Volume Title: In Pursuit of Leviathan: Technology, Institutions, Productivity, and Profits in American Whaling, 1816-1906

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1 In Prospect

Beginning a book about whales and whaling with a survey of literary references has canonical authority. Melville himself ([1851] 1983, ix) begins *Moby-Dick* not with "Call me Ishmael" but with "Etymology" (our version is in chapter 2) and "Extracts," an anthology of eighty-one quotations "affording a glancing bird's eye view of what has been promiscuously said, thought, fancied, and sung of Leviathan."[1] Naturally enough, the first extract is *Genesis* 1:21, "And God created great whales"; Melville includes also three biblical passages that refer to Leviathan, and *Jonah* 1:17—"Now the Lord had prepared a great fish to swallow up Jonah."[2] He moves on to Plutarch ("what thing soever . . . cometh within the chaos of this monster's mouth . . . down it goes all incontinently that foul great swallow of his") and Lucian ("a great many Whales and other monsters of the sea appeared"), among the ancients; *Wharton the Whale Killer* ("he saw the distended jaws of a large Sperm Whale close to the head of the boat, threatening it with instant destruction"), among the moderns. More than one-half of Melville's selections make the point that whales are very large, many others, that they are evil or monstrous.

Melville disingenuously credits a librarian with having compiled his extracts, but acknowledges in the phrase "a glancing bird's eye view" that they are a far from exhaustive survey. The bulk of references to whales in English

1. Much of *Moby-Dick* is about the process of writing the novel; in that context scholars have seen "Extracts" as Melville's bid to make himself a part of the community of authors (i.e., of the literary tradition) who wrote about whales. That is, he wanted his individual labors—labors that were directed toward whaling—to be included in the much greater body of labor about whales in general (Cindy Weinstein, private communication, 26 October 1994).

2. We have adopted the literary use of *Leviathan* as an equivalent for *whale,* but this may not be what the Hebrew writers intended. The biblical Leviathan is not a large mammal; in Melville's version of *Isaiah* 27:1, it is the "crooked serpent . . . the dragon that is in the sea." See Ellis 1991, 34. The "great fish" that made a meal of Jonah, however, is understood to have been a whale: "For as Jonas was three days and three nights in the whale's belly" (*Matthew* 12:40).

literature are less flamboyant than those he has selected. Compare, for example, Milton's description, which was chosen by Melville, with Christopher Smart's, which was not. Milton is expansive and audacious (and factually mistaken):

> There Leviathan
> Hugest of living creatures, on the deep
> Stretch'd like a promontory sleeps or
> swims,
> And seems a moving land,[3] and at his gills
> Draws in, and at his trunk spouts out a sea.[4]

Smart is subdued, modest, and affecting:

> Strong, the gier-eagle on his sail,
> Strong against tide, the enormous whale
> Emerges as he goes.[5]

When a literary whale is not large and evil, what is it? According to Chaucer, it is fat; in "The Summoner's Tale," monks are said to be "fat as a whale." According to Shakespeare, it is hungry:

> And there they fly or die, like scaled schools
> Before the belching whale.

> I knew the young Count to be a dangerous and lascivious boy, who is a whale to virginity and devours up all the fry it finds.

> I can compare our rich misers to nothing so fitly as to a whale; 'a plays and tumbles, driving the poor fry before him, and at last devours them all at a mouthful.[6]

This characteristic gave rise to the proverb "Throw out a sprat to catch a whale," and, if the whale is hungry enough, to the proverb "Throw out a tub to the whale," meaning offer the voracious one something other than you or your boat to swallow.

3. "Stories are found in the folklore of many languages about sailors mistaking a sleeping whale for an island; they moor their ship to it and go ashore to prepare a meal, whereupon the whale awakes and dives, drowning the men and dragging their ship to the bottom. This story is incorporated in the legend of St. Brendon . . . , the Irish Benedictine abbot who, in A.D. 565, is said to have sailed west into the Atlantic to search for the Promised Land of the Saints. In the course of this voyage he and his men landed on the back of an immense whale, mistaking it for an island. The saint set up an altar and celebrated the Mass; he did not suffer the usual result of making this mistake" (Harrison Matthews et al. 1968, 25).

4. John Milton, *Paradise Lost,* book 7, lines 412–16. This is Milton's gloss on *Genesis.* (A whale has neither gills nor a trunk, and breathes not water but air.)

5. Christopher Smart, *A Song to David.* A gier-eagle is a vulture.

6. William Shakespeare, *Troilus and Cressida,* act 5, scene 5; *All's Well That Ends Well,* act 4, scene 3; *Pericles, Prince of Tyre,* act 2, scene 1.

In 1940 Walt Disney made an animated film of the late-nineteenth-century children's book *Pinocchio.* In the original Italian, the marine creature that swallows Pinocchio is a *Pesce-cane* (dogfish), a large shark, "who, for his slaughter and for his insatiable voracity, had been named the 'Attila of fish and fishermen.' Only think of poor Pinocchio's terror at the sight of the monster."[7] In the film the shark has become a whale named Monstro, and Pinocchio is every bit as frightened—although considering that Geppetto, whom Pinocchio is out to rescue, has been living for weeks in Monstro's belly along with his cat and his goldfish, and they are all eating and breathing just fine, one may wonder what the fuss is about. Did Disney make the change in order to allude to the story of Jonah and reassure American children that it is possible to emerge from a whale alive? If so, the reassurance must be subliminal, for Monstro is decidedly bad-tempered and indefatigable.

In recent years, as the whale fishery has receded and natural history has turned from finding prey to publicizing marvels, whales have changed completely.[8] They are no longer dangerous, or disgusting. When Michelle Gilders writes in *Reflections of a Whale-Watcher* (1995, 3), "This was the year I touched a whale," she is not saying, "This was the year I experienced terror and revulsion," but, "This was the year I experienced awe." In motion pictures, boys no longer risk their lives to save humans from monstrous whales; now they risk their lives to save whales from monstrous humans. In 1956 Gregory Peck, as Captain Ahab, killed a ship's crew by trying to kill a sperm whale. In 1986 William Shatner, as James T. Kirk, saved everyone on Earth by saving two humpback whales from Norwegian hunters.[9]

In the present climate, in which the whale shares with the panda the status of environmentalist emblem, and northern Californians stand alongside the Sacramento River anxiously urging a lost baby gray back to the ocean, and we are asked not simply to save whales but even perhaps to adopt one, it is an imaginative exercise to study a world industry that depended on slaughtering these fascinating and often beautiful creatures.

