The Decline of U.S. Whaling: Was the Stock of Whales Running Out?

LANCE E. DAVIS, ROBERT E. GALLMAN, and TERESA D. HUTCHINS

¶ *Re-emerging from the disruption caused by the Revolution and the War of 1812, the American whaling industry grew to dominate the seas between 1820 and 1860, only to suffer a severe decline during and after the Civil War. In the following article, Professors Davis, Gallman, and Hutchins examine the hypothesis that the U.S. whaling industry collapsed because the stock of whales was being depleted. After investigating the size of the original whale populations, their breeding habits, and the estimates of whales taken during the nineteenth century, the authors conclude that the overfishing of whales of various species occurred either not at all or too late to have been a contributing factor in America's whaling decline.*

At the end of the War of 1812 the American whaling fleet was in disarray. It had been the victim of wars—military and economic—between England and the United States beginning with the Revolution; only those Americans with very long memories could recall the successes previously achieved. In the years following 1814, however, the fleet began to reassemble. In the crucial northern grounds it quickly attained productivity levels far superior to those of the British fleet, which had dominated the whaling industry for more than thirty years. The Americans employed smaller crews than did their British rivals, but crews of higher quality. They shipped many able seamen and artisans of various types, whereas the British recruited chiefly green hands. The artisanal skills aboard American vessels permitted the U.S. whalers to maintain try works to boil down blubber and to do a certain amount of refitting while at sea, so that their fleet could hunt two seasons in the north—Davis Strait, Hudson's Bay, the North Atlantic—and an intervening season in the South Atlantic before returning to port. The British, on the other hand, came home after each season. Their vessels

LANCE E. DAVIS is Mary Stillman Harkness Professor of Social Science, California Institute of Technology. ROBERT E. GALLMAN is Kenan Professor of Economics and History, University of North Carolina, Chapel Hill. TERESA D. HUTCHINS is assistant professor of economics at Ramapo College of New Jersey.

Mssrs. Davis and Gallman are also research associates of the National Bureau of Economic Research. When the final draft of this article was written, Gallman was Senior Visiting Scholar, Olin Program on Capital Formation, NBER. Funding for the research underlying the paper came from the NBER (programs on Productivity and Industrial Change in the World Economy, and the Development of the American Economy), the National Science Foundation, and the Kenan Foundation. The authors thank Emil Friberg for research assistance, Stanley Engerman, Haven Wiley, Karin Gleiter, and David Guilkey, who read an earlier version of this article and provided helpful suggestions, and John Bockstoce, who kindly allowed the authors to see his book in proof. The project from which this article is drawn is being conducted within the Carolina Population Center.

Business History Review 62 (Winter 1988): 569–595.

brought back unprocessed blubber, and refitting was carried out in port. Their northern fleet was therefore actively hunting for only about three months out of the year and bringing back a raw product, whereas the Americans remained at sea for nearly eleven months out of twelve and returned with a semi-finished product. American factor inputs—vessels and men—were not only productive, but also cheap, placing the American industry in a strong position to capture the world market in whale products.

The British government responded to the revival of American whaling by protecting the domestic market and by subsidizing British firms. These actions may have slowed, but they did not halt, the decline of the British fleet. By the mid-1840s, when protection and subsidy were abandoned, British whalers had virtually disappeared from the seas, and the Americans controlled the industry.[1]

The golden age of American whaling lasted from about 1820 to 1860, when it was brought to a close by the Civil War. Confederate raiders demolished many of the whaling ships that were at sea when hostilities broke out and discouraged new ventures by owners whose vessels were in port. Recovery after the war was substantial, but never again was the industry as large as it had been in the 1850s. By the end of the century, it was minuscule. In a period of eighty years the U.S. whaling fleet had passed from insignificance to world dominance and back again to insignificance.[2]

