food, water, ice, bait, lubricants, unloading costs, minor gear repair, and other gear costs, such as lines, hooks, twine, and chain links. Repairs generated $25 million of expenditures in 1997, loan payments totaled $8 million, and other overhead, including financial services and business services, generated $23 million. Other overhead included insurance, which was about one-half of total overhead, office expenses, settlement costs, professional fees, and other typical overhead costs of small business. Total expenditures other than labor costs for commercial fishing were $132 million in 1997.

The authors used output/labor ratios for fuel, retail sales, services, repairs, overhead, insurance, and financial services from various 1992 census reports to convert expenditures to employment and earnings. Dockside commercial fishing services employed 494 people in New Bedford, 89

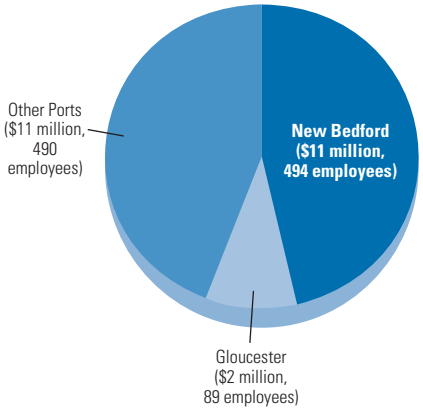
Payments for Commercial Fishing Services, 1997

Total payments = $132 million



Employment and Earnings in Commercial Fishing Services, 1997

Total employment = 1,073 Total earnings = $25 million



people in Gloucester, and 490 people in the combined other ports in 1997. These jobs paid a total of $25 million in wages and salaries.

MARINE AQUACULTURE

Marine aquaculture, or mariculture, includes the growing of marine finfish and shellfish in controlled environments, in open seas, bays, estuaries, or tanks. In Massachusetts, almost all commercial marine aquaculture takes place in the southeastern part of the state, and almost all products are shellfish, mainly quahogs and oysters, as well as bay scallops, soft-shell clams, blue mussels, and sea scallops. There have been a few attempts to farm summer flounder (fluke), hybrid striped bass, and tilapia, but these have been experimental, with very few commercial sales.

Acres under cultivation and the number of leases have increased in Massachusetts. According to the Division of Marine Fisheries, the number of acres increased from 645 in 1994 to 1,009 in 1997, with 232 separate leases in 1997.

Revenue, employment, and earnings are more difficult to estimate. Using survey data, the most recent Aquaculture Industry Situation and Outlook Report estimates that sale of marine aquaculture products in Massachusetts in 1995 was about $7 million. Quahogs generated about $4.5 million of that total. The Massachusetts Division of Marine Fisheries generates a lower estimate of $1.5 million in 1997. The Aquaculture White Paper & Strategic Plan for Massachusetts estimates revenue at maximum production of $30,000 per acre, or $30 million. This indicates that either estimate is far below maximum production for the amount of acres currently in production.

The recent success of aquaculture in other parts of the United States has not taken place in Massachusetts because there are more valuable uses of the commonwealth's seacoast. Currently aquaculture supplies less than three percent of the catch in Massachusetts.

There have been no completed surveys of employment and earnings in marine aquaculture. The Strategic Plan uses a rough rule of thumb of one person working full time for each license or 232 full-time jobs in 1997. Industry sources indicate that few people are employed in aquaculture full time. Using one-half the average per-person earnings in fish harvesting as a measure of earnings ($15,000 per year) in aquaculture yields total earnings of about $4 million in 1997.

World aquaculture has grown at a rapid rate. Between 1987 and 1996 (the last year for which data are available) world aquaculture production more than tripled and in 1996 supplied more than 20 percent of the world's fishery products. Between 1987 and 1996, U.S. production increased by 40 percent, but currently aquaculture production supplies only about 5 percent of total domestic supply.

The recent success of aquaculture in the commercial production of catfish, oysters, and salmon in other parts of the United States has not taken place in Massachusetts because there are more valuable uses of the commonwealth's seacoast. Currently aquaculture supplies less than three percent of the catch in Massachusetts. Aquaculture supplies seed for quahogs and bay scallops in many coastal towns, but in general aquacultured seed and fish fry have had little effect in increasing native stocks of other species.

While it is tempting to compare aquaculture to farming, three important differences from farming restrict aquaculture's potential. The first is the control that farmers have over their environment. Farmers increase the productivity of crops and livestock by controlling moisture, nutrients, and disease. As more crops are raised in greenhouses, farmers can even control temperature and sunlight. That level of control is almost impossible in the ocean and in estuaries. Controlling the environment in tanks is easier, but the expenses associ-

ated with raising fish and shellfish in this manner are often prohibitive. Significant environmental problems can also arise when aquaculturists try to control the environment. Aquaculture produces fish waste and introduces diseases, and aquaculture restricts the gene pool when farmed animals escape or are released into natural habitats.

Second, farmers supply products to large-scale commodity markets for which there is widespread demand, or they supply high-quality produce to niche markets, where demand is growing. To pay high development and production costs, aquaculturists would have to develop markets for high value-added products. This is risky because these markets are susceptible to sudden increases in supply that quickly depress prices. Payment for aquaculture products is also risky. Buyers are often financially unreliable or haggle over prices after they receive delivery, when it is too late to reclaim live or fresh fishery products.

Marine aquaculture may be financially successful in the future, at least where demand for competing uses are low, and if land tenancy and other problems can be resolved.

Third, aquaculturists face problems of land and sea tenancy. Farmers own or rent their land; aquaculturists do not. Rights in land tenancy, although increasingly subject to dispute, are crystal clear compared to licenses or other tenancy instruments that aquaculturists typically hold. While aquaculturists own their products, they do not own the estuaries, tidal flats, or other environments used to grow their products. The marine aquaculture industry of the commonwealth is based on leases granted by towns, which allocate small plots of coastal shore or the sea bottom to shellfish aquaculturists. There are several lawsuits currently in the Massachusetts judicial system that have been filed by upland residents who object to aquaculture operations in their backyards.

Murky ownership rights that are subject to local politics restrict investment because banks and other venture capital sources are less willing to write loans in this environment. This shortage of capital causes aquaculture to lose land-use conflicts with competing shore-side uses like residential housing, recreation, and tourism. Product demand will probably never be high enough to pay the high cost of seashore rights. In addition, local control of aquaculture licenses restricts large-scale planning and coordination and other economies of scale necessary for economic growth.

Marine aquaculture may be financially successful in the future, at least where demand for competing uses are low, and if land tenancy and other problems can be resolved. Prices for native species and their products will likely remain high because most commercial fish stocks will not recover soon. High-valued products such as oysters, bay scallops, flounders, and sea bass are more likely to be successful in Massachusetts, where coastal land and sea costs are high.

An example of successful public-private cooperation is the Martha's Vineyard Shellfish Group, a consortium of shellfish offices in the towns. Raising shellfish from seed to plant in public waters was their original goal. A few years ago, it secured public funds to help fishermen receive shellfish licenses from the various towns in order to switch from fishing to aquaculture. Most of these small operations have raised sufficient crops of shellfish, mostly oysters, to sell to local fish markets and restaurants. The Group participates in an event every summer, called "Taste of the Vineyard," where they serve aquaculture products and explain aquaculture to shore-side property owners.

FRESH FISH PROCESSING

Fresh fish processing and frozen fish processing are two separate industries in Massachusetts, each with its own customers, firms, and industrial organizations. While both face declining revenues, each has been subject to different market pressures.

Fresh fish processors buy whole fresh supplies from fishermen locally and at other New England ports, and import fresh supplies from other parts of the U.S. and other countries. They process the product (for example, cutting fish into fillets) and sell these products to wholesalers, retailers, restaurants, and other final users. When landings were plentiful in the past, most processing firms specialized in specific products, but a few firms, mostly in Boston and New Bedford, processed a wider assortment of fishery products to serve as a kind of one-stop shopping point for their customers.

Supply of fresh fishery products is highly volatile because most fish and shellfish are essentially captured in the wild. Farmed fishery products, a much less important source of supply, are also subject to far more variability than domestic live-

stock, fruit, or vegetables. Prices that processors pay at the dock and the prices they receive for their products, therefore, vary daily and sometimes hourly. Haggling defines the fresh fish business.

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The fish business is also risky. Fresh fishery products are marketed under extreme time pressure and with incomplete information. The products must be sold within a week to 10 days to final users, who are very concerned about product quality. Yet wholesalers and others who buy from processors do not generally know product quality because most sales are made over the telephone and the product arrives after the sale has been agreed on. Buyers take serious risks with their suppliers, expecting high-quality product delivered on time. Processors and wholesalers selling in this market also take risks with their customers because they can't reclaim the product for bad debts. To avoid risk, customer loyalty develops between processors, their suppliers, and their buyers. Product quality and financial responsibility are the ties that bind fresh fish processors to their good customers and vice versa.

The expansion of the fishing industry that followed the 200-mile limit carried over into the fresh fish processing industry. Established firms in Boston, New Bedford, and Gloucester hired fish cutters, trimmers, packers, and other specialized tradespeople, and they paid good wages to prepare fresh fillets for the market. New firms sprang up in these ports. In the smaller ports, especially on Cape Cod, new firms and fishing cooperatives tried their hand at cutting and marketing fresh fillets. Fresh fish was available on the docks, and fresh product was easy to sell at high prices to health-conscious consumers. Fishermen increased their catch of other products such as sea scallops, which are almost always shucked at sea; other high-valued species, such as lobster; and lesser-valued products like herring and squid. Shore-side processors bought and processed or simply repackaged whatever fishermen landed and quickly sold the products on the wholesale market for high prices. Business was good.

Fresh product values fell by more than 50 percent from its peak in 1986. Almost all the decline in fresh product value was in fresh fillets caused by the collapse of groundfish landings in New England.

When fishing began its downward spiral in the early 1980s, the fresh fish-processing sector followed. Rising prices pushed revenues higher, but not for long, because higher prices generated consumer demand for substitute products. Prices for fishery products were limited by the prices of these substitutes.

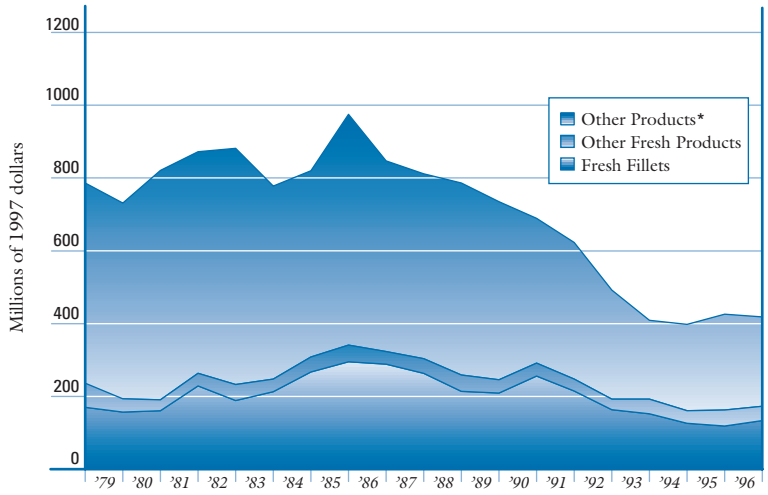
The value of fresh processed products in Massachusetts reached its peak in 1986 at $261 million, but fell to $150 million by 1995, before recovering somewhat to $173 million in 1997. When adjusting the value of fresh and frozen seafood processing for inflation by converting to 1997 dollars, there is a more dramatic decline. Fresh product values fell by more than 50 percent from its peak in 1986. Almost all the decline in fresh product value was in fresh fillets caused by the collapse of groundfish landings in New England. About 40 firms have left the processing sector since 1992, more than one-third of the firms in business then.