7. The Pinocchio stories were written by Carlo Lorenzini and published under his pseudonym, Carlo Collodi, beginning in 1880. The quotation is from Collodi n.d., 235–36.

8. At an extreme of the marvellous might be *Mind in the Waters* (1974), in which, for example, John Lilly is quoted as saying, "I suspect that whales and dolphins quite naturally go in the directions we call spiritual, in that they get into meditative states quite simply and easily" (83). Of another order entirely, and wonderfully written, is Roger Payne's *Among Whales* (1995)—for example, "In the past twenty years there has been repeated speculation about whether we or whales possess the greater intelligence. I have stayed out of this discussion because it is obvious that we have no clear idea as to the nature of the intelligence abiding in the brains of whales (or our own, really). It all depends on what we mean by intelligence. If we mean an enduring intelligence, then whales are the winners hands down, simply because they have been around for tens of millions of years longer than we have. Besides, they do not use their extraordinary brains to do things that can destroy the world" (346).

9. *Pinocchio* (1940), *Free Willy* (1993), *Moby Dick* (1956), *Star Trek IV: The Voyage Home* (1986).

1.1 American Whaling

Whaling, today, is pursued by small fleets of Norwegian and Japanese vessels, and by Inuit living beside the Arctic Ocean. In the context of the world economy, the industry is minute. Its supporters defend it, not on economic grounds, but for its cultural value or its putative contributions to scientific research.[10] Most nations have agreed not to hunt whales at all; the United States not only prohibits hunting but also excludes whale products from American foreign trade.

One hundred and fifty years ago, the world was different. Whaling was a major economic activity, and it was centered in the United States. In value of output, whaling was fifth among U.S. industries; it provided raw materials for the chief lighting and lubricating products of the day. New Bedford, Massachusetts, the leading whaling port, was said to be the richest town in the country,[11] and Hetty Green, later called the Witch of Wall Street, would shortly inherit two New Bedford whaling fortunes and become the wealthiest woman in America. There was no need to justify whaling in terms other than the economic.

How the U.S. industry achieved this distinction and why it declined so rapidly, disappearing before the end of the 1920s, are questions of substance, not grist for antiquarian mills. There are lessons to be learned from the history of American whaling that are germane to modern interests—indeed, modern preoccupations. This book is concerned with these lessons.

1.2 Economic Growth: Lessons from Whaling

Economists since Adam Smith have been interested in economic growth and change, but, despite the lapse of more than two hundred years since he wrote, we have grasped only the principal outlines of the subject. As Nobel laureate Simon Kuznets demonstrated in 1930 (1967), the process is certainly related to the rise and decline of industries. Additionally, as he suggested in his presi-

10. The cultural importance of whaling is asserted by Norwegians and Inuit. Japanese apologists claim scientific gains from hunting but, as Matthiessen (1995, 71) says, "'scientific whaling' . . . is generally considered a great fraud." See also Cousteau and Paccalet 1988, 47, for a harsh critique of what is called "aborigine whaling."

11. Or the world: "New Bedford, in the mid-nineteenth century, was perhaps the richest city per capita in the world" (Allen 1973, 82). "Probably no city in the Union, perhaps no city in the world can show such an amount of property in proportion to the number of inhabitants. Taking the last United States census as the basis of population, a division of the wealth of the city would give to every man, woman and child in New Bedford, a fraction over $1615 each" (*WSL* 15 August 1854).

The *Whalemen's Shipping List* (*WSL*) may have been right. According to the 1860 census, the total value of tax assessments per head in the United States was $385. (The census gives three different wealth estimates: tax assessments, census marshalls' estimates of true value, and individual census wealth returns. The *WSL* seems to have been referring to New Bedford tax assessments. [U.S. Census Office 1864b, 599; 1866, 294]). For more on New Bedford wealth, see chapter 10 below.

dential address to the Third International Conference of Economic History, technical change has been the "major permissive source of modern economic growth" (1968, 20). Douglass North, co-Nobel laureate in 1993, was awarded the prize in part for his work on the role of institutional invention and innovation in the process of growth (Davis and North 1971; North and Thomas 1973; Wallis and North 1986).

What else do we know? Technical changes may be central to the rise and fall of industries, but economic agents (entrepreneurs, workers, investors, consumers) play major roles. Moreover, the drama is enacted against a backdrop of institutions (property rights, labor contracts, government regulations, commodity and factor markets). History can provide a laboratory—less than ideal, but better than none at all. Evidence drawn from that laboratory can be used to check theories and suggest modifications. The quality of the laboratory depends, of course, on the relevance of the historical incidents to the problems under study. The American whaling industry is a nearly ideal laboratory for the study of economic change.

First, the industry was dynamic, not static; because it was dynamic one can examine the effects of changes in technology, in institutions, and in the preferences of economic agents under a variety of conditions. American whaling rose to world dominance, and then collapsed, within a single century. In terms of capital stock, it employed an annual average of only eighteen thousand vessel-tons in the years 1816–20. Over the next three decades, tonnage increased more than elevenfold. In 1896–1900, however, after a decline of many years, the capital stock was smaller than it had been in 1816–20. (See table 1.1.) In terms of the value of output, the story is much the same. In 1880 dollars, the industry's average annual receipts grew from three-quarters of a million in 1816–20 to almost ten million in 1851–55, but by 1901–5 had fallen to less than one million dollars. (See table 1.2.)

Second, although a typical vessel made several whaling voyages (the mean number from New Bedford was six), the owners and agents, who organized and directed the enterprise, treated each voyage as a separate venture. Thus, the voyage is an ideal unit of analysis, virtually the same as the *firm* of economic theory. Also useful is the fact that the industry was competitive; given competition, one can use economic models based on optimization and profit maximization with little distortion of reality.

Third, in some industries—agriculture and mining, for example—firms draw on a stock of locationally specific and privately owned resources, making it almost impossible to disentangle differences in natural endowment from differences in productivity. In whaling the natural resource (the stock of whales) was owned by no one, and all firms were normally free to exploit it. Finally, the production process was relatively simple: each of its stages—finding, killing, and rendering whales—is easy to describe.