SUPPLY AND DEMAND

The spectacular rise of U.S. whaling was due not only to the exceptional productivity and low factor costs of the fleet, and thus its ability to displace British whalers, but also to favorable changes in domestic and foreign markets. The process of industrialization in the United States and Europe led to dramatic increases in the demand for the various products of the fishery. Sperm oil—produced by boiling the blubber of sperm whales—is a superb lubricant of light, fast-moving machinery, such as spindles; the oil taken from baleen whales—known as whale oil or train oil—lubricated heavy machinery. Both types were also refined and used for illumination: sperm oil in lighthouses, street lamps, and public buildings; whale oil for lamps in the home. Whale oil figured in the production of cleansing agents and other chemical products, and

[1] Lance E. Davis, Robert E. Gallman, and Teresa D. Hutchins, "Technology, Productivity, and Profits: British-American Whaling Competition in the North Atlantic, 1816–1842," *Oxford Economic Papers* 39 (Dec. 1987): 738–59; Gordon Jackson, *The British Whaling Trade* (London, 1978), chaps. 6, 7.

[2] Elmo Paul Hohman, *The American Whaleman* (New York, 1928), 306; Lance E. Davis, Robert E. Gallman, and Teresa D. Hutchins, "The Structure of the Capital Stock in Economic Growth and Decline: The New Bedford Fleet in the Nineteenth Century," in *Quantity and Quiddity: Essays in U.S. Economic History in Honor of Stanley Lebergott*, ed. Peter Kilby (Middletown, Conn., 1987).

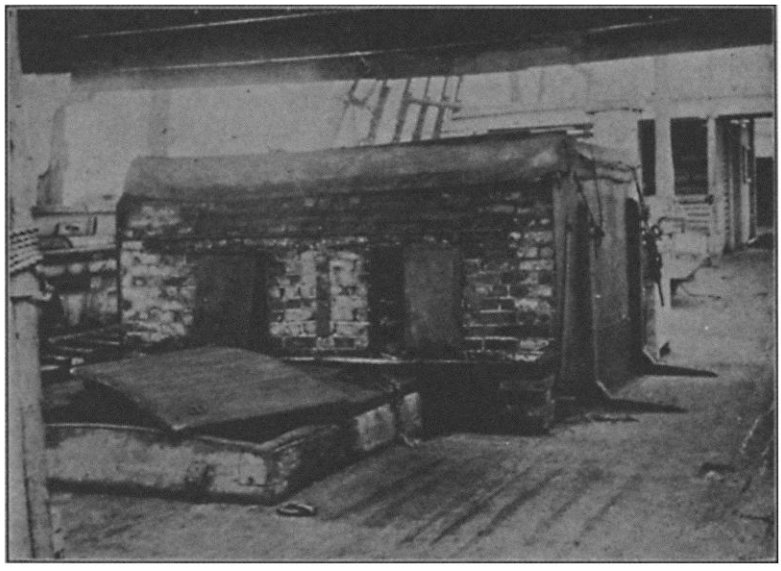
FRONT STREET, NEW BEDFORD, 1869

Although this seems an imposing sight to the modern viewer, the American whaling fleet after the Civil War was considerably reduced from its heyday earlier in the century. In addition to losses to Confederate raiders, a contingent of whaling ships was deliberately sunk off the southern coast during the war to serve as a blockade. (Reproduced from Old Dartmouth Historical Society Sketch, *number 77, plate XX, Baker Library Manuscripts and Archives, Harvard Business School. This pamphlet contains material from the Whaling Museum, New Bedford, Mass.)*

the waxy substance called spermaceti, taken from the head of the sperm whale, made excellent candles. Finally, the flexible sieve-like material found in the mouths of baleen whales (baleen, or whalebone) was used industrially where today plastics and spring steel serve. The growth of the industrial sector therefore expanded the markets for whale products directly, while the increases in population, in the number and size of cities, and in per capita income that were associated with industrialization raised the demand for illuminants and other final products made from the blubber and bone of whales.[3]

Demand changes are also usually assigned a major role in explaining the collapse of the American whaling industry. Coal oil, manufactured gas, camphene, improved lard oil products, and linseed oil all entered the illuminant and chemicals markets as rivals of the products of the whaling industry before the Civil War. Petroleum became a competitor in both illuminant and lubricant markets during and after the war. As the quality of petroleum-based lubricants improved in the postwar decades, and as petroleum prices plummeted with the discovery of new reserves, the whalers were put under intense competitive pressures. The

[3] Davis, Gallman, and Hutchins, "Technology, Productivity, and Profits"; Teresa D. Hutchins, "An Investigation of the American Whale Fishery" (Ph.D. diss., University of North Carolina, Chapel Hill, 1988).