Surviving firms adopted a wide assortment of strategies to stay in business. They intensified buying within New England to maintain their share of dwindling landings. They went farther afield from their home ports to establish new buying relationships. Processors attended display auctions in New Bedford and Gloucester. These auctions are modeled on the Portland Fish Exchange, which had success in modernizing Maine's fishing industry. As supply continued to shrink, the surviving processors scoured the smaller ports for product, buying wherever they could, often in very small lots.

Surviving processors also imported more whole and processed fish. However, Canada, the traditional supplier of groundfish to the United States, has also suffered a sharp decline in landings. In 1991, Canada closed the Grand Banks to fishing for cod. This area was once the richest cod grounds in the world. Imports of groundfish from Canada have largely been replaced by imports from Iceland and elsewhere. Fresh fish processors also brought in more fresh and frozen Pacific cod to process as fresh fillets.

Processors switched to different species and products because they couldn't find enough traditional products to satisfy their customers. They successfully persuaded their customers to buy substitutes, even though New England consumers were reputed to have an indissoluble attachment to traditional species. Processors and wholesalers

Wholesale Value of Processed Seafood Products, 1979 – 1997



*"Other products" refers to frozen and other products that are not fresh (e.g., dried, canned, etc.)

Source: National Marine Fisheries Service

imported farmed salmon, shark, tilapia, mahi-mahi, and orange roughy, and they brought products from other parts of the country, such as catfish from the South, to supply restaurants and retail fish counters in New England and elsewhere.

Some fresh fish processors exploited niche markets, like the sale of high-quality product directly to customers for catered business cocktail parties, promotions, trade shows, and even private parties. Some processors stopped cutting fillets in order to save expenses and concentrated instead on using their business contacts and inside information to wholesale products without processing them.

All surviving processors paid more attention to the bottom line. Shortage of supply of raw material intensified competition in buying whole groundfish among fresh groundfish processors. Other costs also increased. Substantial new investment in both equipment and training was necessary to conform to new health regulations. Prices at the retail level, however, didn't rise as much; competition from substitutes such as chicken severely limited price increases for fishery products. Supermarkets improved their handling and marketing of fresh fish products, attracting customers rebelling against higher prices in specialized fish markets. Processors sold less product to fish markets, where they had developed personal relations, sometimes over several generations, and more product to supermarkets, which operated on narrow margins of their own and traditionally drove hard bargains with their suppliers. Dozens of small fish markets went out of business.

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Most of these survival strategies favored Boston firms. Access to Logan Airport and to the New England regional food wholesaling system in Boston gave them an advantage over processing firms in other ports. Access to raw material gave other ports an advantage during the boom in landings, but this has disappeared with the decline in landings. New Bedford processors, who used to truck whole fish into the city from other ports, now process only the fish that is landed locally. Processors in Gloucester and other Massachusetts ports now process fillets for local customers and ship the rest whole to Boston for processing.

FROZEN FISH PROCESSING

Few fresh groundfish processors produce frozen product, and those that do sell special orders to institutions, usually government agencies, who are sometimes required to purchase U.S. product. Frozen groundfish processors buy frozen inputs, which are imported into the United States from Canada, Iceland, Norway, and other countries. These frozen inputs, mostly frozen blocks of fillets, are processed into frozen portions, sticks, and nuggets for sale to supermarkets, restaurants, and institutions. Frozen products keep for a long time and are not subject to the same time constraints as fresh products. Prices are less volatile, markets more impersonal, and business relations more competitive. Frozen groundfish plants are also much larger than fresh groundfish plants, and they operate longer through the day and through the year.

Frozen fish processors, located mostly in Gloucester and New Bedford, faced a different set of problems than the declining supply that limited fresh fish processors. Consumer demand for fish sticks and portions, the major products of this sector, has been declining since mid-1980, driving down prices and production. The combination of falling production and prices caused a sharp drop in revenues. Actual revenues for frozen fishery

Upscale frozen and freeze-dried products for easy preparation in microwave ovens are high value-added products that are popular in Northern Europe, but have never caught on in the U.S.

products processed in Massachusetts dropped more than 50 percent from their peak in 1986. After accounting for inflation, frozen processed product sales dropped by more than 60 percent. Fish canneries left Massachusetts long ago.

Upscale frozen and freeze-dried products for easy preparation in microwave ovens are high value-added products that are popular in Northern Europe, but have never caught on in the U.S. Increasing value-added through better product remains the main hope for an industry where the source of supply is declining. However, raising prices for higher quality has rarely worked in any sector of the U.S. fishing industry.

EMPLOYMENT AND EARNINGS IN PROCESSING AND WHOLESALING

Wholesalers do not specialize in either fresh or frozen product. They sell a wide assortment of fishery products, and sometimes sell meat products, vegetables, or fruit. While the fresh groundfish business has been severely curtailed due to reduced availability of groundfish, the fish wholesale business has suffered fewer losses. Per capita consumption of commercial seafood has remained around 15 pounds per year for the last 10 years. The decline in availability of local product has been filled by imports, which have increased 15-fold over the last 10 years and created new opportunities for wholesalers.

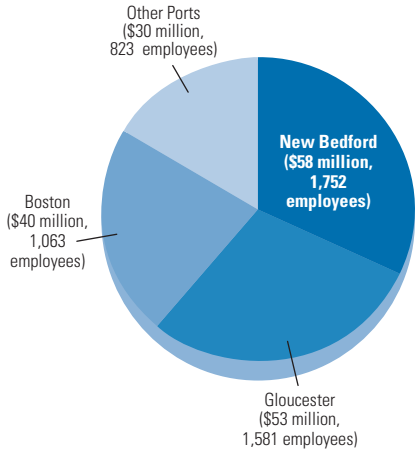
While the fresh groundfish business has been severely curtailed due to reduced availability of groundfish, the fish wholesale business has suffered fewer losses.

It is difficult to estimate employment in this sector of the industry. Some fish processing and wholesaling workers are self-employed and not included in DET data. Fish processing and wholesaling firms often use employment services to supply labor, but do not report the employment to DET. Employment service companies probably report this employment, but the figures for fish processing are a very small percentage of employment reported by service companies and are impossible to extract from DET data. The authors used employment estimates gathered by NMFS for processing plants because plant managers report at least some of this contract labor to NMFS.

According to NMFS, the number of fish processing plants in Massachusetts dropped from 112 in

Employment and Earnings in Seafood Processing and Wholesaling, 1997

Total employment = 5,219 Total earnings = $181 million



1988 to 73 in 1997. Employment dropped from 3,600 employees to 2,600 employees over the same period. Unfortunately, NMFS no longer collects data on the number and employment of wholesale firms. DET data show that the number of fish wholesaling firms in Massachusetts increased from 250 to 300 firms between 1988 and 1997. Wholesaling employment, however, dropped from 3,100 to 2,600 over the same period.

When considering processing and wholesaling employment and earnings by port, New Bedford (1,752 employees) and Gloucester (1,581 employees) have both fresh and frozen fish processing plants, while Boston (1,063 employees) specializes in fresh fish production and wholesale marketing. In Massachusetts, 5,219 employees earned $181 million processing and wholesaling seafood products in 1997.

RETAIL AND FOOD SERVICE SALES

Consumers buy fish at supermarkets and other retail outlets for home consumption, and they order seafood in restaurants and from other food services. Retail outlets in the United States, such as supermarkets, bought about the same amount of seafood at the wholesale level as restaurants and food services did in 1997. Because restaurants and food services add value by preparing

In 1997, consumers in the United States bought $15 billion of seafood at retail outlets and ordered $31 billion of seafood at restaurants and other food services.

meals, their value of sales to consumers was roughly twice as high as the value of sales to consumers at supermarkets and other stores. In 1997, according to an NMFS financial model, consumers in the United States bought $15 billion of seafood at retail outlets and ordered $31 billion of seafood at restaurants and other food services, for total consumption of $46 billion. This figure was up from $27 billion in 1991. There was a slight increase in the retail sales share of the seafood market over this period.

Consumers are more likely to purchase seafood at supermarkets than at fish markets and to order seafood at ordinary restaurants instead of seafood restaurants. Because supermarkets and restaurants are not required to report sales by product, retail figures for revenues, employment, and earnings from seafood are estimated as small percentages of revenues, employment, and earnings reported by supermarkets and restaurants.

During the 1980s most supermarkets established seafood departments. National industry sources complained about high costs and low revenues from fresh fish sales, but fish departments, complete with lobster tanks, became the industry standard because they attracted customers to the deli section. According to surveys by *Supermarket Business,* this trend has continued. Seafood department sales in U.S. supermarkets rose 15 percent between 1993 and 1996. Average consumer purchases rose from $5.70 to $6.30 over the same period. In 1996, according to the supermarket survey, finfish accounted for 40 percent of revenue, shrimp for 31 percent, prepared entrees for 23 percent, and 6 percent for the rest.

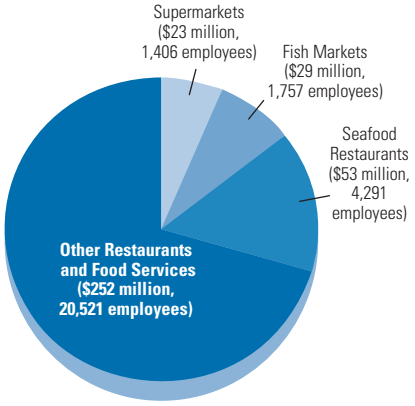
To estimate retail fish employment and earnings, we separated the sector into fish markets, fish departments in supermarkets, seafood restaurants, and seafood sales at other restaurants. We extracted much of these data from larger categories of employment in retail and food services, which required some assumptions about shares of employment attributed to seafood sales.

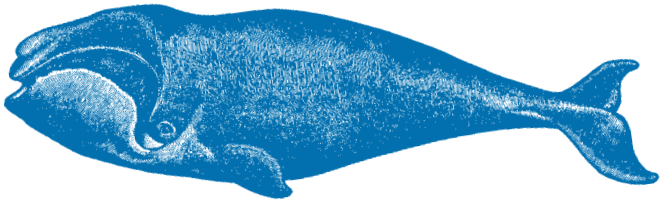
According to iMarket data (DET data do not separate employment for fish markets), 1,757 people worked full time in fish and seafood markets in 1997. A manager of a large supermarket chain in Massachusetts estimates that four employees per store generally work in seafood departments. Supermarkets range from 75 to 200 employees, with an average of 108 in 1997. Therefore, roughly 4 percent of supermarket employees worked in seafood departments. Employment in Massachusetts supermarkets was 35,000, which would translate to 1,406 people working in seafood departments. Therefore, approximately 3,163 people worked full time in seafood retailing in 1997 at an average annual salary of $16,362 per year, which resulted in $52 million in total earnings.

Data from iMarket (DET data do not separate employment for seafood restaurants) indicate that 4,291 people worked in fish and chips and seafood restaurants in 1997. Other restaurants and food services, ranging from fast-food places such as McDonald's to white-tablecloth restaurants, however, probably serve the bulk of seafood meals. Food services prepare meals for schools, colleges, hospitals, factories, office buildings, nursing homes, and other institutions. Marriott Food Services, which serves food at schools and other institutions, probably serves more fish meals than any other supplier in the commonwealth. Multiplying seafood's share of total restaurant and food service sales by Massachusetts employment in eating and drinking places, and subtracting employment in seafood restaurants, provides an estimate of 20,500 employees.

Employment and Earnings in Seafood Retailing and Food Service, 1997

Total employment = 27,975 Total earnings = $356 million





Marine Transportation, Tourism, and Recreation

Between 1985 and 1990, employment in ship- and boat building and repair fell from more than 6,000 jobs to fewer than 1,000 jobs, with most of the drop immediately after 1985, due to the closing of the Quincy Shipyard.