Whaling was a nexus for almost all the forces that economists have suggested are important to the processes of growth and change. Accompanying

Table 1.1 **Tonnages and Numbers of Vessels, U.S. and New Bedford Whaling Fleets, Annual Averages, 1816–1905**

	Tonnage			Number of Vessels		
	U.S.[a]	New Bedford[b]	New Bedford/ U.S.	U.S.[c]	New Bedford[d]	New Bedford/ U.S.
1816–20	18,395	7,568	.411	—	31	—
1821–25	37,161	14,701	.396	—	56	—
1826–30	47,953	23,105	.482	—	80[e]	—
1831–35	92,750	44,912	.484	—	142[e]	—
1836–40	133,897	54,685	.408	—	173	—
1841–45	185,678	72,881	.393	672	228	.339
1846–50	208,347	82,035	.394	656	252	.384
1851–55	195,938	105,482	.538	628	314[e]	.500
1856–60	195,692	108,551	.555	628	320[f]	.510
1861–65	111,167	73,026	.657	374	220	.588
1866–70	73,224	58,331	.797	312	180[f]	.577
1871–75	58,514[g]	39,888	.682	209	124[f]	.593
1876–80	46,517[g]	39,217	.843	178	129[e]	.725
1881–85	40,838[g]	29,815	.730	152	96	.632
1886–90	31,364[g]	18,492	.590	113	59	.522
1891–95	24,143[g]	10,700	.443	92	38	.413
1896–1900	15,588[g]	6,809	.437	62	26[e]	.419
1901–5	10,462[g]	6,810	.651	40	23	.575

[a]The U.S. annual average tonnage figures have been computed from annual data given in Tower 1907, 121, appendix table 1. Tower uses the tonnages recorded when vessels were registered (i.e., contemporary tonnages). Since the system for computing tonnage changed in 1865, his figures for the years after 1864 are not perfectly comparable to those for earlier years. In the aggregate, post–1864 tonnages appear to have been from 10 to 25 percent smaller than pre–1865 tonnages (see chapter 3). We therefore adjusted Tower's U.S. tonnages by raising them 17.5 percent. We began the adjustment with the 1871–75 figure, since new tonnage evaluations were not all made in 1865, but in the years in which vessels were reregistered. Reregistrations tended to take place when vessels sailed; given typical voyage lengths, the complete change must have taken three to six years.

[b]The annual figures of which the table reports five-year averages were computed by summing the tonnages of the New Bedford vessels that were involved in whaling voyages during a year. These annual figures underreport tonnages for two reasons. (1) Occasionally only the sailing date or only the arrival date of a voyage is known; when one date is missing, we assumed the voyage was completed within the calendar year of the other date—but voyages generally lasted longer than that. (2) We do not know the tonnages of seventeen New Bedford vessels active between 1816 and 1905; their twenty-two voyages in this period do not figure in the annual sums.

The figures for New Bedford annual average tonnage were computed from the Voyages Data Set (see chapter 3). We calculated the tonnage of each New Bedford vessel registered after 1864 according to the law in effect before 1865 in order to arrive at an old-rule tonnage figure, and used those old-rule tonnages in calculating the New Bedford averages. (All New Bedford tonnages reported in this book are old-rule tonnages.)

[c]The U.S. annual average numbers of vessels come from Tower 1907, 121. Tower's counts of numbers of vessels in the U.S. fleet begin with 1843. The 1841–45 number here is therefore the average of only the three years 1843–45.

[d]The New Bedford annual average numbers of vessels were computed from the Voyages Data Set.

[e]This number is one greater than the average number of vessels for which tonnage is known, during these five years. See note b.

[f]This number is two greater than the average number of vessels for which tonnage is known, during these five years. See note b.

[g]Adjusted tonnage; see note a.

Table 1.2 **Real Value of Output, U.S. and New Bedford Whaling Fleets, Annual Averages, 1816–1905 (1880 dollars)**

	U.S.	New Bedford	New Bedford/U.S.
1816–20	764,922	222,428	.291
1821–25	1,652,013	485,804	.294
1826–30	2,349,900	914,966	.389
1831–35	4,489,210	1,550,053	.345
1836–40	6,245,711	2,043,798	.327
1841–45	8,750,263	2,997,698	.343
1846–50	8,484,838	3,517,398	.415
1851–55	9,630,201	4,507,450	.468
1856–60	8,752,811	4,806,959	.549
1861–65	4,623,194	3,163,453	.684
1866–70	3,760,800	2,177,034	.579
1871–75	2,440,180	1,795,010	.736
1876–80	2,409,458	1,893,965	.786
1881–85	2,217,906	1,507,756	.680
1886–90	2,178,452	1,154,786	.530
1891–95	2,111,910	671,362	.318
1896–1900	1,341,443	402,447	.300
1901–5	877,771	419,263	.478

Sources: Output prices come from a variety of sources, summarized in appendix 9A. The same prices were used to value both U.S. and New Bedford outputs.

Output amounts for the United States come from Tower 1907, 126, appendix table 3. Output amounts for New Bedford were computed from the Voyages Data Set.

Tower's output series is not perfectly comparable to ours. In the first place, as his table note says, he used data from two sources: Starbuck 1878, and *WSL* 17 March 1843–29 December 1914. We used a wider variety of sources (see chapter 3). In the second place his series associates output with the year in which the output itself, not the vessel producing it, returned to port. Our series associates all the output of a voyage with the year in which the vessel returned to port, even though some of it may have been shipped home in advance of the vessel's return. (This difference should roughly wash out in the five-year averages reported in this table.)

Notes: The term *real value* means current price value, deflated by the Warren and Pearson "All Commodities" wholesale price index (U.S. Department of Commerce 1975, series E-52).

the rise and decline of the industry, and presumably producing them, were (1) changes in the level and structure of demand; (2) changes in the competitive vigor of West Coast whaling ports and foreign fleets; (3) supply-side shocks, both positive (the discovery of new hunting grounds) and negative (perhaps the depletion of whale stocks); (4) changes in systems of business organization (the rise of such ports as Honolulu and Panama as transshipment and refitting points, for example); (5) the innovation of appropriate vessel sizes, rigging types, whalecraft, and hunting techniques; and (6) changes in the cost and quality of capital and labor, and in the supply of entrepreneurial ability.

Such changes are of great interest. An industry rises rapidly and then declines; the rise and decline carry important consequences for the institutional environment and for the level and structure of the capital stock; those factors, in turn, affect best-practice techniques, productivity, output, and employment.

This book centers on such developments, not as ends in themselves, but as ways to investigate both the forces encouraging expansion and collapse and the responsiveness of economic agents to opportunities and problems. The goal is to investigate forces underlying economic growth and change and to understand how they function.

To economists, usually faced with scrappy data, often indirect, the history of the American whaling industry is extraordinarily rich. Take only three examples. In whaling, Kuznetsian technical change took the form not only of new vessel and whalecraft designs, but also of institutional innovations in both the industry and the general economic environment. Given the large number of firms (voyages), separated in space and time, the impact of these aspects of technical change can be studied in detail.[12] Second, questions of managerial control—an agent's control over a captain working thousands of miles away, and a captain's control of his crew—raise issues at the heart of all principal/agent problems. Here again, the laboratory yields many observations. Third, in a world marked by great risk (vessels sometimes sank and captains sometimes found few whales), and a world that required close cooperation between officers and crewmen, the labor contract was extremely important. What was the nature of the contract, and how efficient was it? These are but three of many topics that make the history of whaling relevant to modern analytical and interpretive concerns.