TRY WORKS, c. 1903

One of the great advantages of the American whaling fleet was the ability of ships to process blubber into oil during the voyages. Try works were essentially large brick kilns built on deck, in which the blubber was boiled down to oil, which then could be stored in barrels. (Reproduced from George Francis Dow, Whale Ships and Whaling: A Pictorial History of Whaling during Three Centuries [*Salem, Mass., 1925*], *413.)*

fleet rapidly shrank. Baleen prices, however, remained high and continued to rise. In response to these developments, the distribution of effort among hunting grounds and whale species shifted, as did the structure of output: whalebone became the leading product. The end of the industry was thereby modestly delayed; it came early in the twentieth century with the invention of spring steel and the widespread substitution of this product for baleen.

Supply-side factors also appear in the traditional account of U.S. whaling decline. It has been asserted that overhunting reduced the stocks of whales and sharply increased production costs. The putative decline in whale stocks is also said to have reduced whaling "wage rates" relative to wage rates in other sectors of the economy, thereby lowering the quality of whaling crews. The argument runs this way: The decline in whale stocks diminished the financial returns of the typical whaling voyage. Since crewmen were paid by the lay system—shares in net revenues from each voyage—smaller financial returns meant lower "wage rates." The pool of workers from which whaling agents could recruit crews thus became smaller and poorer. Improvements in opportunities in other sectors of the economy are said to have exacerbated this

problem.[4] Reductions in the stock of whales, then, are believed to have raised costs both directly, by increasing search costs, and indirectly, by contributing to the deterioration of the quality of crews.

Evidence on the real prices of whale products and on the productivity of whalers suggests that the demand-side explanation may be the more powerful. The real prices of whale oil and sperm oil rose, and the productivity of New Bedford whalers fell, during the years in which the fisheries expanded and were prosecuted most intensively, but when the industry contracted, real prices fell and productivity rose.[5] This evidence suggests a demand curve moving first to the right and then to the left and interacting with a stable, upward-sloping long-run supply curve.

The evidence does not, however, rule out the possibility of a leftward movement of the long-run supply curve during the period of industry contraction. To sort these matters out, one would be obliged to fit appropriate supply and demand curves to the data. One of the principal factors said to be at work on the supply side—the depletion of whale stocks—can be approached more directly, however, and that exercise is the purpose of this article.

The problem of U.S. whaling decline is more complex than the précis rendered above suggests. Whaling did not stop when American whalers withdrew. The Norwegians entered the industry in larger numbers than before and the hunt continued, although for new reasons and in new ways. The Norwegians catered to markets different from those the Americans entered (whale meat and cooking oils markets), pursued a new group of whales (the fast-swimming rorquals, whales that could rarely

[4] See Hohman, *The American Whaleman*, 290, 297–300; John R. Bockstoce, *Whales, Ice, and Men: The History of Whaling in the Western Arctic* (Seattle, Wash., 1986); John R. Bockstoce and Daniel B. Botkin, "The Historical Status and Reduction of the Western Arctic Bowhead Whale (Baleena mysticetus) Population by the Pelagic Whaling Industry, 1848–1914," *Scientific Reports of the International Whaling Commission*, Special Issue No. 5 (1983): 107–41; Robert Burton, *The Life and Death of Whales*, 2d ed. (New York, 1980), 132–34; George W. Schuster, "Productivity and the Decline of American Sperm Whaling," *Environmental Affairs* 2 (Fall 1972): 345–57; M. J. Maran, "The Decline of the American Whaling Industry" (Ph.D. diss., University of Pennsylvania, 1974); John R. Spears, "Introduction" to William N. Davis, *Nimrod of the Sea* (Boston, 1926), xviii; Foster Rhea Dulles, *Lowered Boats: A Chronicle of American Whaling* (New York, 1933), 221; Charles Nordhoff, *Whaling and Fishing* (New York, 1895), 161, 162.