Marine transportation, tourism, and recreation are important sectors in the Massachusetts marine economy. They comprise 34 percent of the total marine economy of the state, second only to commercial seafood industries. In 1997, 30,471 people worked in these sectors, earning $629 million. Coastal tourism employed the most people and generated the most earnings, followed by recreational fishing, transportation, recreational boating, and shipbuilding.

The growth in employment for this sector has been modest. Marine transportation's share of the Massachusetts economy declined steadily during the late 19th and early 20th centuries but has stabilized more recently. Marine recreation and tourism have also grown at low rates. The author's 1991 study, which used roughly the same methods for estimating employment and earnings in these sectors, reported employment of 28,300 in 1989. This benchmark implies an average growth rate for employment in this sector of around 1 percent per year, which was slightly higher than the state's job growth over the same period. The growth in earnings was much higher. Total earnings in 1989 were $380 million, which implies a growth rate of about 6 percent per year in earnings. This was higher than the 4 percent average growth of wages in the state's economy.

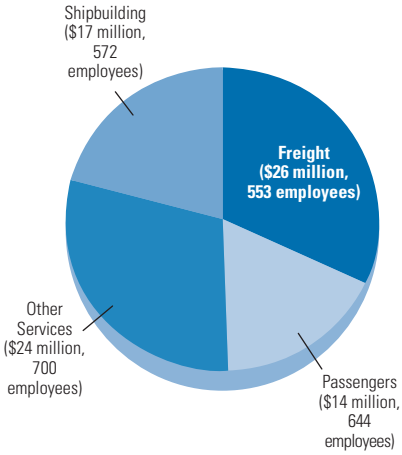
TRANSPORTATION AND SHIPBUILDING

Water transportation and shipbuilding employed almost 2,500 people and paid them $81 million in 1997. Freight, which includes both foreign and domestic water transport, employed nearly 600 people with a total payroll close to $26 million. Water transportation of passengers employed about 650 people, who earned almost $14 million. Other services, which included cargo and handling, towing, and other water transport services, employed 700 people and paid them over $24 million. Finally, ship and boat building and repair employed almost 600 people with a payroll of $17 million.

Between 1990 and 1997, seagoing freight employed an average of 550 people per year, except in 1991, when employment climbed to 875. Earnings remained around $30 million per year throughout the period. Employment in water

Employment and Earnings in Water Transportation and Shipbuilding, 1997

Total employment = 2,469 Total earnings = $81 million



passenger transportation, however, increased from 438 to 644, and total earnings rose from $8 million to $14 million.

Employment for water transport services, including cargo handling, tug and towing services, and other transport services, ranged from 500 to 800 over this period, and total payroll varied from $15 million to $21 million. These figures do not capture all employment in these services because some people are self-employed, and some of the employment is probably included in firms' home states outside of Massachusetts.

Between 1985 and 1990, employment in ship and boat building and repair fell from more than 6,000 jobs to fewer than 1,000 jobs, with most of the drop immediately after 1985, due to the closing of the Quincy Shipyard. From 1990 through 1997, employment varied from about 600 to 800 jobs. In 1997, employment in this sector included 572 people, who earned $17 million. Most employment in this category is in boat building and repairs; shipbuilding and repair employed only 130 people in 1996.

COASTAL TOURISM

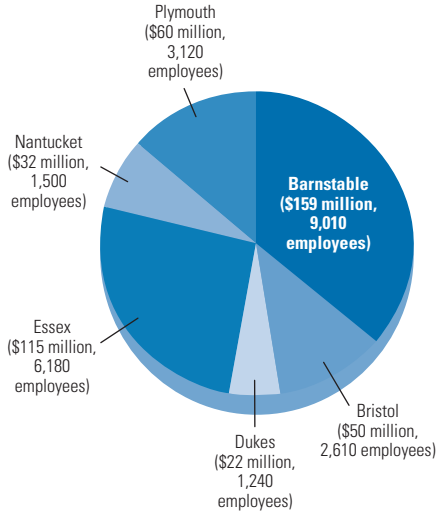
Marine tourism and recreation have always been important social and economic activities in Massachusetts. Groups of Native Americans summered on coastal shores to gather shellfish and to enjoy coastal living long before the Pilgrims arrived. Tourism continues as a major economic activity in the commonwealth.

In a recent study of whale watching, the authors concluded that almost 1 million people paid $21 million in 1996 to firms offering this service, mostly in Plymouth and Provincetown. About three-fourths of this revenue was paid out as wages, salaries, and profits to skippers, crews, owners, and associated service employees. This estimate does not include spending for travel, overnight stays, and other expenses by whale watchers.

According to the Massachusetts Office of Travel and Tourism (MOTT), Massachusetts attracted 26.7 million domestic (over one-half from New England) and 1.9 million foreign travelers (about one-fourth from Canada) in 1997. Domestic tourists paid $9.1 billion in direct expenditures, generating 110,640 jobs that paid a total of nearly $2.4 billion in wages and salaries. Massachusetts ranked twenty-first among states in domestic

Employment and Earnings from Coastal Tourism by County, 1997

Total employment = 23,660 Total earnings = $439 million



tourism. MOTT estimates economic impacts from domestic tourism by county. Data were not available for international tourist visits to coastal areas.

In 1997, one-half of total employment and earnings from coastal tourism was located on Cape Cod, Martha's Vineyard, and Nantucket; tourists visiting Cape Cod and the islands generated 11,750 jobs with a payroll of over $200 million.

Boston is not included as a coastal community, because most tourists do not come to Boston for marine activities. Excluding Boston eliminates a major share of tourism since Boston is the destination of about one-half of tourists visiting the commonwealth. Tourists often visit several locations, and analyzing specific spending among these multiple destinations is a major problem in estimating economic impacts of tourism. MOTT takes a conservative approach to estimating economic impacts, which probably leads to an underestimate of the economic impact on the commonwealth from marine tourism. Eliminating spending from international tourists also leads to a conservative estimate of economic effects from coastal tourism.

Double counting is another major problem in estimating employment and payroll from tourism. Economic impacts from recreational fishing overlap with impacts from tourism. Fortunately, MOTT includes as tourists only people who traveled 100 miles one way or stayed overnight. Most recreational anglers travel less than this distance and would therefore not be included in MOTT's tourist data.

According to a MOTT report "Travel & Tourism in Massachusetts," which was used in the 1991 baseline report, 26.8 million U.S. residents and 1.3 million international travelers visited the state in 1988. The number of domestic travelers did not increase between 1988 and 1997, and foreign visitors increased by 600,000 over the nine-year span. Domestic travelers' expenditures in 1988 were $7.4 billion, which generated 112,727 jobs and a payroll of $1.9 billion.

Between 1988 and 1997 travelers' expenditures increased an average of 2 percent per year, employment from tourism increased about 1 percent per year, and earnings increased about 4 percent per year. These increases in jobs and earnings from tourism were roughly the same as the increases in the overall Massachusetts economy.

The increases in jobs and earnings from tourism in coastal counties in Massachusetts were also about 1 percent per year and 4 percent per year, respectively, from 1988 to 1997, about the same rate of growth as in the Massachusetts economy. Employment and earnings from tourism on Cape Cod, however, decreased over this period by 3 percent per year and 1 percent per year, respectively, reflecting the decline in tourist spending on Cape Cod of about 4 percent per year. The decrease in wages and salaries from tourism on Cape Cod was especially significant because it was 4 percent lower than the increase in earnings in the economy as a whole. Cape Cod has evolved from a seasonal tourist location into a year-round residential area complete with year-round employment in local industries and businesses.

RECREATIONAL FISHING

Recreational fishing is a rapidly growing activity. Anglers travel to fresh- and saltwater fishing sites, pay license fees, buy or rent boats, buy fishing gear and associated equipment, eat in restaurants, and rent lodging or own vacation homes. Individually and through their organizations, they have also become a political force in competing with the commercial fishing industry for their share of fishing stocks. In Florida, where recreational fishing generated $6 trillion in direct and indirect sales in 1996, recreational fishing associations succeeded in banning commercial fishing in some areas.

According to the most recent National Survey of Fishing, Hunting, and Wildlife Associated Recreation by U.S. Fish and Wildlife Service, 429,000 saltwater anglers spent almost 4 million days fishing in Massachusetts in 1996, spending $222 million in direct expenditures related to saltwater recreational fishing. The American Sportfishing Association (ASA) uses multipliers to estimate an overall economic impact of $425 million, which includes both spending by recreational anglers and additional spending induced by these direct expenditures. ASA estimates that total direct and induced spending generated 5,000 jobs, paying

Extracting employment from indirect expenditures used by ASA, the authors estimate that direct expenditures from saltwater recreational fishing generated 2,600 jobs, paying wages and salaries of $62 million in 1996.

$120 million in wages and salaries. Extracting employment from indirect expenditures used by ASA, the authors estimate that direct expenditures from saltwater recreational fishing generated 2,600 jobs, paying wages and salaries of $62 million in 1996. Using the average increase in wages and salaries in manufacturing for Massachusetts, these jobs paid $64 million in wages and salaries in 1997.

RECREATIONAL BOATING

Thousands, perhaps hundreds of thousands, of people sail or use powerboats in Massachusetts coastal waters for recreation other than fishing. The National Marine Manufacturing Association (NMMA) estimates that Massachusetts boaters spent $120 million in 1996 on boats, motors, trailers, and accessories. NMMA, however, makes no distinction between boats used for fishing and those used for other purposes. Extrapolating from their data on total expenditure, boaters in the commonwealth spent about $300 million on all retail and service expenditures for boating.

The NMMA has issued a request for proposals to estimate economic impacts by state from boating, but the results from these analyses are at least a year away. There is currently no other economic impact analyses of recreational boating in Massachusetts.

Marine Technology and Education

The authors estimate that marine technology and education in Massachusetts employed 9,240 people, who earned $420 million, in 1997.

Massachusetts is a world leader in marine technology and education. The commonwealth is home to dozens of marine research and educational institutions that range in size from the Woods Hole Oceanographic Institution, which is the world's largest independent oceanographic laboratory and employs almost 1,000 people, to the Maritime Museum in Cohasset, which employs only a few people. Some are private, nonprofit organizations like the Marine Biological Laboratory in Woods Hole, and some are public institutions like UMass Dartmouth's Center for Marine Science and Technology in New Bedford.

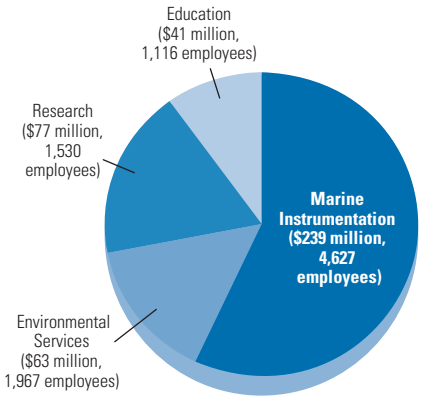
Funding for marine research and education comes from a variety of sources. Research laboratories, both private and university based, compete for millions of dollars in federal and private funding. Private and state colleges and university academic marine programs are funded through tuition and appropriations from the commonwealth. Entrance fees and private donations fund the various marine museums and other educational centers.

Estimating employment and earnings in marine technology and education was extremely difficult. Defining the scope of marine technology was the first challenge. The narrowest definition is the manufacture of marine instruments, and the widest definition would incorporate all users of those instruments, including fishing vessels. The authors followed the definition used by the Woods Hole Oceanographic Institution in several studies dating back to 1969, which defined marine technology as marine instrumentation, environmental services, and research. For this report, marine education was included in this sector because of the overlap between research and education.