1.3 The Plan of the Study

If this book were solely an economic history, it might best be organized chronologically. Given the nature of our interests, however, an organization based on the microeconomic model—the production function, input and output markets, firm behavior, and industrial response—is more appropriate.

The first section, chapters 1–3, gives the raison d'être and plan of the study. Later in this chapter we introduce four aspects of whaling (the trends in productivity, the idiosyncratic labor contract, the entrepreneurs who made business decisions, and the products of the industry) that make it of particular interest to economists, and describe the central role played by New Bedford. In chapter 2 the whales (sperms, rights, humpbacks, grays, and bowheads) that Americans regularly caught, as well as the whales (seis, blues, minkes, and finners) that they seldom managed to catch, are described. The chapter also gives a brief account of the development of hunting methods from the seventeenth century to the early twentieth. Chapter 3 describes the contents and construction of the data sets on which our analyses are based.

The second section, chapters 4–8, focuses on the whaling production function—the process of converting physical inputs (land, capital, and labor) into

12. The New Bedford fleet, for example, the largest component of the American fleet, made more than forty-three hundred whaling voyages between 1816 and 1906.

physical outputs (sperm oil, whale oil, and whalebone). Chapter 4 describes the demography of whales, estimates their numbers in the oceans at the beginning and at the end of American whaling, and evaluates the impacts of American hunting on whale populations. Chapter 5 describes the labor contract, discusses both the lays—the shares of output received by crewmen—and the wages they represented, compares those earnings with wages in other industries, and explores the relationship between manning decisions and productivity. Chapter 6 describes nineteenth-century vessels and whalecraft (equipment used to catch whales). Chapter 7 describes the changes in vessels and whalecraft, as well as in the institutions that governed cooperation and competition, that took place during the American industry's century-long life. Chapter 8 models the production process, examines changes over time in the average productivity of New Bedford whaling voyages, and attempts to explain, for example, why the 1857 voyage of the *George Howland* was more productive than its 1842 voyage, and why the New Bedford fleet was more productive in both 1825 and 1885 than it was in 1855.

The third section, chapters 9–11, moves from questions of productivity narrowly defined to a more general evaluation of whaling firms as business enterprises. Chapter 9 examines the evolution of the markets for the industry's three major products. Its focus is on demand, with an emphasis on the development of substitutes and the role of foreign markets. Chapter 10 examines the roles of agents (the men who organized enterprises and exercised general control), captains (the men on the spot who made day-to-day decisions), and owners. It gives a quantitative assessment of the quality of entrepreneurial responses to changing economic conditions. Chapter 11 computes the profits earned on individual voyages, giving an alternative measure of the success of particular captains and agents.

The fourth section, chapters 12 and 13, is largely historical. It traces the long-run fortunes of the industry, the result of the interplay of technology, markets, and entrepreneurial creativity. Chapter 12 describes the competition between the whaling fleets of the United States and Great Britain in the early decades of the nineteenth century and analyzes the reasons for initial British dominance and final American triumph. Chapter 13 describes the increasingly effective competition offered by the Norwegian industry after 1880 and explains the failure of the Americans to counter it.

In the final chapter the major threads of the argument are drawn together and related to the question of technical progress. In addition, we draw from the whaling experience some general ideas about technology and economic growth and decline.

1.4 What the Reader Needs to Know

No matter where one begins the story of American whaling, four subjects crop up: productivity, the labor contract, the entrepreneurs, and the markets for

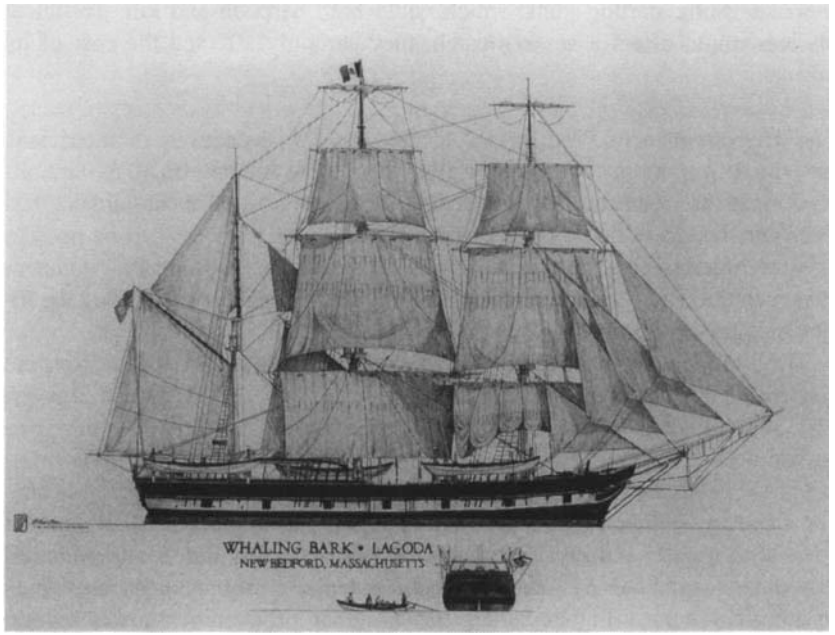
whaling products. The reader should be introduced to them before embarking on this study of the economics of whaling.

Managerial Decisions. Leaving aside luck (perhaps the most important factor), the productivity of a whaling venture was strongly influenced by the choices of its agent as he planned the voyage. The first was the ground to be hunted. Registrations of New Bedford vessels list fifty, including such exotic places as Patagonia, Delagoa Bay, the Sea of Okhotsk, and Tristan da Cunha. We have generally grouped the fifty into four: the Atlantic, the Indian, the Pacific, and the Western Arctic. (For a list of the fifty grounds and their distribution among these four, see appendix 3A.) Parts of the first three grounds had been systematically hunted before the War of 1812. The last, the Western Arctic, was first hunted in 1848, when Captain Thomas Welcome Roys sailed the bark *Superior* of Sag Harbor through the Bering Strait and found "whales innumerable, some of which yielded two hundred and eighty barrels of oil" (Scammon [1874] 1968, 58).