[5] Davis, Gallman, and Hutchins, "The Structure of the Capital Stock"; Lance E. Davis, Robert E. Gallman, and Teresa D. Hutchins, "Productivity in American Whaling: The New Bedford Fleet in the Nineteenth Century," in *Markets in History: Economic Studies of the Past*, ed. David Galenson (New York, 1989). The productivity measurements refer to total factor productivity of New Bedford whalers. (New Bedford was the principal U.S. whaling port.) They were derived from a translog multilateral index taken from Douglas W. Caves, Laurits R. Christensen, and Erwin W. Diewert, "Multilateral Comparisons of Output, Input, and Productivity Using Superlative Index Numbers," *The Economic Journal* 92 (March 1982): 73–86. The form of the index is:

$$\ln\eta_{kn} = 1/2\ \Sigma_i(R_i^k + \bar{R}_i)\ (\ln Y_i^k - \overline{\ln Y_i}) - 1/2\ \Sigma_n\ (W_n^k + \bar{W}_n)(\ln X_n^k - \overline{\ln X}_n),$$

where: the R's are the shares of total revenue produced by the various outputs (sperm oil, whale oil, baleen);

the Y's are the quantities of individual outputs;

the W's are factor shares in income (labor income, property income);

the X's are quantities of factor inputs (man-months, vessel ton-months);

the $\bar{R}$'s, $\bar{Y}$'s, $\bar{W}$'s, and $\bar{X}$'s are average values across all years.

be taken by American methods), hunted a different region (the Antarctic), and employed different techniques. Was American decline a consequence of a failure to penetrate the new markets? Or was it due to the depletion of the stocks of whales that the Americans had traditionally pursued, coupled with a failure to adopt the hunting methods necessary to capture the blue, fin, sei, and minke whales being taken by the Norwegians?[6] In this article we are interested only in the first part of the second question: "was it due to the depletion of the stocks of whales that the Americans had traditionally pursued?"

Although many students of the subject have asserted that the American fisheries contracted during the nineteenth century because whales became scarce (see note 4), we have been unable to discover comprehensive estimates of the relevant whale populations at the end of the century. There are, however, estimates of the stocks of whales before intensive hunting began, and there is evidence of the reproductive capacity of whales. Our approach to the problem of depletion, then, is to compare the numbers of animals killed by whalers in the nineteenth century with pre-existing population sizes, taking into account potential levels of reproduction.

The impact of depletion on the whaling industry (if any) must have been a function not only of the decline in whale numbers, but also of the sensitivity of whaling productivity to diminished numbers. There is the further possibility that hunting led to changes in the behavior of whales that reduced their reproductive capacity or made them more difficult to capture. In this article we are concerned chiefly with the issue of depletion, conceived of as a decline in numbers. We also consider briefly the possibility that whale reproductive behavior changed, as well as the proposition that whales learned to avoid hunters, but we reach no final conclusions on these matters. A detailed treatment of the impact of depletion (if any) and altered whale behavior (if any) on whaling productivity must be left to another occasion.[7]

ESTIMATING WHALE POPULATIONS

Whales are much-studied creatures. Marine biologists know a considerable amount about the feeding habits, migration patterns, social

[6] Davis, Gallman, and Hutchins, "The Structure of the Capital Stock"; J. N. Tønnessen and A. O. Johnson, *The History of Modern Whaling*, trans. from the Norwegian by R. Christophersen (Berkeley, Calif., 1982). The only rorquals that the Americans hunted with success were the humpbacks. The Norwegians concentrated on the blue, fin, sei, and minke whales, although they also took other baleens, such as humpbacks and probably rights.