Estimating employment and earnings provided the second challenge because data for almost all aspects of marine technology and education are entangled with data from other sectors. Marine instrumentation, research, and marine environmental services do not fit easily into their own SIC categories. Nautical equipment, for example, is always combined with aeronautical equipment; the Commercial Physical and Biological Research category makes no distinction between marine and other research, and none of the environmental service SIC codes isolates marine environmental services. Furthermore, marine instrumentation, research, environmental firms, and educational organizations are usually scattered across a wide assortment of SIC codes.

Employment and Earnings in Marine Technology and Education, 1997

Total employment = 9,240 Total earnings = $420 million



In general, the geographic location of firms producing instrumentation or providing research and environmental services was used to identify those firms connected with marine technology. Employment was estimated for specific firms, universities, or research institutions that included marine technology in World Wide Web sites. Web sites and other directories were searched for universities, institutions, and museums connected to marine research and education. A questionnaire was mailed to these organizations, asking for employment figures.

Given these limitations, the authors estimate that marine technology and education in Massachusetts employed 9,240 people, who earned $420 million, in 1997.

Trends in employment and earnings could not be estimated for this sector. Earlier studies of marine technology either did not estimate employment and earnings or used different definitions of marine technology. (See the conclusion section for further discussion of this issue.)

INSTRUMENTATION

Marine instrumentation includes design, development, manufacture, application, and sales of instruments used to measure geological, seismic, biological, oceanographic, chemical, and meteorological information in and around the ocean, bays, rivers, and lakes. Marine instruments are used to navigate on and under the sea, monitor ocean processes and weather, and map the sea floor to keep shipping channels open for trade and commerce. Marine instruments also survey beneath the ocean floor in search of oil, gas, and minerals, and monitor the coasts for pollutants and naturally occurring events that affect coastal water quality.

Examples of the marine instruments include ocean bottom survey sonar equipment, acoustic positioning systems, underwater imaging systems, current measurement, data acquisition equipment, temperature sensors, weather buoys, navigation equipment, marine environmental sensing instruments, remotely operated underwater vehicles, antisubmarine warfare equipment, welding and machining services, composite materials for flotation, and mooring systems.

Marine technology also includes ocean-marine electronic services that lease and rent oceanographic instruments, execute oceanographic surveys, perform underwater photography and inspection, process marine data, test marine instruments, and analyze marine information regarding positioning, navigation, and other uses. The employment and earnings for users of marine instruments in the various sectors of the marine economy are included in this report. These sectors include commercial fishing, marine transportation and shipbuilding, marine environmental services, marine research, and marine education. Of the 75 marine instrumentation manufacturers listed in their 1988 study of marine instrumentation, researchers at the Woods Hole Oceanographic Institution located 16 in the commonwealth.

Major users of marine instrumentation include oil and gas exploration companies. Benthos, of North Falmouth, produces Remote Operated Vehicles for the exploration and production of oil and gas. Many marine instrumentation products are funded and used by the U.S. Navy for strategic purposes. Industry experts indicate that the share of products sold to the U.S. Navy is shrinking and the share sold to scientific research laboratories and private firms is growing. Industry experts also estimate that more than one-half of the private sector products and services are exported.

Marine instrumentation is a "high-tech" industry. These firms employ a higher percentage of professionals and highly skilled workers (scientists and engineers) than other manufacturing industries, which accounts for the much higher wages of this sector of the marine economy.

Universities, private research institutions, and government-funded research institutions are also major users of marine instrumentation. Oceanographic data are collected with buoys, beacons, and other measurement instruments created by marine instrumentation firms. Webb Products Corp. of East Falmouth produces small buoys that float in the mid-ocean and not at the ocean surface, measuring currents that distribute heat throughout the world. Datasonics, Inc., a division of Benthos, is located in Cataumet and creates beacons that find black boxes of downed planes and geophysical systems that are mainly used to measure topographical data and other information.

Marine instrumentation is a "high-tech" industry. These firms employ a higher percentage of professionals and highly skilled workers (scientists and engineers) than other manufacturing industries, which accounts for the much higher wages of this sector of the marine economy. High-technology industries require higher-than-average investment in research and development (R&D). For technology industries in general, this R&D input is estimated to be between 7 and 10 percent of sales. In some cases the R&D component is as high as 15 percent of sales. Because of the high levels of scientific and engineering skills required for marine electronic innovation, marine instrumentation firms tend to be clustered in areas near scientific institutions and universities specializing in marine research.

The growing popular and legal interest in conserving and regenerating the environment has led to diverse activities in marine environmental services.

Identifying marine instrumentation firms from either the DET or iMarket data is difficult. Four-digit SIC codes, the most refined data reported by DET, do not correspond well with marine technology. In most cases, marine instrumentation firms are either small portions of 4-digit categories or are scattered across many different 4-digit codes. Market data were used because they include firms' addresses, for several 4- or 8-digit SIC codes containing marine instrument producers, and include all firms in coastal cities and towns. Boston was not included since the city probably contains many firms within these SIC codes that are not marine instrument producers.

Most firms that produce marine instrumentation are small. A few firms, including Sippican Ocean Systems Inc. in Marion, which manufactures oceanographic instrumentation for marine research labs and for the Navy, employ several hundred people. Some large firms have small divisions that produce marine instrumentation. For example, EG&G, Inc., is a large international corporation with corporate headquarters in Wellesley and a plant in Salem that produces search and navigation equipment. Distributors of marine instruments and consultants that specialize in the use of marine instrumentation also tend to have relatively few employees.

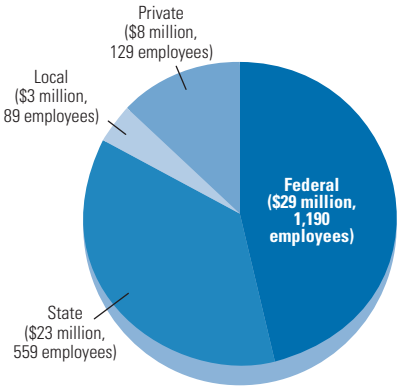
A few organizations represent the marine technology industry. The Marine Technology Society is a professional association with a chapter in New England that is mainly concerned with technical and professional rather than business issues. The Massachusetts Ocean Technology Network (MOTN) is a trade association founded in 1994 with a small grant from the Bay State Skills Corporation. MOTN, which now has about 40 marine instrumentation firms and distributors as members, publishes Marine Technology Reporter, a monthly newsletter, and shares information and marketing costs among its members. In 1999, MOTN received the Export Achievement Award from the Alliance for the Commonwealth and the Massachusetts Port Authority for promoting trade and international marketing.

ENVIRONMENTAL SERVICES

The growing popular and legal interest in conserving and regenerating the environment has led to diverse activities in marine environmental services. These activities include managing wetlands, fisheries, and other coastal resources; preserving coastal resources; and reducing pollutants. Various state and federal laws, such as coastal zone management and fishery regulations, require some of these services. In other cases, laws prescribe these activities after environmental accidents, such as cleaning oil spills. In a few cases, individuals and firms buy these services directly.

Employment and Earning in Marine Environmental Services, 1997

Total employment = 1,967 Total earnings = $63 million



Government agencies, nonprofit corporations, and private companies provide environmental services in Massachusetts. Federal government agencies include the U.S. Army Corps of Engineers, the National Marine Fisheries Service, and the National Park Service. The New England District of the U.S. Army Corps of Engineers oversees flood control, shoreline protection, and navigation improvements and maintenance. The NMFS has several offices and laboratories in Gloucester, including the Northeast Regional headquarters. The National Park Service operates the Cape Cod National Seashore, visited by almost 5 million people in 1998. The U.S. Congress created the New England Fishery Management Council in 1977 to manage fish stocks in federal waters. This organization recently moved to Newburyport.

State government agencies also provide marine environmental services. The Department of Fisheries, Wildlife & Environmental Law Enforcement manages fish stocks within three miles of shore. Massachusetts Coastal Zone Management, the Department of Environmental Management, and the Department of Environmental Protection are interlocking agencies that manage and protect the commonwealth's wetlands and coastal areas. Most coastal cities and towns employ shellfish wardens and others who manage local government marine resources. Finally, private companies supply marine environmental services.

RESEARCH

Massachusetts leads the nation in marine research; much of it located in and around Woods Hole. The Northeast Fisheries Science Center, the direct descendent of Spencer Baird's marine laboratory founded in 1871, is the world's oldest fisheries research facility. The center employs 180 scientists and support staff who investigate fish abundance and other aspects of marine biology and social science. The Marine Biological Laboratory currently employs a staff of 200 full-time scientists and supporting personnel and hundreds of visiting scientists who study various aspects of cell, marine, and coastal biology and ecology.

The Woods Hole Oceanographic Institution (WHOI) is the largest research organization in Woods Hole, employing almost 800 scientists and staff people, most of whom focus on deep water oceanography. The U.S. Geological Survey employs about 100 people who investigate the current and past underwater geography off the east coasts of the U.S. and Central America. The smallest and most recent Woods Hole research institution, the Woods Hole Research Center, employs 30 people to study global warming, deforestation, and other issues concerning the global environment.

Other marine research and policy organizations dot the Massachusetts coastline. Manomet Center for Conservation Sciences is a private, nonprofit coastal zone laboratory near Plymouth that specializes in science-based solutions to environmen-

Marine Research Laboratories in Massachusetts

Organization	Location
Center for Oceanic Research and Education	Essex
Conte Anadromous Fish Research Center	Amherst
Manomet Center for Conservation Sciences	Manomet
Marine Biological Laboratories	Woods Hole
NMFS Northeast Fishery Science Center	Woods Hole
Northeast Regional Aquaculture Center	Dartmouth
UMass Center For Marine Science and Technology	New Bedford
UMass Division of Marine Operations	Boston
UMass Gloucester Marine Station	Gloucester
UMass Nantucket Field Station	Nantucket
UMass Urban Harbors Institute	Boston
U.S. Geological Survey	Woods Hole
Woods Hole Oceanographic Institution	Woods Hole
Woods Hole Research Center	Woods Hole

tal problems. Manomet focuses on sustainable forestry, wetlands conservation, sustainable fisheries, and avian biodiversity and is funded both through grants from government, conservation, and environmental organizations and through business partnerships.

The Marine Biological Laboratory in Woods Hole currently employs a staff of 200 full-time scientists and supporting personnel and hundreds of visiting scientists who study various aspects of cell, marine, and coastal biology and ecology.

The commonwealth's marine technology and research capabilities were made famous by the discovery of the Titanic on the ocean floor in 1985. Robert Ballard, director of the Woods Hole Oceanographic Institution's Deep Submergence Lab, used the manned submersible Alvin and unmanned vehicle Jason to explore the ship. The lab continues its exploration program, using highly sophisticated marine electronic hardware and software.

The University of Massachusetts and private universities operate marine research laboratories and field stations that are usually connected with degree programs. Boston University and Massachusetts Institute of Technology (MIT) have long been associated with the research institutions in Woods Hole. MIT and WHOI share the designation of Sea Grant Institutions for Massachusetts within this federal program. UMass Dartmouth's Center for Marine Science and Technology (CMAST) operates a marine science laboratory in New Bedford, specializing in oceanography, marine biology, and underwater acoustics. The Gloucester Marine Station, which specializes in testing fishery products, is under the direction of UMass Amherst. The Nantucket Field Station, the Urban Harbors Institute, and the Division of Marine Operations are three facilities of UMass Boston, which join together for education, research, and management of the coastal environment. The Conte Anadromous Fish Research Center is located at UMass Amherst and is funded by the U.S. Department of the Interior. Work at the center focuses on the habits of salmon and other ocean species in order to reestablish them in New England rivers and streams. The Northeast Regional Aquaculture Center, which funds research and pilot programs on aquaculture, is located at UMass Dartmouth.