A second choice was the class of vessel and its size: a ship (three masts, square-rigged on all), a bark (three masts, square-rigged on the foremast and mainmast, fore-and-aft-rigged on the mizzen), a brig (two masts, square-rigged on both), a schooner (two masts, fore-and-aft-rigged on both), or a sloop (one mast, fore-and-aft-rigged). On average, ships were larger than barks, barks larger than brigs, brigs larger than schooners, and schooners larger than sloops, but within a rigging class there was a range of sizes, making some barks, for example, larger than some ships. (Size was expressed in tons—for merchantmen and whalers a measure of capacity, not, as for warships, of displacement).[13] The average size of the sixty-two whaling ships that sailed from New Bedford in 1850 was 368 tons, but they included the *Leonidas* at 231 tons and the *Gladiator* at 650.

Manning decisions, too, affected productivity. Most whaling vessels were ships or barks. Such a vessel had a captain, at least two mates, some number of boatsteerers (the men who harpooned the whales and steered the whaleboats when the whales ran), a cooper, a cook, a steward, and a number of seamen—some skilled (able seamen), some semiskilled (ordinary seamen), some unskilled (greenhands), and perhaps a boy or two. Choices remained. Should the vessel carry four, five, or six whaleboats? Depending on the decision, the agent would need to hire four, five, or six boatsteerers and three, four, or five mates. If the voyage was to be lengthy, the vessel would need a carpenter and a blacksmith, and the agent might choose to add a boatbuilder, a sailmaker, perhaps a painter. As technology improved, it became possible to substitute greenhands for able and ordinary seamen, but this required not only more greenhands but also more supervisory personnel. Those sixty-two ships that left in 1850 carried an average crew of twenty-nine, but the number ranged from twenty-three

13. See chapter 6 for a description of the legal formulas for computing tonnage.



The *Lagoda* was built in Scituate, Massachusetts, in 1826 and originally rigged as a ship. She was 107.75 feet long and 26.5 feet wide (an "old measure" tonnage of 340.7), with two decks, a square stern, and a billethead. The vessel came to New Bedford in 1841 from Boston, where she had been employed as a merchant vessel. The *Lagoda* made six whaling voyages from New Bedford as a ship. In 1860 she was rerigged as a bark, in which guise she made another nine New Bedford voyages. During the last in 1890, she was condemned and sold at Yokohama, Japan. Note the ensign of her New Bedford agent, Jonathan Bourne Jr.

This is a reproduction of a watercolor by Arthur Moniz (1991), used with the permission of the Old Dartmouth Historical Society–New Bedford Whaling Museum.

on the *Ann Alexander,* the *Barclay,* the *Iris,* and the *Leonidas,* to thirty-six on the *Globe.*

Finally, changes in technology forced agents to choose between new techniques and familiar ones. Early whaling vessels were drawn from the merchant fleet; if whaling proved unprofitable, they could easily be returned. In the 1850s new modified clippers—barks designed specifically for whaling—began to appear, offering a choice between specialization and versatility. In rigging, some midcentury builders believed that a greater number of small, flat sails was more efficient than a few large, baggy ones, and that wire rope or chain, although more costly, was better than the traditional hemp. In equipment, some preferred mechanized ventilators, capstans, and winches. In whalecraft, suppliers offered double-flued, single-flued, and toggle irons (harpoons), iron and steel hand-lances, guns that shot explosive lances, and, after

the mid-1860s, darting guns, which could both harpoon and kill. Technical choices might affect a vessel's catch; they certainly affected the cost of its voyage.

The Measurement of Productivity. In the past two decades econometricians have made important contributions, both theoretical and empirical, to our ability to measure total factor productivity. For this study, the most valuable has been the discovery that a class of multilateral index numbers can be used to measure intertemporal and interfirm productivity differences, making it unnecessary to fit econometric functions. The implicit aggregator underlying the index numbers is a translog function.[14]

The multilateral index used here to measure productivity comes from the work of Douglas W. Caves, Laurits R. Christensen, and W. Erwin Diewert (1982b) and is particularly well suited to the whaling industry. It is designed to handle multiproduct firms; nineteenth-century whalers sought three products. The economic model that underlies the index assumes optimizing behavior; firms in competitive industries such as whaling are forced by the market to minimize costs and maximize profits. Computation is simple and demands few data (see chapter 8). The index is, in essence, a ratio of physical outputs to physical inputs; higher values mean higher productivity, lower values, lower productivity.

Trends in Productivity. An index of the average productivity of the vessels returning to New Bedford in each year from 1816 to 1898 is shown in table 1.3 and figure 1.1. It declines from 1826, when the New Bedford fleet was still quite small, to the mid-1830s, when it was quite large. Over the rest of the century, there are significant, but less marked, changes. From the mid-1830s to the mid-1860s, the curve declines less sharply; from the mid-1860s to the end of the century, productivity increases again; by 1875 the index has returned to the level of the mid-1850s.

There are at least three possible explanations of this pattern of movement. It has been said that the stocks of whales were hunted down as the industry grew. Fewer whales would mean greater costs, and a consequent decline in productivity. This account is favored by some historians and many environmentalists. It is consistent with the movements of the index from the 1820s to the 1860s; it is not consistent with the movements in the years after the Civil War or with the pattern of hunting and the demography of whale populations (see chapters 4 and 8).

A less widely held view relates to changes in the industry's size—the entry of vessels into and exit of vessels from the fleet. As the industry expanded, competition for whales would have grown more intense. More vessels search-

14. See chapter 8 for citations. We thank Douglas Caves, V. Kerry Smith, Richard Hydell, Jeffrey Dubin, and David Guilkey, who discussed these indexes with us.

Table 1.3 **Index of Total Factor Productivity, New Bedford Whaling Fleet, 1816–98 (mean 1816–98 = 100)**

Voyage Arrival Years	Index of Productivity	Voyage Arrival Years	Index of Productivity	Voyage Arrival Years	Index of Productivity
1816	205.187	1844	147.665	1872	55.910
1817	130.220	1845	127.016	1873	66.000
1818	168.956	1846	121.042	1874	55.531
1819	162.123	1847	110.834	1875	71.037
1820	141.365	1848	117.996	1876	81.374
1821	153.469	1849	97.705	1877	88.315
1822	154.630	1850	99.563	1878	66.319
1823	146.732	1851	136.501	1879	58.654
1824	138.809	1852	61.490	1880	55.268
1825	240.176	1853	80.207	1881	80.483
1826	224.315	1854	98.752	1882	67.929
1827	151.401	1855	69.655	1883	79.300
1828	186.284	1856	83.868	1884	68.286
1829	172.617	1857	92.317	1885	49.683
1830	179.601	1858	69.787	1886	58.310
1831	144.790	1859	72.399	1887	50.770
1832	173.576	1860	84.021	1888	33.240
1833	161.495	1861	57.606	1889	99.503
1834	114.068	1862	54.111	1890	82.690
1835	84.011	1863	44.773	1891	124.665
1836	105.258	1864	37.047	1892	79.382
1837	136.261	1865	58.703	1893	–0.952
1838	114.497	1866	75.973	1894	111.169
1839	109.128	1867	89.403	1895	47.549
1840	100.920	1868	73.165	1896	96.430
1841	93.377	1869	110.157	1897	94.164
1842	97.725	1870	44.993	1898	–16.914
1843	99.727	1871	88.436		

Notes: The productivity index is explained in the text of this chapter, and its derivation is described in chapter 8.