[7] The question is pursued in another context in Davis, Gallman, and Hutchins, "Productivity in American Whaling," which analyzes variations in productivity among more than 2,300 New Bedford whaling voyages between 1820 and 1896 by means of multiple regression analysis. The results suggest that changes in the quality of whaling crews may have affected productivity, but that hunting pressures on the whale stocks probably did not. Measures of hunting pressure (essentially lagged indexes of the number of animals killed) were computed for baleens and sperms by hunting ground.

organization, mating customs, fertility levels, and mortality rates of the principal groups of hunted whales. Furthermore, since whales have been endangered, much effort has gone into estimating the effects of hunting and the capacity of whale stocks to recover from overhunting. In part such work has rested on direct observation and in part it is the result of theoretical model building. California gray whales, a group that has been protected and that has successfully recovered from earlier overhunting, have been the subject of intense observation.[8] At the same time the demography of particular groups of whales has been modeled.[9] These models have helped predict how whale stocks would grow in the absence of hunting, the forces that would bring growth in a given group to a halt, and the population level and structure that could produce the maximum sustainable yield—that is, the largest number (or weight) of whales of a given type that could be taken each year without reducing the stock of these whales. The maximum sustainable yield occurs at a population level and structure at which the positive disparity between births and deaths is maximized, and it depends on the relative abundance of food for the whales, the feed/whale ratio.

In general, the models assume that, since the whale has almost no natural enemies other than man, in the absence of hunting the size of a given whale population will depend on the available feed: krill in the case of baleen whales (right whales, Arctic bowheads, grays, and humpbacks, among the whales hunted in the nineteenth century), and squid and other such creatures in the case of toothed whales (sperm whales). The adjustment process—a process that leads the population to expand in the presence of extra feed and to cease to expand when the feed is being appropriately exploited—is believed to turn on the age of sexual maturity, which is thought to fall when feed is abundant and to rise when it is scarce. (The models sometimes express this phenomenon as changes in the pregnancy rate of females above a given age.) It should be said, however, that not all of the parameter estimates are firmly based. There is also little or no direct evidence of the characteristics of the stationary population. Life expectation in the absence of hunting is not well established, and the impacts of hunting on fertility are not known with certainty.[10]

The demographic models make it possible to estimate the levels of whale populations at a date before hunting began, if the supplies of krill and squid at that date are known. Presumably such supplies have varied with climatic changes. The relationships among different types of whales competing for the same feed must also be established, because those

[8] See, for example, D. W. Rice and A. A. Wolman, *Life History and Ecology of the Gray Whale*, American Society of Mammalogists, Special Publication 3 (Stillwater, Okla., 1971).

[9] See, for example, the treatment of the sperm whale model in Sir Sydney Frost, *The Whaling Question* (San Francisco, Calif., 1979).

[10] Ibid.

relationships might have been upset by the sequence of whaling. The population of sei whales, for example, apparently increased when the fin and blue whales were initially hunted.[11]

Despite these difficulties, the procedure can be applied more safely to whales than to other animals. As K. Radway Allen points out, whales

> would be less susceptible to such changes [in food supplies, due to climatic changes] than many animals. Compared with fish . . . whales have a much longer life cycle than nearly all fish, and their reproductive pattern, with an average of less than one young per year, obviously does not provide the flexibility required to produce the major changes in strength of cohorts which can occur with fish. Compared with terrestrial mammals, whales would seem to be living in a much more stable environment, which is not subject to drastic climatic changes such as droughts, that may occur on land.[12]

In any case, estimates of population levels before the rise of American whaling have indeed been made. Although they differ a good deal from one to the next, there is some clustering and some degree of consensus, and useful conclusions can be drawn from them. Four sets of estimates are presented in Table 1.[13]

SPERM WHALES

The data with respect to sperm whale stocks appear to be particularly complete. (They omit the North Atlantic populations, but those would be small in any case.) The "original" sperm whale stock (total population, exclusive of the North Atlantic) can be set at between 1.8 million (Scharff) and 2.4 million (Frost, Allen). Six hundred thousand is a wide range, but it is not remarkably wide, given the problems of estimation involved.

Even 1.8 million is a very large figure relative to the number of whales killed by sperm whalers in the nineteenth century. According to Charles Scammon, during the period of intensive American whaling (1835 through 1872), U.S. whalers caught about 147,000 sperm whales and killed but lost another 15,000. Scammon based his estimate on the assumption that the average whale taken yielded 25 barrels of oil and

[11] D. E. Gaskin, *The Ecology of Whales and Dolphins* (Exeter, N.H., 1982), 319.