Some museums and other nonprofit organizations engage in marine research. The New Bedford Whaling Museum researches the history and current status of whales and whaling. The New England Aquarium has an extensive research department that investigates many aspects of marine life. These organizations are included in the following section on marine education because education in the form of permanent or temporary displays and educational programs for teachers and students are their major focus. The authors could not separate their research from their educational employment and earnings.

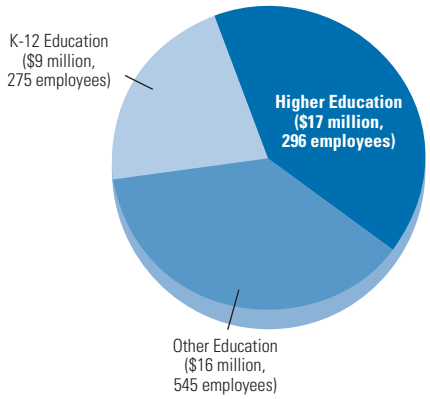
Some of the information on employees and total budgets can be found on public documents or on the Internet. Some was gathered through confidential sources such as telephone conversations or postcard questionnaires. The employment and payroll for these institutions are not listed because some of these data are confidential. Adding figures from public sources and private inquiries, and taking the most conservative estimates, the authors estimate that total employment for marine research facilities was around 1,500 employees and their total payroll was over $75 million in 1997.

EDUCATION

Marine education services and organizations in Massachusetts are many and varied and are often overlooked as a sector of the marine economy. The coastline evokes interest among many people. Increasing numbers of educational services, which

Employment and Earnings in Marine Education, 1997

Total employment = 1,100 Total earnings = $41 million



employ hundreds of staff, seek to satisfy this natural curiosity.

There is considerable overlap between marine education and research. Many marine science laboratories, such as Woods Hole Oceanographic Institution, offer courses and degree programs; academic departments on college campuses combine courses and degree programs with marine research, and museums specializing in marine activities usually have research departments.

Marine education also overlaps with tourism. The New England Aquarium, which provides both marine education and research, is one of the primary tourist attractions in the commonwealth.

As with other sectors in marine technology, standard sources of data on employment and earnings were not very useful. Marine educational organizations and attractions are embedded in larger categories. SIC codes do not distinguish between marine and other types of museums, and they also combine museums with art galleries.

A wealth of college and university degree programs can be found across the state.

Almost all colleges and universities in the commonwealth offer marine biology and other marine science courses, as well as degree programs ranging from bachelor degrees to Ph.D.s in these fields. UMass Dartmouth separates marine biology from other biology courses and programs. One-third of the 50 biology graduates specified the marine option in 1997. The registrar there identified about 45 UMass Dartmouth graduates in the sciences, social sciences, and engineering who specialized in marine studies in 1997. Few colleges and universities, however, separate marine biology and marine science programs from other biology and science programs, so there is not an accurate count of numbers of students or faculty and staff supporting those programs.

For over 100 years, Massachusetts Maritime Academy, located in Buzzards Bay, has trained students for jobs at sea and in marine-related occupations. About 800 students were enrolled full time there in 1997. Mass Maritime offers college degrees in marine engineering, marine transportation, facilities and environmental engineering, and marine safety and environmental protection.

Web sites of Massachusetts four-year colleges and universities list faculty connected with marine science. We excluded faculty and professional staff who were listed in other marine research and education programs, to avoid double counting. Using this method, we estimate that 300 faculty taught in higher education marine degree programs in the commonwealth in 1998. Using the average salary for associate professors (the middle rank among professors) in 1997, we estimate that total earnings for these individuals was $17 million.

K-12 programs provide early preparation.

Many high schools and primary schools teach some aspects of marine studies. Much of the commonwealth's population lives near the sea, and the coastal environment offers teachers the opportunity to connect to children's natural curiosity about their experiences. Marine biology, chemistry, geology, geography, history, and literature are some of the curriculum fields related to marine studies covered by K-12 teachers in the commonwealth.

The Massachusetts Marine Educators was formed by high school and higher education faculty who were interested in sharing ideas and coordinating their work in marine education. The group currently has 300 members. About one-half are high school teachers; the remainder are college faculty and other marine educators. Massachusetts Marine Educators publishes a newsletter, *Flotsam & Jetsam*,

Higher Education Marine Science Degree Programs

College or University	Department, Program, or Center	Location
Boston College	Biology Department	Boston
Boston University	Boston University Marine Program	Boston
Hampshire College	Five College Coastal and Marine Sciences Program	Amherst
Harvard University	Department of Earth and Planetary Science	Boston
Mass Maritime Academy		Buzzards Bay
MIT	Program for Atmospheres, Oceans, and Climate	Boston
Mount Holyoke College	Five College Coastal and Marine Sciences Program	South Hadley
Northeastern University	Marine Science Center	Nahant
Smith College	Five College Coastal and Marine Sciences Program	Northampton
UMass Amherst	Five College Coastal and Marine Sciences Program	Amherst
UMass Boston	Graduate Department of Environmental, Coastal, and Ocean Sciences	Boston
UMass Dartmouth	Center For Marine Science and Technology	New Bedford
UMass Lowell	Center for Environmental Engineering, Science, and Technology	Lowell

For the last five to 10 years, Durfee High School in Fall River has offered a course in marine aquaculture. Students in the course taught by Greg Medeiros and Jack Scammels, both commercial and recreational fishermen, raise saltwater and freshwater fish in tanks. Students study the behavior of the fish, test various feeds and environmental changes, and analyze market conditions for products from these species.

Rick Brown, Coordinator of Aquaculture and Service Occupation Trades at Greater New Bedford Regional Vocational and Technical High School, teaches students to breed and raise tilapia and other aquaculture species and to grow plants in a hydroponic environment using waste water from the fish tanks. These students have constructed dozens of closed aquaculture and hydroponics systems, which they give to primary and middle schools throughout the commonwealth for teachers and students to use in their classrooms. Students in culinary arts, under Chef Paul Amaral, prepare, cook, and serve these fish at school functions. They have also created recipes for tilapia and other aquaculture and nontraditional species.

and runs a High School Marine Science Symposium every spring for high school students and faculty. In 1999, about 600 students attended a total of 28 workshops on marine topics, led by experts in their fields.

Other educational programs offer hands-on classes to the public.

Museums, centers, and aquariums throughout Massachusetts provide education and information on marine and coastal topics, such as marine wildlife, maritime history, whaling and fishing, and coastal ecology. These organizations make information on various aspects of marine life and habitat easily accessible to the general public. The commonwealth's coastline and long connection to the sea draw people to visit and join these organizations.

Massachusetts has a rich assortment of marine educational institutions. The New England Aquarium opened in 1969 on Central Wharf in Boston with a 180,000-gallon glass-enclosed, saltwater tank, one of the largest in the country. The aquarium is home to more than 6,000 marine animals, and over the years it has expanded into education programs, public forums, outreach programs, and marine research. The New England Aquarium has recently joined with a group in New Bedford to establish a large aquarium in that city.

The New Bedford Whaling Museum offers a historic look at commercial whaling and the effects that whaling had on the economic structure of New Bedford and Massachusetts. The museum also offers educational programs on whaling and other marine topics and researches a wide range of marine issues.

The Plimoth Plantation in Plymouth is a world-famous re-creation of the Pilgrim village from the early 1600s. While most of this living museum is dedicated to life in the Pilgrim village, much attention is given to marine education and tourism, including full-size replicas of the Mayflower and coastal shallops that carried trade goods among Colonial ports. The authors estimate that 10 percent of employment at Plimoth Plantation was devoted to marine research and education in 1997.

Many centers along the commonwealth's coast that are not directly connected to high schools and colleges offer marine education to students, teachers, and other interested groups and individuals. The Sea Education Association in Woods Hole uses large sailing ships as classrooms for "semesters at sea" and "summers at sea" for high school and college students. The Lloyd Center for Environmental Studies in Dartmouth offers courses and programs for K-12 students and teachers on marine biology, the coastal environment, and the teaching of science to K-12 students. The Lloyd Center also studies and monitors coastal birds and endangered species. The Center for Coastal Studies in Provincetown offers one-week courses on coastal ecology, geology, and biology to college students, teachers, and others. The center also studies whales and their habitat around Cape Cod.

Several large sailing ships offer education on sailing and marine life. The schooner *Ernestina*, which has served as a Gloucester fishing schooner, Arctic explorer, WWII supply ship, and packet ship between Cape Verde and the United States, was given by Cape Verde to the people of the United States in 1982. The *Ernestina* offers marine educational programs to K-12 students. The fishing schooner *Adventurer* is currently being restored in Gloucester to join the *Ernestina* as an open-air classroom.

About 550 employees provided educational services to 3 million visitors in 1998, indicating that museums, centers, and other public institutions dedicated to marine education are an important sector of the marine economy in Massachusetts.

Marine Education Organizations

Organization	Location
Battleship Cove	Fall River
Cape Ann Historical Museum	Gloucester
Cape Cod Museum of Natural History	Brewster
Center for Coastal Studies	Provincetown
Custom House Maritime Museum	Newburyport
Essex Shipbuilding Museum	Essex
Expedition Whydah Sea Lab	Provincetown
Friendship Salem Maritime Historic Site	Salem
Hull Lifesaving Museum	Hull
Lloyd Center for Environmental Studies	Dartmouth
Marine Museum at Fall River	Fall River
Maritime Museum	Cohasset
National Marine Life Center, Inc.	Bourne
New Bedford Whaling Museum	New Bedford
New Bedford Whaling National Historical Park	New Bedford
New England Aquarium	Boston
Peabody Essex Museum	Salem
Plimoth Plantation	Plymouth
Sandy Bay Historical Society and Museum	Rockport
Schooner *Adventurer*	Gloucester
Schooner *Ernestina*	New Bedford
Sea Education Association	Woods Hole
Seaman's Bethel	New Bedford

Coastal Population and Construction Growth

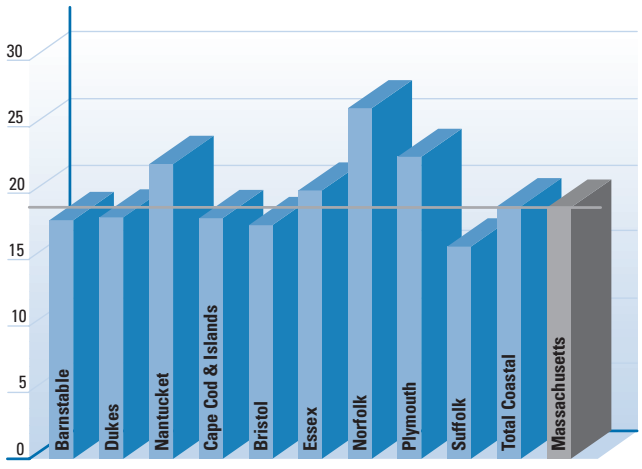
Between 1980 and 1997, the population in coastal counties grew by more than 10 percent, more than three times faster than the rest of the commonwealth. Cape Cod and the islands of Martha's Vineyard and Nantucket grew by 33 percent over this period.

Employment and earnings in coastal residential construction and real estate are included in this study because the coast is a marine resource and an amenity that attracts people to move there. Growth in coastal population, income, building, and real estate sales has increased significantly in the past few decades and has contributed greatly to the marine economy.