Annual productivity index means were calculated (a productivity index number is applied to an individual voyage upon its return), and the mean of these annual means formed the comparison base for this table.

ing for a fixed stock should have had, ceteris paribus, an adverse effect on productivity. Later, as the industry contracted, hunting pressures would have eased and productivity should have risen.

According to the third explanation, the rapid expansion of the 1820s and 1830s must have affected the supply of vessels. During those decades most new whalers were transfers from the merchant fleet. Since carrying goods and hunting whales are quite different activities, vessels built for one were not well designed for the other. As the whaling fleet expanded, this problem would have become more acute. The best-suited vessels would have been chosen first; with expansion, progressively less suited vessels would have been used. In the years

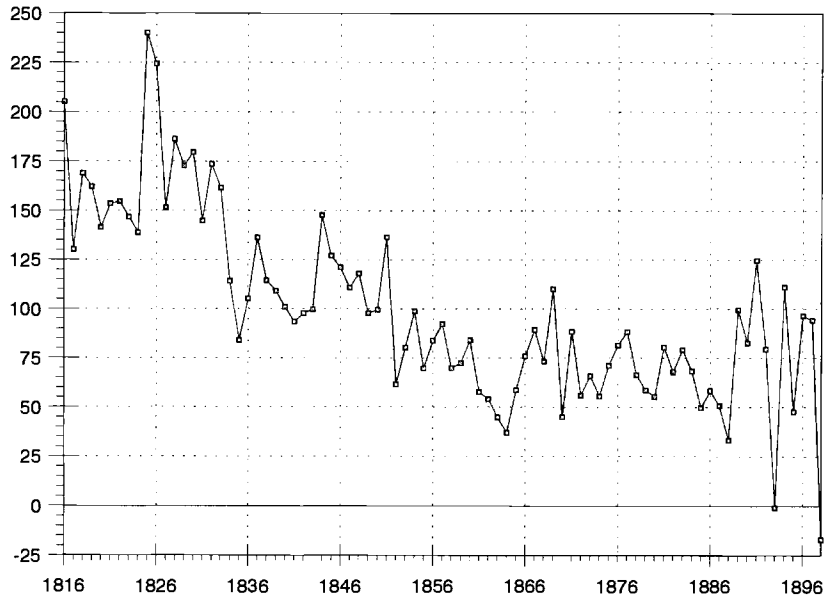


Fig. 1.1 Index of total factor productivity, New Bedford whaling fleet, 1816–98 (mean 1816–98 = 100)
Source: Data are from table 1.3.

of contraction the process would have been reversed. In fact, the reversal should have been accelerated by the innovation of vessels specifically designed for whaling. Also, vessels had to be manned; greater competition would have exerted pressure on the supply of experienced labor. The postwar contraction should have relieved the problem. (These issues are treated further in chapters 5 and 8.)

The Labor Contract. Other labor contracts reward workers on the basis of time worked (wages or salaries) or individual output (piece rates); the whaling contract called for a worker to receive a share (a *lay*) of the net value of the voyage.[15] There was a standard station-to-station structure of lays from captain to boy (a *station* was a position—cooper, carpenter, cook, etc.), but there were vessel-to-vessel differences, and even on the same vessel not all men assigned to the same station received the same lay. The lays of New Bedford captains ranged from 1/8 to 1/20, and it was not atypical for four boatsteerers on a vessel to receive lays varying between 1/70 and 1/100, depending on their ex-

15. The term *lay* is sometimes mistakenly used for the cash value of the share, that is, the lay multiplied by the net value of the catch. A lay was expressed as a fraction (perhaps 1/16 for a captain or 1/200 for a greenhand), but was often referred to as the reciprocal of the fraction—a *sixteen* or a *two hundred.*

perience and skill. The lay system was in use in whaling as early as the seventeenth century. Although it superficially resembles the payment schemes of some agricultural and fishing activities, it was very nearly unique.[16]

A whaleman typically took an advance, but was not entitled to any more of his income until the voyage ended. This sometimes made for stormy relations between officers and crew. (Sixty percent of New Bedford voyages lasted more than two years.) Despite that weakness, the system had two characteristics that contributed to productivity and to profits, if not necessarily to the welfare of crews.

First, from the point of view of the owner, it addressed the riskiness of the business. Of the 787 vessels in the New Bedford fleet, 272 were lost on whaling voyages. Since most made several voyages, the risk of loss was much lower than the 35 percent those figures suggest; nevertheless, more than 6 percent of New Bedford voyages ended in the loss of the vessel. The lay system, like a share-cropping contract, transferred part of this risk from owner to worker. Given the lengths of voyages, there was also a substantial risk that the catch would not be sold profitably. (It is difficult to predict commodity prices years in advance.) Part of this risk too was shifted to the worker. On the other side of the bargain, the contract offered a risk taker a chance for a big win. In 1880 dollars, New Bedford captains averaged an income of $98.31 a month (plus room and board) between 1840 and 1858, but their incomes ranged from a low of $0.66 to a high of $345.34.