[12] K. Radway Allen, *Conservation and Management of Whales* (Seattle, Wash., 1980), 19.

[13] James E. Scharff drew most of his data from draft reports of the Food and Agricultural Organization. Frost and Allen used data from Raymond Gambell (a compilation published in 1976 in *Mammal Review*) and from the International Whaling Commission, although they apparently filled some gaps with their own estimates. Frost also drew on the work of G. P. Kirkwood. The work of Frost and of Bockstoce and Botkin appears to be particularly careful and well-founded. Frost's estimates are available in great geographic detail, which makes them particularly useful.

Whale stock estimates most often refer to the "exploitable stock" (that is, to mature animals), but sometimes adjustments are made to reflect the size of the full population. The conversion coefficient from "exploitable" to "total" population used to generate the figures in Table 1 (2.0) is taken from Scharff, "International Management," 332. Scharff uses it to convert both current (i.e., disequilibrium) and initial (i.e., equilibrium) figures, which is a little surprising. Allen, *Conservation and Management of Whales*, 19, also gives a ratio of 2 to 1 between the original total populations of sperm whales and the original exploitable populations.

TABLE 1

Estimated Whale Stocks before the Advent of Intensive Hunting (000)

	SCHARFF	FROST	ALLEN	BOCKSTOCE & BOTKIN
Southern Hemisphere				
Rights	30–40 +	100 + *	(100 +)	
Humpbacks	100–150	100*	130	
Sperms	1,168	578*	1,250	
North Pacific				
Bowheads	10–20?	25 + [a]	20	30
Other Rights	unknown	unknown	(20)	
Grays	11–12	15[b]	(20 +)	
Humpbacks	unknown	unknown	13	
Sperms	612	580*	1,150	
North Atlantic				
Bowheads	10?	7[c]	n.a.	
Other Rights	unknown	unknown	n.a.	
Grays	not present	unknown	n.a.	
Humpbacks	4 + ?	1–2*[d]	n.a.	
Sperms	unknown	unknown	n.a.	
TOTALS				
Bowheads	20–30	32	20[e]	30[e]
Other Rights	30–40 + [e]	100*[e]	120 + [e]	
Grays	11–12	15[e]	20 + [e]	
Humpbacks	104–154[e]	101–102*[e]	143	
Sperms	1,780[e]	1,158*[e]	2,400[e]	

Notes: All of the figures refer to stocks before intensive hunting began, except for Frost's data for sperm whales in Division 5 of the southern hemisphere (date: 1946), and the Western Division of the Pacific (date: 1910), and bowheads in the North Pacific—really the Bering Strait and Okhotsk Sea (date: 1850, two years after the ground was opened for hunting). The original stocks in all three cases were almost certainly larger than the figures in the table show.

? and ( ) are taken from the sources and presumably are expressions of uncertainty.

* Exploitable stocks only. The other estimates apparently refer to the entire population, although the authors are not always as clear as one would wish. Scharff's own instructions have been used to convert his figures from exploitable stock data to total population estimates.