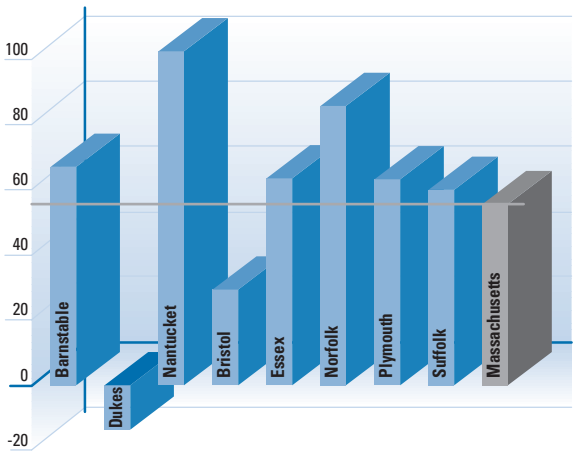
Between 1980 and 1997, the U.S. population grew more than twice as fast as the population in the commonwealth. Coastal counties in Massachusetts grew much faster than the rest of the commonwealth. Between 1980 and 1997, the population in coastal counties (with the exception of Suffolk) grew by more than 10 percent. This is more than three times faster than the rest of the commonwealth. Cape Cod and the islands of Martha's Vineyard and Nantucket grew by 33 percent over this period.

Income in most coastal counties also grew faster than income in the rest of the commonwealth. From 1980 to 1997, median household income grew by 21 percent in coastal counties, compared to 14 percent in non-coastal counties. While income growth in coastal communities is less promi-

Percentage Growth of Median Household Income, by County, 1989 –1995



Percentage Change in Value of New Single Family Homes, 1990–1997



nent than increases in population, the commonwealth's residents show a clear preference for locating near the coast. In 1997, almost 4,000 permits to build single-family houses worth a total of over $500 million were issued in Massachusetts coastal communities.

Except for Dukes and Bristol counties, which both had high rates of construction in 1990, construction of additional single-family houses in coastal counties has increased faster than average in Massachusetts. The highest increase was in Nantucket, followed by Norfolk, Barnstable, Essex, Plymouth, and Suffolk. The state's overall increase in new single-family homes from 1990 to 1997 was 56 percent.

To estimate new housing caused by demand for coastal living, the normal or expected rate of new housing construction was used. It was assumed that construction in excess of this was caused by demand for coastal living. The authors estimated the expected number of new single-family housing permits and their total value in coastal towns relative to the state's, based on their share of state population. Subtracting expected permits and housing values from the actual figures for coastal towns gave an estimate of housing generated by the demand for coastal living. Coastal cities were excluded because population has declined or grown little in these cities.

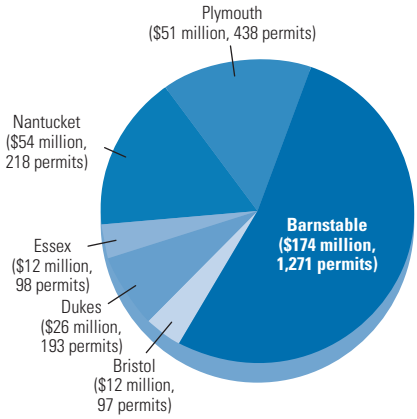
Using this method of estimating housing construction generated by the demand for coastal living, the authors concluded that 2,315 permits in 1997 for single-family houses worth $329 million could be attributed to demand for coastal living.

More than half of single-family construction attributed to coastal demand was in Barnstable County (Cape Cod), which had 1,271 new houses in 1997 that were assumed to be built to meet demand for coastal living. The largest percentage increase in construction of single-family homes was in Nantucket. The total number of permits given there for single family houses from 1990 through 1997 equaled 25 percent of the island's housing, more than five times the average increase in Massachusetts.

Total employment in the construction of these houses was 4,212 jobs with total earnings of $166 million in 1997. Plymouth, Cape Cod, and the islands accounted for almost all of this employment and earnings with more than one-half of this employment in Barnstable County.

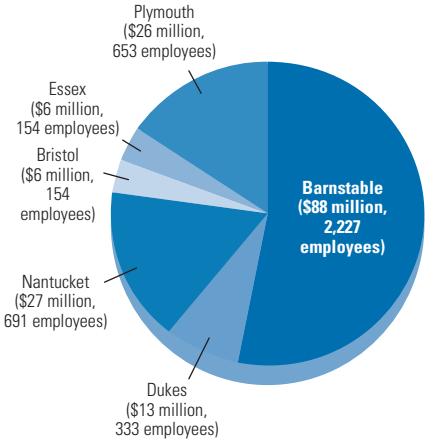
New Housing Value and Permits Due to Coastal Demand, 1997

Total value=$329 million Total permits=2,315



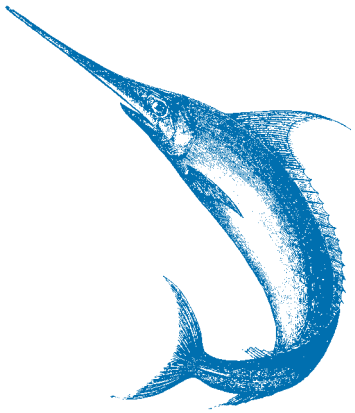
Employment and Earnings in Coastal Residential Construction, 1997

Total employment = 4,212 Total earnings = $166 million



The demand for homes in these coastal communities generates sales of existing houses leading to employment of real estate agents and others. The authors estimated the expected employment of real estate agents for each coastal county as a percentage of state employment of real estate agents based on the county's population. These estimates were subtracted from actual employment reported to DET to estimate the number of real estate agents generated by coastal demand. Coastal demand generated employment of 300 real estate agents with total earnings of $11 million in the commonwealth. Almost all real estate employment generated by coastal demand was located in Plymouth, Cape Cod, and the islands.

Employment and earnings of construction workers and real estate agents due to coastal demand in 1997 were probably higher than these figures indicate, because many construction workers, tradespeople, and real estate agents are self-employed and are therefore not included in the DET figures.



Conclusions

The marine economy in Massachusetts employed over 80,000 people who earned almost $2 billion in 1997. Roughly half of these jobs were in commercial seafood industries. About one-third were in transportation, tourism, and recreation. Marine technology and education employed about 10 percent of the total, and construction and real estate due to the demand for coastal living employed about 5 percent. The average annual wage in the marine economy was about $23,000, less than two-thirds of the roughly $36,000 average wage in the commonwealth. Like most sectors of the Massachusetts economy, the marine economy has high-paying jobs, mostly in marine technology and education, and low-paying jobs in food services and tourism, which were the major employers in the industry.

In 1997, about 3 percent of the 3 million jobs in the commonwealth and about 2 percent of the $100 billion in total earnings in 1997 were generated by the marine economy. This was a small share of the Massachusetts economy. State government alone employed more people, and all government (federal, state, and local) employed almost five times as many people as the marine economy did.

The marine economy has declined relative to other sectors of the Massachusetts economy over the long term. Fishing and other marine activities were the backbone of the economy from Colonial times through the nineteenth century, but other manufacturing and services have eclipsed Massachusetts' economic connections to the sea.

From 1988 to 1997, however, the marine economy grew slightly more than the Massachusetts economy in number of jobs and about 2 percent more than the overall economy in terms of earnings, using estimates from the author's study (Hogan, et al., 1991). Rates of growth were estimated only for the seafood sector and transportation, tourism, and recreation. Growth in employment and earnings in coastal residential construction and marine technology could not be estimated using the benchmark study.

Parts of the marine economy attract significant interest from federal and state governments. This public policy attention originates, in part, by recognition of the commonwealth's marine and industrial heritage, needs for resource management, and public interest combined with recognized opportunities to seed private-sector economic growth.

COMMERCIAL SEAFOOD INDUSTRIES

Despite mitigation by the New England Fisheries Management Council, the catch of most commercial species continues to fall or remain at low levels. The precipitous decline in the catch has spread beyond fishermen to other sectors of the commercial seafood industry. Most participants and observers would agree that fishery management in New England has failed to either conserve stocks or preserve the livelihood of people who work in the industry. This is not simply a case of government interference; open access did not work very well either.

Open access to fisheries generally causes stocks to decline because if one vessel does not catch the fish, another one will. Open access, called "the Tragedy of the Commons" in the literature, often leads to overfishing, reduced fish stocks, falling catches, government subsidies to those harmed by falling catches, and eventually to more overfishing. Few countries or regions have devised policies to interrupt or reverse this cycle.

New regulations offer solutions.

Three options, either individually or in some combination, offer potential solutions. None of these options is easy, and each runs counter to deeply held beliefs concerning open access to the sea and its riches. Each requires that some fishermen leave the industry; programs to help displaced fishermen and onshore workers move into alternative employment have not been successful.

The first option is to define a set of regulations that are supported by most in the industry and to leave these regulations in place long enough to assess their effectiveness. Since the 200-mile limit, the New England Fishery Management Council has operated in a crisis atmosphere, often caused by conflicting and inconsistent scientific assessments of fish stocks. Regulations governing fishing change frequently, causing mistrust among people connected to the industry and loss of trust in the federal agencies governing fishing. People and organizations in the industry have also learned to use political levers to influence the council, adding another source of instability.

The second option is to establish some form of rights to catch fish, such as individual vessel quotas, which would mitigate the race to catch as much fish as quickly as possible. Individual quotas give vessel owners incentives to preserve fishing stocks, at least in theory. For individual quotas to work, many problems, including legal issues, have to be worked out, but individual quotas have proven successful in some fisheries in other parts of the world.

The third option is to restrict access or define ownership over specific fishing grounds to some fishing organization in order to instill incentives to rebuild fishing stocks. This is the most radical departure from current fishery management policy, but it has roots in ancient systems of fishing tenancy where islands, villages, or tribes had claims over inland or coastal waters and managed those waters successfully.

Days at sea and stock-recovery policies look promising.

Individual vessel DAS regulations currently in effect in the groundfish and scallop fisheries in New England have several advantages for vessel owners. They allow owners to fish when they want rather than race to catch fish before other boats. Vessels are allocated approximately half of the days they traditionally fished, but they can fish those days whenever vessel owners or captains decide to.

For the most part, vessels can land whatever they catch (under earlier regulations that set quotas for species, fishermen often had to discard fish, which had already died in the net, after the quota for that species had been reached.) DAS regulations have advantages to vessel owners who are market-conscious. They use their DAS when demand and prices are high, because fishing days have become too valuable to use when prices are low. Under the DAS, captains and crew can take vacations because they don't lose days fishing, and also they don't have to fish in bad weather.

Rotating areas to fish in order to allow stocks to rebuild is another policy that shows promise. In 1999, large stocks of mature scallops were discovered in areas of Georges Bank that had been closed

to scallop and groundfishing vessels since 1994 to protect groundfish spawning grounds. The scallop management plan and the groundfish plan were adjusted to allow scallop vessels to fish these areas as part of their DAS. Due to high prices and increased landings, the value of the catch has rebounded. June 1999 was the first month that scallop vessels could fish in the closed areas. During that month the value of scallop landings in New Bedford, the leading scallop port, exceeded $8 million. This was an increase of nearly $2 million over the previous month's landing value. In July 1999, the catch surpassed $9.5 million, near the monthly record in New Bedford. After six months the areas were closed again because catch limits were reached, and the success of the plan has led to proposals to rotate areas fished. The rich scallop catch in 1999 returned New Bedford to the leading fishing port in the U.S., a position that it held from 1983 to 1991.

TRANSPORTATION, TOURISM, AND RECREATION

Marine transportation, tourism, and recreation have also long been connected with public policy ranging over time from the construction of Long Wharf in Boston in 1710 to the "Massachusetts, Take a Real Vacation" promotion currently on the Massachusetts Office of Travel and Tourism Web site. Marine transportation, tourism, and recreation are mature industries in Massachusetts. Employment in this sector has increased at about the same rate as employment for the state, and earnings have increased about 2 percent more per year than the state average.

Marine transportation has lain dormant for several decades. There is little reason to believe that Boston and other ports in Massachusetts will regain the position in shipping that they held in the nineteenth century, and the commonwealth's standing in tourism among the states has slipped to twenty-first.