Second, profits aside, the form of the contract had a direct effect on productivity. Successful whaling depended on a crew's close and continued cooperation. Observe the crew of a small boat attack a whale and the need is obvious. Less obviously, cooperation was needed when a carcass was cut in and rendered or when a vessel faced heavy winds, weather, or surf. Monitoring cooperation is difficult. Wages provide no incentive to work, let alone to cooperate; the incentive is provided by the threat of dismissal. Place rates reward individual effort, and often penalize cooperation. Under the lay system, each man's pay depended on the performance of the entire group.[17]

Entrepreneurs: Agents and Captains. Team effort characterized the crew of a whaler; a similar, if sometimes strained, interdependence existed between its

16. For a complete analysis of the labor contract and the lay, see Hohman 1928. See also chapter 5 below.

17. Writing about the whalemen of Martha's Vineyard in the late eighteenth century, Crèvecoeur ([1782] 1912, 121) says, "They have no wages; each draws a certain established share in partnership with the proprietor of the vessel; by which economy they are all proportionately concerned in the success of the enterprise, and all equally alert and vigilant." Jefferson (1990, 54) makes the same point about the whalemen of Nantucket before the Revolution: "Their seamen, instead of wages, had a share in what was taken. This induced them to fish with fewer hands, so that each had a greater dividend in the profit. It made them more vigilant in seeking game, bolder in pursuing it, and parcimonious in all their expences."

agent and its captain. When a vessel returned to New Bedford from a whaling voyage, or entered the fleet from the merchant marine or a builder's yard, the agent prepared it for sea. He oversaw the renewal of masts, spars, and rigging and, if needed, the repair of the hull. He replaced lost or broken whalecraft, arranged for provisions, and hired the officers and men of the crew. (Some of these functions, particularly provisioning and hiring, could be subcontracted to others, but the agent kept close track. His profits from the voyage were a share of the proceeds—a strong inducement for him to plan carefully.)

The agent's work was not over when the vessel sailed. The captain made day-to-day sailing and hunting decisions and, in an emergency, might be charged with more fundamental ones, such as deciding whether a storm-damaged vessel was worth repairing. At the same time, in spite of distance and the difficulties of communication, the agent exercised general authority. He saw that cash or access to credit was available for supplies or repairs in distant ports. He cajoled and berated his captains, urging vigorous hunting and niggardly expenditures. On the basis of information received from the captain and whatever other sources he had, an agent might direct a vessel to what he believed would be more productive hunting grounds, or order the captain to sell the catch at a foreign port where prices exceeded those at home, or warn him to avoid resupplying at San Francisco in 1849, lest the crew desert to the gold fields.

The captain ran the vessel while it was at sea. Since the hunt often took him to unexplored waters, which could contain hidden shoals and uncharted islands, he had to be a better navigator and seaman than his peers in the merchant service, who followed charted trade routes. He was charged with refitting, reprovisioning, and recruiting, and, because whaling voyages were long, these demands on his management skills were great. He was also charged with locating whales and with killing them. He had to understand their migration patterns; he had to command a whaleboat during the actual hunt; he had to be as skilled as any whaling mate with a lance or darting gun. It's little wonder his pay averaged more than three times that of a merchant captain.[18]

The Industry's Output. Sperm whales were hunted for sperm oil. In the early nineteenth century, it was valued primarily as an illuminant. Later, as the factory system spread, it was used to lubricate high-speed machinery. Baleen whales were hunted for whale oil and whalebone. Inferior to sperm oil, whale oil was the illuminant of the average consumer, and was used to lubricate heavy machinery. Whalebone, or baleen, is not true bone but fringed plates of cartilage making up a sieve through which the animal screens seawater in order to

18. "[Captain] Spicer needed some new rudder gudgeons made and summoned the blacksmith . . . to do the job. The man confessed that he was actually not a blacksmith, but had called himself a mechanic to escape the [Civil War] draft. . . . Spicer turned to and made the gudgeons himself, thereby demonstrating the versatility of some experienced shipmasters of this era" (Stackpole 1969, 19).

remove food. It was used by humans when a strong but flexible material was needed: in corset stays, whips, and umbrellas, for example.[19]

Sperm oil production increased rapidly from 1815–19 to 1840–44. Then, until the end of the century, it followed a gentle downward trend. The real price of sperm oil tracked production fairly closely: it more than doubled between 1816–20 and the 1850s, but by 1896–1900 had fallen back to its 1816 level. The early history of whale oil production was similar, but the peak of output was not reached until 1845–49, after which time output declined. In the early decades the whale oil real-price profile also paralleled that of sperm oil (its price almost doubled between 1816–20 and 1861–65). Thereafter, although prices declined, the rate of decline was slower; as late as 1896–1900, the real price of whale oil was still one-third above that of 1816–20. (See tables 9.8 and 9.11.)

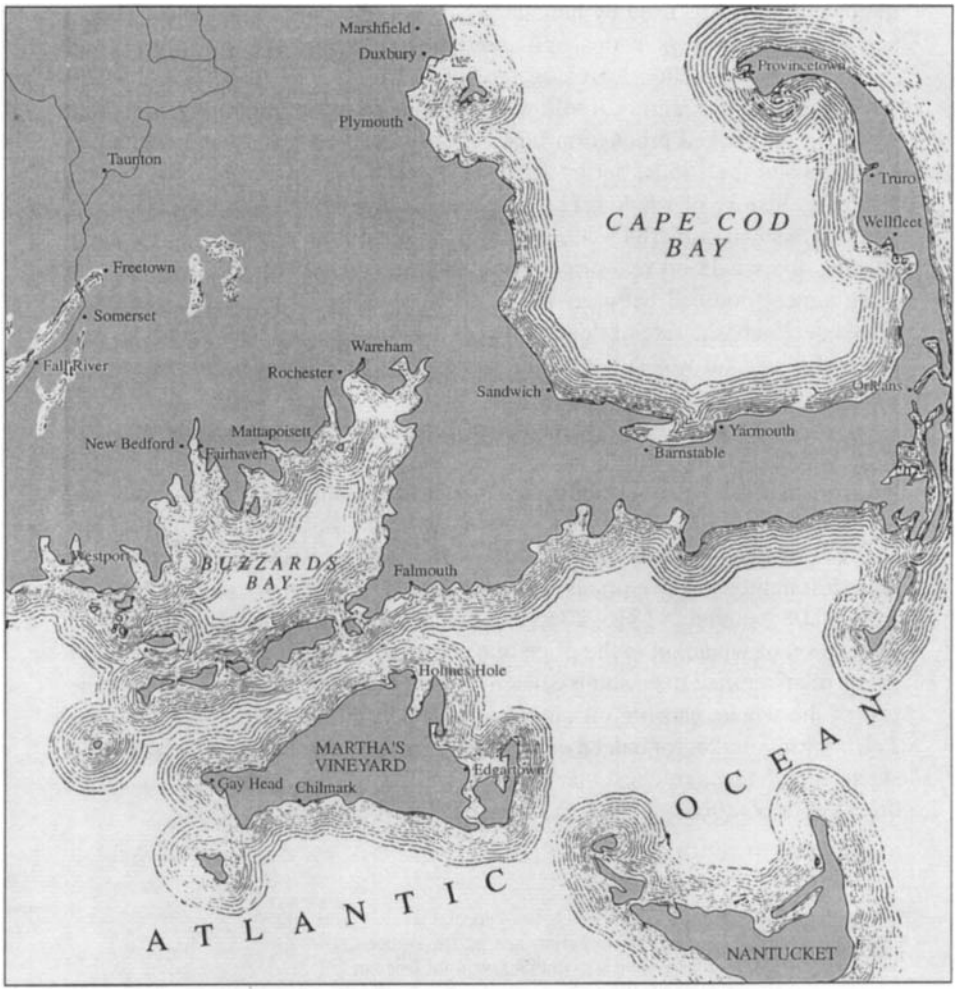
Given the technical complementarity between whale oil and baleen, it is surprising that their output trends are not congruent. Although the pattern for baleen is also one of rise, stability, and decline (see table 9.8), the increase was less steady, and the decline that began in the late 1850s was less rapid. The change in the ratio of the output of oil to that of baleen was no doubt influenced by a shift in their relative prices (see table 9.11).[20] The real price of baleen rose from $0.08 a pound in 1816–20 to $5.15 in 1891–95, and the ratio of the price of a gallon of whale oil to the price of a pound of baleen fell from 4.5 to 0.1.[21] As its relative price rose, some whalemen took only baleen and abandoned the rest of the whale, causing oil output to fall sharply relative to baleen output. The buoyant market for baleen did not last, however. The invention of specialty steels and changes in consumer tastes at the turn of the century combined to drive the price of baleen back to its pre-1820 level.