[a] Bering Strait and Okhotsk Sea

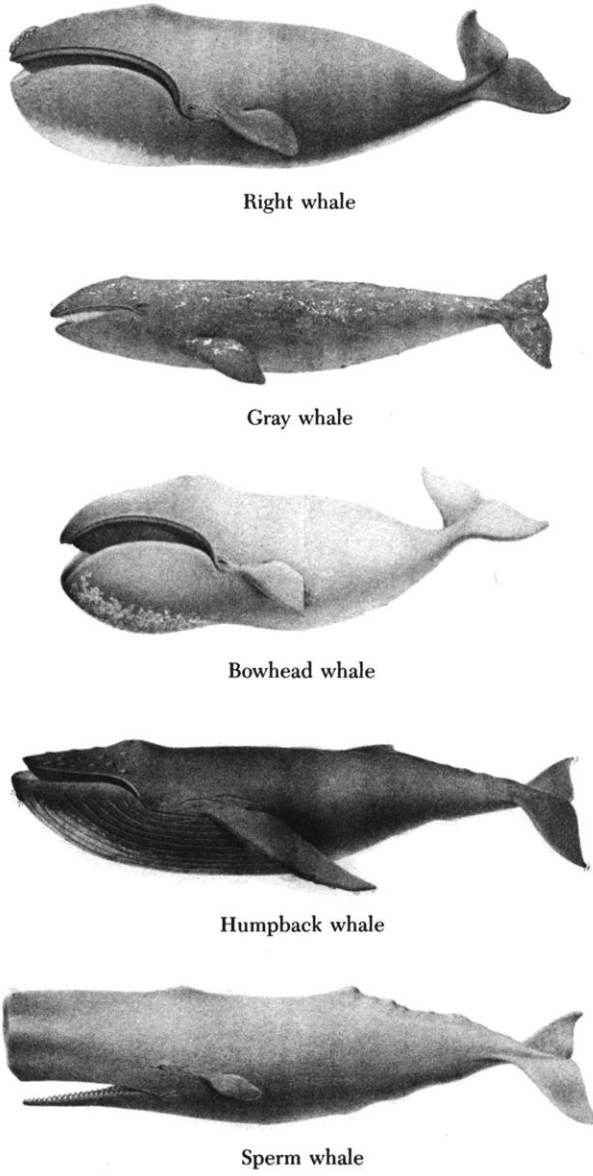
[b] Eastern stock only

[c] Davis Strait and Hudson's Bay

[d] Western stock only

[e] Incomplete totals (see previous panels in the table)

Sources: James E. Scharff, "The International Management of Whales, Dolphins, and Porpoises: An Interdisciplinary Assessment," part one, *Ecology Law Quarterly* 6 (1977): 332; Sir Sydney Frost, *The Whaling Question* (San Francisco, Calif., 1979), 266–67; K. Radway Allen, *Conservation and Management of Whales* (Seattle, Wash., 1980), 19; John R. Bockstoce and Daniel B. Botkin, "The Historical Status and Reduction of the Western Arctic Bowhead Whale (Baleena mysticetus) Population by the Pelagic Whaling Industry, 1848–1914," *Scientific Reports of the International Whaling Commission*, Special Issue No. 5 (1983): 107–41.



TYPES OF COMMONLY HUNTED WHALES

These illustrations are reproduced from the drawings by Charles M. Scammon in his The Marine Mammals of the Northwestern Coast of North America *(1874).*

that a number equal to 10 percent of those captured escaped the whalers, but subsequently died from their wounds. Given these assumptions and the amount of oil brought back by the whalers, it was possible for him to estimate the total number of sperm whales killed.

The 25-barrel figure may be too low an appraisal of the average yield from sperm whales. Estimates ranging upward to an average of 45 barrels have appeared in the literature. According to the firmest set of figures, which covers the period 1800–1929, the whales taken by American vessels averaged 33.6-barrels of oil. Applying this value to the oil output data for the years 1804 through 1900, and assuming with Scammon that whales killed but lost amounted to about 10 percent of those captured, one obtains an estimate of 177,000 sperm whales destroyed by Americans in the years 1804 through 1900. Since Americans probably accounted for about three-quarters of the sperm whales taken in this period, the total number killed by all whaling fleets would come to about 236,000. Substituting Scammon's 25-barrel average yield for the 33.6-barrel figure employed above raises the number to 331,000, whereas adopting the equally well-founded average yield of 45 barrels lowers it to 184,000.[14] That is, whalers appear to have killed, in total, between 8 and 18 percent of the initial stock, and the harvest was distributed across ninety-seven years. Even the largest single-year American catch was considerably less than half of one percent of the initial stock and was only a small fraction of the maximum sustainable yield that lay within the procreative capacity of sperm whales.[15] Modern levels of sperm whale populations suggest that damage by whaling was not disastrous.