The most promise for this sector rests in the thousands of recreational boats moored in dozens of harbors along the Massachusetts coastline. The dockside support services: ship repair, marine supplies, engine repair, and other businesses that have oriented themselves toward these recreational boats are flourishing. The stock market boom and general increase in wealth have generated demand for all sizes of recreational vessels, including large pleasure craft. Gloucester, Boston, and New Bedford have deepwater ports near city centers that can moor and service these vessels. More would be gained if attractions existed to bring these boaters ashore and they could reach these attractions easily. The infrastructure, especially access to downtown attractions, must be improved to entice boaters ashore.

MARINE TECHNOLOGY AND EDUCATION

Marine technology and education may be the most promising sector of the marine economy. Massachusetts remains among the world leaders in marine instrumentation, research, and education. By conservative estimates, 10,000 people earning almost $500 million worked in this sector in 1997. This is the only sector of the marine economy with average yearly salaries significantly above the state average.

Marine technology has received little attention from state policy makers. Little is known about the size and scope of this sector, and even the definition of marine technology has not been resolved. The Ocean Resources Branch of Hawaii's Department of Business would be a useful model for promoting and developing marine technology in Massachusetts. They publish industry reports and a directory of ocean research and development businesses, organizations, academic institutions, and government agencies in the state. This sector of the Massachusetts marine economy, which includes marine instrumentation, research, environmental services, and education, merits its own study, since a full and detailed investigation is beyond the scope of this study.

Appendix A

COASTAL AREAS

Coastal areas are defined as counties, cities, and towns that have access to the ocean, either directly or through river connections, and whose local economies are substantially marine-oriented. Coastal cities and towns in Massachusetts include the following:

Barnstable County:
Towns of Barnstable, Bourne, Brewster, Chatham, Dennis, Eastham, Falmouth, Harwich, Mashpee, Orleans, Provincetown, Sandwich, Truro, Wellfleet, Yarmouth

Dukes County:
Towns of Chilmark, Edgartown, Gay Head, Gosnold, Oak Bluffs, Tisbury, West Tisbury

Nantucket County:
Town of Nantucket

Cape Cod & Islands:
Counties of Barnstable, Dukes, and Nantucket

Bristol County: (Partial)
Cities and towns of Dartmouth, Fairhaven, Fall River, New Bedford, Somerset, Swansea, Westport

Essex County: (Partial)
Cities and towns of Beverly, Essex, Gloucester, Ipswich, Lynn, Manchester, Marblehead, Nahant, Newbury, Newburyport, Rockport, Rowley, Salem, Salisbury, Swampscott

Norfolk County: (Partial)
Cities and towns of Cohasset, Quincy, Weymouth

Plymouth County: (Partial)
Towns of Duxbury, Hingham, Hull, Kingston, Marion, Marshfield, Mattapoisett, Plymouth, Scituate, Wareham

Suffolk County:
Cities and towns of Boston, Chelsea, Revere, Winthrop

Total Coastal Areas:
All of the above counties, cities, and towns

Appendix B

INDUSTRIAL CATEGORIES

Data for the number of employees and total payroll are available for Massachusetts from the Division of Employment and Training (DET), ES202 file. Industries are classified in terms of the Standard Industrial Classification (SIC) code used by the U.S. Department of Commerce in its various economic censuses and other reports.

The 2-digit classes are the most comprehensive and are made up of one or more 3-digit classes. These 3-digit components are thus more detailed breakdowns of industries. In the same way, the 4-digit industries are breakdowns of the 3-digit industries. Some of the marine industries are adequately captured by 2-digit industries, (e.g., 44, Water Transportation). Other marine industries are captured by 3-digit industries, (e.g., 091, Commercial Fishing). Others are 4-digit industries, (e.g., 2092, Fresh and Frozen Fish Processing). Data for the 4-digit industries are not always available in the DET files. Thus, for example, wholesale seafood firms, SIC 5146, are not separately identified from other 514 firms; engineering services, SIC 8711, are not separated from other 871 firms. In yet other cases, even a 4-digit industry breakdown may not be sufficiently defined to separate out marine activities from non-marine activities within the same category.

Data from iMarket are broken down further than the 4-digit SIC codes used by the DET. Using the SIC code, iMarket adds 2- and 4-digit codes, ending up with 6- and 8-digit codes. This was useful in separating marine activities from non-marine activities, such as SIC 5812, Eating and Drinking Places. With just the DET figure, establishments like Red Lobster, LePage's Seafood, and Long John Silver's would be included, as well as Outback Steakhouse and McDonald's. With the iMarket codes, the list can be refined to seafood-related establishments.

Endnotes

Overview of Employment and Earnings

1. Sources for this section include *Of Plymouth Plantation, 1620-1647,* by William Bradford (Alfred E. Knopf, 1952), *The Maritime History of Massachusetts,* by Samuel Morison (Houghton Mifflin, 1921), *The New England Fishing Industry,* by Donald White (Harvard University Press, 1954), *Down on T Wharf,* by Andrew German (Mystic Seaport Museum, 1982), *The Cod Fisheries,* by Harold Innis (University of Toronto Press, 1940), *Cod: A Biography of the Fish that Changed the World,* by Mark Kurlansky (Walker and Co. 1997), and "Quincy Shipyard To Close" The *Boston Globe,* July 25, 1985, p. 9.

2. Source for quotes from the Fishery Conservation and Management Act is http://www.wh.whoi.edu/magact/.

3. Data for Employment and Earnings in the Marine Economy in 1997 were taken from other figures in this report.

Commercial Seafood Industries

1. Sources for this section include *The New England Fishing Economy,* by Peter Doeringer, Philip Moss and David Terkla (University of Massachusetts Press, 1986); *Troubled Waters: Economic Structure, Regulatory Reform, and Fisheries Trade,* by Peter Doeringer and David Terkla (University of Toronto Press, 1995); "Fisheries of the United States" (various years), by NMFS; "The Status of the Fishery Resources off the Northeastern United States in 1998," by Northeast Fishery Science Center; *Behind a Cape Cod Fish Pier,* by Robert Carlisle and Gordon G. Zellner (Oyster River Pub, 1996); "The Cost of Hook Fishing for Groundfish in Northeastern United States" (1998) and "The Cost of Fishing for Sea Scallops in Northeastern United States" (1999), by Daniel Georgianna; "The Costs of Small Trawlers in the Northeast" (1998) and "The Costs of Large Trawlers in the Northeast" (1999), by Philippe Lallemand et al. (all from the NMFS); *Northeast Region Aquaculture Industry Situation and Outlook Report, 1994-1995,* by Spatz, Anderson, and Jancat (1996); "Aquaculture White Paper & Strategic Plan," by Massachusetts Coastal Zone Management (1995); "New England's Marine Economy," by H. Kite-Powell in *Connection,* Vol. 13.:1 (1998); "The Effects of Reduced Groundfish Landings on New England Fresh Fish Processors," by Daniel Georgianna and Joel Dirlam (NMFS, 1999); "Recent Adjustments in New England Groundfish Processing," by Daniel Georgianna and Joel Dirlam in *Marine Resource Economics,* (1994); "1998 Annual Report on the United States Seafood Industry," by H.M. Johnson and Associates; and "The Massachusetts Fishing Industry," by Daniel Georgianna in *Massachusetts Benchmarks* (1999).

2. Data for Employment and Earnings in the Seafood Industry, 1997, are from the detailed figures in this section.

3. The increase in employment and earnings do not include fishing supplies and services, because employment for this sector was not included in *The Massachusetts Marine Economy,* by Hogan, Georgianna, and Huff (1991).

4. Rates of growth in employment and earnings for Massachusetts are taken from the *State and Metropolitan Area Data Book,* Table A-22, at http://www.census.gov/prod/ 3/98pubs/smadb-97.pdf.

5. Payments to fishermen by ports in this report differ somewhat from payments reported in "The Massachusetts Fishing Industry" in *Massachusetts Benchmarks.* The studies of costs in scalloping and trawling (see 1, above) which were completed after "The Massachusetts Fishing Industry," show higher payments to scallopers and draggers than were estimated in that article.

6. An interview with a local supermarket personnel coordinator provided the estimate of four seafood employees per supermarket in Massachusetts.

7. Source for Value of Landings by Port, 1976-1997, is Fisheries of the United States and NMFS Web site, http://www.st.nmfs.gov/st1/.

8. Source for Value of Landings by Species, 1997, is NMFS, http://www.st.nmfs.gov/st1.

9. Source for Employment and Earnings of Commercial Fishermen, 1997, is DET, SIC 091, Commercial Fishing (0912, Finfish; 0913, Shellfish) and correspondence from NMFS on the number of fishing vessels in Massachusetts.

10. Sources for Payments for Commercial Fishing Services, 1997, are "The Cost of Hook Fishing for Groundfish in Northeastern United States" (1998) and "The Cost of Fishing for Sea Scallops in Northeastern United States" (1999) by Daniel Georgianna, "The Costs of Small Trawlers in the Northeast" (1998)" and "The Costs of Large Trawlers in the Northeast" (1999) by Philippe Lallemand et al.

11. Source for Employment and Earnings in Commercial Fishing Services, 1997, is DET: SIC 3731, Shipbuilding and Repairing; 5541, Gasoline Service Stations; 5551, Boat Dealers; 6141, Personal Credit Institutions; 6411, Insurance Agents, Brokers, and Service; and 8721, Accounting, Auditing, and Bookkeeping Services.

12. Source for Wholesale Value of Processed Seafood Products, 1979-1997, is NMFS and Northeast Fisheries Science Center, http://www.wh.whoi.edu/noaa.html.

13. Sources for output/labor ratios were for 1992 and include Census of Retail Trade, Census of Service Industries, Census of Manufactures, and Census of Financial, Insurance, and Real Estate Industries.

14. Source for Employment and Earnings in Seafood Processing and Wholesaling, 1997, is DET, SIC 209, Miscellaneous Food Preparations and Kindred Products (2091, Canned and Cured Fish and Seafoods; 2092, Prepared Fresh or Frozen Fish and Seafoods), and 5146, Fish and Seafoods, Wholesale Distributors.

15. The sources for the descriptive information in the "Retail and Food Service Sales" section are the Annual Report on the United States Seafood Industry, by H.M. Johnson, and several studies of fish processing by Georgianna et al.

16. Sources for Seafood Retailing and Food Service Employment and Earnings, 1997, are iMarket, Inc. MarketPlace: 5411-01, Supermarkets; 5421-01, Fish and Seafood Markets; 5812-07, Eating and Drinking Places, Seafood Restaurants, and DET, SIC 581, Easting and Drinking Places.

17. Employment for seafood departments in supermarkets (four percent of total employment), fish markets, and seafood restaurants were taken from iMarket, Inc. MarketPlace data. Employment in other restaurants and food services was estimated as (the percent of sales from seafood in the U.S. eating and drinking places) times (Massachusetts employment for eating and drinking places from DET) minus (employment in seafood restaurants.)

Marine Transportation, Tourism, and Recreation

1. Sources for this section include *The Demand for Whalewatching at Stellwagen Bank National Marine Sanctuary,* by P. Hoagland and A. Meeks, 1997. *Mimeo,* WHOI; *The Economic Importance of Sport Fishing,* by the American Sport Fishing Association, 1998; and *The Statistical Abstract of the United States,* 1999.

2. Data for Employment and Earnings in Marine Transportation, Recreation, and Tourism, 1997 are taken from other figures in this section.

3. Web sites are Northeast Fishery Science Center at http://www.wh.whoi.edu/noaa.html; the Massachusetts Office of Travel and Tourism at http://www.mass-vacation.com/ research.html; American Sport Fishing Association at www.asafishing.org; the National Marine Manufacturing Association at http://www.nmma.org/facts/boatingstats; Massachusetts DET at http://www.detma.org/lmi/es-202/202973d.txt; and Massachusetts Institute for Social and Economic Research (MISER) at http://www.umass.edu/miser/.