19. To fifty chosen Sylphs, of special note,
We trust th' important charge, the Petticoat:
Oft have we known that sevenfold fence to fail,
Though stiff with hoops, and armed with ribs of whale.

(Alexander Pope, *The Rape of the Lock,* canto 2, lines 117–20). A late-nineteenth-century advertisement for a bone dealer in Boston lists fifty-three "articles made of whalebone" available from him, including probangs (according to *Webster's New Collegiate Dictionary* a probang is "a slender flexible rod with a sponge on one end used esp. for removing obstructions from the esophagus"), tongue scrapers, divining rods, plait raisers, shoehorns, billiard cushion springs, policeman's clubs, and painters' graining combs.

20. That whaling captains were sensitive to relative prices is suggested by a note in the *WSL* 22 December 1874: "A letter from Capt. Babcock, of brig Myra, of Sagharbor, reports her at St. Helena October 12th, having taken 250 bbls. sperm and 400 do. whale oil since May. After filling all his casks he fell in with sperm whales, and threw overboard 100 bbls. whale oil to make room for the same quantity of sperm."

21. These issues are discussed further in chapter 9. The increase in the price of baleen seems to have been a consequence of an increase in demand and a more pronounced decrease in supply. The decrease in supply was driven by developments in the market for oil. Oil prices were weak enough to discourage whaling; those who persisted earned high prices for their baleen, but not much for their oil.



Principal American whaling ports. Courtesy of the Printing Services department at the University of North Carolina, Chapel Hill.

1.5 Why New Bedford?

Chapters 12 and 13 are concerned with the interrelations between the whaling fleet of the United States and the fleets of other nations, and references are made to both the American and foreign fleets elsewhere as well. Many towns served as home ports for the American fleet (see table 3D.1); in 1850, for example, whalers sailed from twenty-two American ports. The focus of most of this book is on those that sailed from New Bedford.

New Bedford is located about fifty miles south of Boston on the west bank of the Acushnet River, just above the entry of the river into Buzzards Bay—

highway to the Atlantic. Cape Cod is about twenty miles to the east, across the neck of the bay. The two islands, Martha's Vineyard and Nantucket, lie about twenty miles to the south-southeast and fifty miles to the east-southeast, respectively. Within a radius of fifty miles of New Bedford are virtually all of the important East Coast whaling ports, Mattapoisett, Fairhaven, and Dartmouth being the closest.

Between the 1820s and the 1880s the Americans dominated world whaling. It is generally agreed that the nation's proportion of the world's total activity had reached about 60 percent by the mid-1830s, and averaged about 70 percent throughout the 1840s and 1850s.[22] New Bedford stood, in relation to American whaling, much as America did in relation to world whaling (see tables 1.1 and 1.2). In the eighteenth century Nantucket had been the center of American whaling. Its fleet was destroyed in the Revolutionary War, recovered, and was destroyed again in the War of 1812. Once again it recovered, but was soon surpassed in size by the New Bedford fleet, and not long after went into absolute decline, due to a constellation of economic and ecological misfortunes.[23] By 1823 New Bedford had become the nation's leading whaling port. Over the years 1816 to 1906, it accounted for more than 45 percent of total U.S. whaling output (see table 1.2). From the mid-1850s to the mid-1880s its share was much higher, ranging between 55 and almost 80 percent. At the turn of the century, New Bedford had relinquished its premier standing to San Francisco, but by then the tonnage of the U.S. fleet had fallen by almost 95 percent.

Not only did New Bedford contribute a large fraction of the total American whaling effort, but also the voyages of its vessels represent a composite of all American ventures. Specialization, in whales sought or grounds hunted, characterized the fleets of many ports. Nantucket was noted for its sperm whalers, Provincetown for its plum'pu'dn'rs employed on short voyages in the Atlantic, New London for the right-whale fishery and for a willingness to contend with the icy seas of Davis Strait and Hudson Bay in the search for bowheads, Sag Harbor and Stonington for the northern and southern right-whale fisheries. New Bedford vessels went everywhere. Given the relative size and the ubiquity of the New Bedford fleet, it is a reasonable proxy for the American industry as a whole.

22. In 1859 *Hunt's Merchants' Magazine,* quoting an 1834 article in the *North American Review* and the "Annual Report of the Secretary of State on Foreign Commerce for 1858," estimated that 400 of the 700 ships engaged in whaling worldwide in 1834 were American registered and that the figures for 1858 were 661 of 900 (Growth of the Whale Trade 1859, 475–76). Scammon ([1874] 1968, 212) estimates that the figures for 1842 were 652 American registered of 882 worldwide. Clark (1887a, 2:192) says that in 1846 the United States accounted for 729 vessels of a world whaling fleet of nearly 1,000, in 1880, 171 out of "not more than" 250.

23. One problem was the sandbar at the mouth of Nantucket harbor, which kept larger vessels out and became more troublesome as time went by. Another was the expense both of gathering supplies to outfit vessels and of dispersing oil, Nantucket being an island. See Mitchell 1949, 7; Hohman 1928, 305–6. Morison (1961, 315) quotes Emerson on New Bedford's success: "New Bedford is not nearer to the whales than New London or Portland, yet they have all the equipments for a whaler ready, and they hug an oil-cask like a brother."