4. Sources for Employment and Earnings in Water Transportation and Shipbuilding, 1997, are DET, SIC 373, Ship and Boat Building and Repairing (3731, Ship Building and Repairing; 3732, Boat Building and Repairing); 44, Water Transportation [441, Deep Sea Foreign Transportation of Freight, 442, Deep Sea Transportation of Freight, 443, Freight Transportation on the Great Lakes – St. Lawrence Seaway, 444, Water Transportation of Freight, NEC, 448, Water Transportation of Passengers, 449, Services Incidental to Water Transportation (4491, Marine Cargo Handling, 4492, Towing and Tugboat Services, 4493, Marinas, 4499, Water Transportation Services)].

5. Source for Employment and Earnings from Coastal Tourism by County, 1997, is Travel & Tourism in Massachusetts, MOTT report, 1989, and MOTT Web page at http://www.mass-vacation.com/research. html.

Marine Technology and Education

1. Sources for this section include the *Final Report of the Massachusetts Marine Science and Technology Education Study, 1969,* by Scott Daubin and James Mavor (WHOI); *Determining the Structure of the United States Marine Instrumentation Industry and Its Position in the World Industry,* 1988, by James M. Broadus, Peter Hoagland, and Hauke Kite-Powell (WHOI); *Developing a National Marine Electronics Agenda: Proceedings of the Marine Instrumentation Panel Meeting September 12–14, 1989* (WHOI); and *Massachusetts Marine Sector Report,* 1995, Committee on Marine Science and Technology, UMass Dartmouth.

2. Data for Employment and Earnings in Marine Technology and Education, 1997, are taken from other parts ot this section.

3. OSHA's Web site at http://www.osha.gov/oshstats/sicser.html provided SIC codes connected with marine instrumentation and technology. The following codes were determined to be relevant:

3812 Search, Detection, Navigation, Guidance, Aeronautical, and Nautical

3822 Automatic Controls for Regulating Residential And Commercial

3823 Industrial Instruments for Measurement, Display, and Control

3824 Totalizing Fluid Meters and Counting Devices

3826 Laboratory Analytical Instruments

3829 Measuring and Controlling Devices, Not Elsewhere Classified

3861 Photographic Equipment and Supplies

8731 Commercial Physical and Biological Research

4. Sources for Employment and Earnings in Marine Environmental Services, 1997, are Web sites and a survey of environmental institutions.

5. Employment at Woods Hole research institutions taken from http://www.whoi.edu/generalinfo/whsc/ on history of marine research and educational institutions in Woods Hole.

6. Employment for the research institutions came from surveys and Web sites.

7. The authors searched the Internet for every university and four-year college in Massachusetts to locate marine programs. Only marine degree programs and not specific courses that relate to marine studies were identified.

8. Most Web sites that list marine programs include faculty in those programs. This count was used to identify employment, after eliminating faculty listed elsewhere in other marine programs.

9. Salary for associate professors is taken from AAUP Salary Survey for 1997 to compute total payroll for degree programs.

10. Hundreds and perhaps thousands of K-12 faculty teach various aspects of marine topics. The authors tried to identify teachers who specialize in marine studies by using the membership in the Massachusetts Marine Educators Association and estimated that one-half of the membership are K-12 faculty.

11. The Web site of the Massachusetts Office of Travel and Tourism and its publicity pamphlets were searched for names of marine museums and other attractions. The Web site for that organization was then searched for information on activities and employment.

12. Letters were sent explaining the project with an addressed postcard asking for number of visitors, number of employees, and annual payroll, all for 1998. The response rate was about 50 percent.

13. The average of employees and salaries from the postcard survey (after eliminating a few large organizations) was used to estimate employment and salary for those institutions for which the authors had no data. These averages were five employees and salary of $25,736.

14. Sources for Employment and Earnings in Marine Education, 1997, are Web sites for colleges and universities with marine science programs, membership in the Massachusetts Marine Educators Association, and the postcard survey of marine museums and other marine educational institutions.

Coastal Population and Construction Growth

1. Sources for Percentage Growth of Median Household Income by County, 1980-1995 are the U.S. Census Bureau, http://www.census.gov/population/www/index.html and http://www.census.gov/datamap/www/25.html.

2. This analysis of coastal versus non-coastal income was taken from a model developed by the U.S. Census Bureau and estimates household income, rather than income per person. Single people, who generally have lower income than multiple-person families, are considered households by the census. Single-person households probably live in greater numbers in Boston and in coastal communities and therefore cause a downward bias in coastal household income. The use of median (middle household) income rather than average income caused additional complications. For example, a higher-than-average-income family that experiences divorce would reduce median household income more than average household income. The 2000 census, when available, will give us better estimates for income growth.

3. For Percentage Change in Value of New Single-Family Homes, 1990-1997, population for each county was estimated by adding the populations for the coastal towns of each county. For example, Barnstable County's population was estimated by adding the populations of all the coastal towns in Barnstable. Source for this information is the official Commonwealth of Massachusetts Web page, "At a Glance" Index of Cities and Towns, http://www.state.ma.us/dls/glance/aagindx.htm. The percentage of residential construction to total construction, 26 percent, is taken from *Statistical Abstract of the United States,* for Massachusetts, Table 1196. Total construction employment and average wage for total construction is from the DET, http://www.detma.org/lmi/es-202/202973d.txt. Real (not expected) housing permit distribution by town was supplied by Massachusetts Institute for Social and Economic Research (MISER).

4. Sources for New Housing Value and Permits due to Coastal Demand, 1997, are the official Commonwealth of Massachusetts Web page, http://www.state.ma.us/dls/glance/aagindx.htm, and the DET Web site, http://www.detma./org/lmi/es-202/202973.

5. To estimate housing construction due to coastal demand, the expected number of permits as the town's share (using population) of total state permits

was calculated. Coastal new housing is the difference between the actual number of permits minus this expected number of permits. Value was computed as the number of permits times the average value of the town's new single-family houses.

6. All cities and Fairhaven, Somerset, Swansea, Manchester, Nahant, Newburyport, Swampscott, Cohasset, Hingham, Hull, Wareham, Chelsea, and Winthrop were excluded from the estimate for coastal construction because of their low rates of growth.

7. To estimate employment and payroll for residential construction of the housing attributed to coastal demand, the authors took the percentage of total construction in Massachusetts that was residential (26 percent) from the Statistical Abstract of the United States, Table 1196. That number was multiplied by the share of total residential construction in Massachusetts attributed to coastal demand, and we multiplied that percentage by total employment and earnings from construction in Massachusetts from DET ES202 files.

8. When graphing employment of real estate agents, only five counties had more agents than was expected. Of these, Suffolk was excluded because of the size of Boston's population. Also, people do not tend to move to Boston to live near the coast, but for other amenities. Therefore, only Barnstable, Dukes, Norfolk, and Nantucket counties were graphed.

9. Source for Employment and Earnings in Coastal Residential Construction, 1997, is DET, SIC 1521, Residential Construction.

Conclusions

1. Source for total employment and earnings in Massachusetts is Massachusetts DET at www.detma.org/lmi.htm.

2. Assessment of DAS from the vessel owners' perspective was provided by Barbara Stevenson in a January 26, 2000, communication to Fishfolk, an e-mail list-serve.

NOTES

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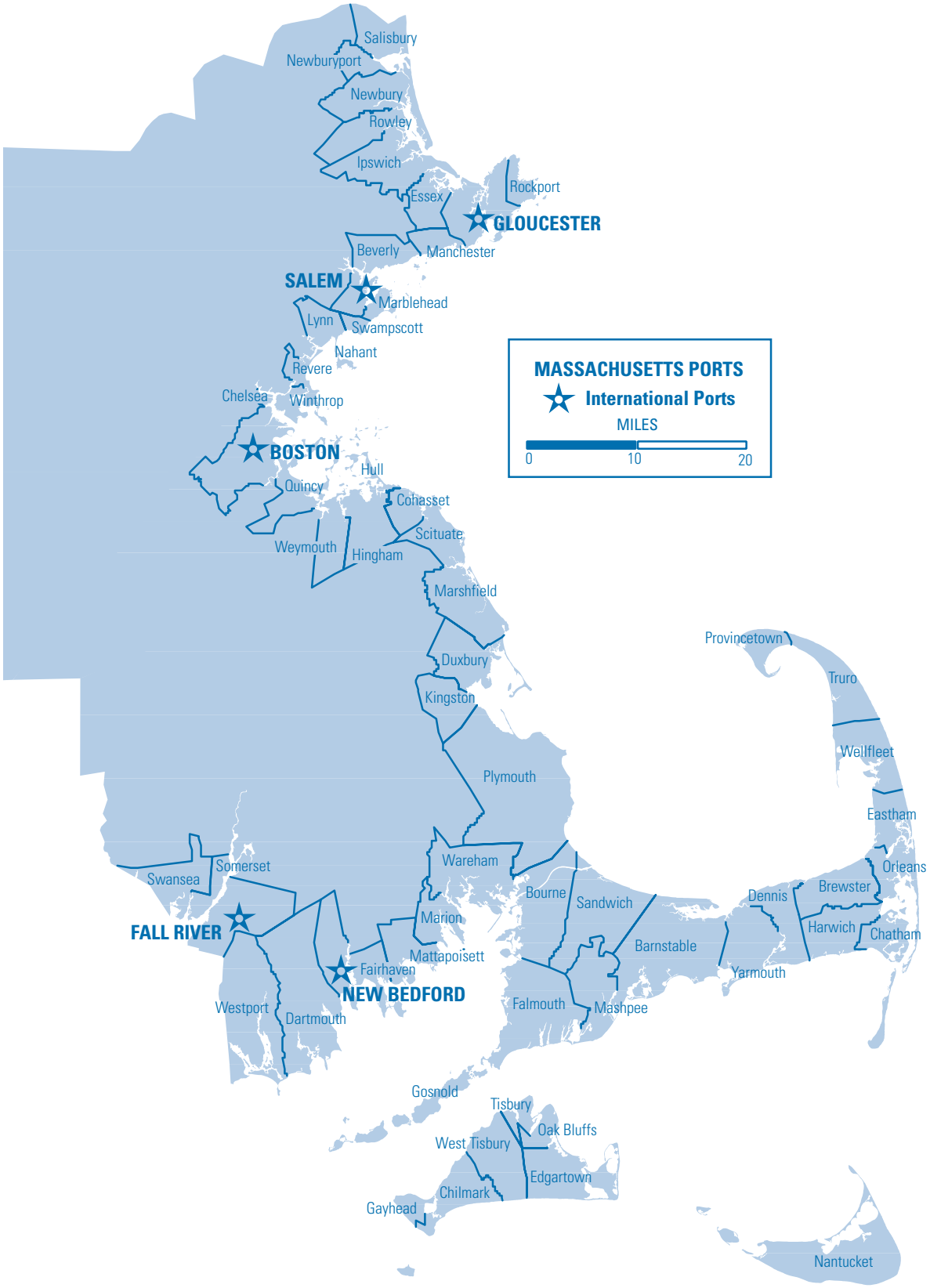
Salisbury
Newburyport
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Rowley
Ipswich
Essex
Rockport
GLOUCESTER
Beverly
Manchester
SALEM
Marblehead
Lynn
Swampscott
Nahant
Revere
Chelsea
Winthrop
BOSTON
Hull
Quincy
Cohasset
Scituate
Weymouth
Hingham
Marshfield
Duxbury
Kingston
Plymouth
Provincetown
Truro
Wellfleet
Eastham
Orleans
Brewster
Dennis
Harwich
Chatham
Barnstable
Yarmouth
Sandwich
Bourne
Wareham
Somerset
Swansea
FALL RIVER
Marion
Mattapoisett
Fairhaven
NEW BEDFORD
Westport
Dartmouth
Falmouth
Mashpee
Gosnold
Tisbury
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