Of course the population of sperm whales was distributed across the Atlantic, Pacific, and Indian oceans. If whalers concentrated on individual hunting grounds until stocks were depleted, and only then moved on to others, even the limited take described above might damage the reproductive capacity of certain sperm whale groups. Two sets of data—both fairly small—suggest that this may have happened in the Indian Ocean and in the Sea of Japan, but the evidence is ambiguous and may mean not that whales became less numerous, but that they became more

[14] Alexander Starbuck, *IIistory of the American Whale Fishery from Its Earliest Inception to the Year 1876* (Waltham, Mass., 1878), 661; Charles M. Scammon, *The Marine Mammals of the Northwestern Coast of North America* ([1874]; rpt., New York, 1968), 244; Charles H. Stevenson, "Aquatic Products in Arts and Industries," appendix to the 1902 *Report of the Commission on Fish and Fisheries* (Washington, D.C., 1904), 187, 192, 204; Peter B. Best, "Sperm Whale Stock Assessments and the Relevance of Historical Whaling Records," in *Scientific Reports of the International Whaling Commission*, 45, 46. According to Best, the United States accounted for 77 percent of the total output of the United States, Britain, and the British colonies. The production of all other whaling nations was negligible. The figures for Britain and her colonies are likely to be too low.

[15] This capacity was probably never achieved, however, since the whale population never fell far enough below the carrying capacity of the food supply to set off those forces that would have raised fertility to its maximum level. See Frost, *The Whaling Question*, 256–60; Davis, Gallman, and Hutchins, "Productivity in American Whaling."

wary. In any case, there is reason to believe that the problem of a scarcity of whales—if it existed at all—did not affect the fishery as a whole. Peter Best's study shows no time trend in the average yield per whale over the years 1816–29 through 1900–1925. If the sperm whale population had been placed under pressure, the average yield surely would have fallen, if only because the density/fertility mechanism would have come into play.[16] Furthermore, there are other reasons to think that individual hunting grounds were not depleted on a large scale.

Sperm whales are polygamous. A heterosexual pod—a group traveling together—typically consists of a bull, ten or fifteen cows, and their young, including some full-grown but socially immature bulls (not yet competitive with the patriarch). In addition, two or three mature bulls trail the pod at a safe distance, waiting to take over the cows when the patriarch dies or becomes disabled. All other mature bulls have been driven away by the patriarch and now travel alone or in male pods.[17] The male pods and the single males could be taken by whalers without adversely affecting the reproductive power of the population. Indeed, successful hunting of these males might actually raise the reproductive power of the group by raising the feed/whale ratio and, thus, lowering the age of sexual maturity.[18] The chances of hunters finding male pods appear to have been about equal to their chances of finding heterosexual pods. Moreover, since mature male sperm whales are three to four times as large as females, they would have been preferred by hunters. Similarly, having stumbled on a heterosexual pod, hunters would choose—if they had the option—to take males. As long as they did not leave the pod totally bereft of socially mature males, the reproductive powers of the pod would be left undisturbed.[19]

There is persuasive evidence that hunters did take disproportionately large numbers of mature bulls. Phoebe Wray and Kenneth Martin have

[16] Phoebe Wray and Kenneth R. Martin, "Historical Whaling Records from the Western Indian Ocean," 226; J. L. Bannister, Sandra Taylor, and Helen Sutherland, "Logbook Records of 19th-Century American Sperm Whaling: A Report on the 12-Month Project, 1978–79," 248–52; and Best, "Sperm Whale Stock Assessments," 46, all in *Scientific Reports of the International Whaling Commission*.

[17] Frost, *The Whaling Question*, 19–21 and Appendix 8. See also L. Harrison Matthews, *The Natural History of the Whale* (New York, 1978), chap. 8, but especially 165–66. Matthews points out that the patriarch-dominated pod is formed only "during the breeding season when he [the bull] serves an average of fourteen cows." The bull then leaves, and the pod is matriarchal until the next breeding season. Between breeding seasons, patriarchs travel alone. Pods of socially immature, but physically mature, males travel together, occasionally with socially mature bulls who have yet to win harems. Sometimes several pods join together to travel as a school. Burton gives a similar account in *The Life and Death of Whales*, 76.

[18] That would be the case if the captured bulls were within the normal migration routes of the nursery pods. Bulls sometimes leave these precincts and travel far north to squid-rich, but cow-poor, waters. Since these areas are off the nursery migration routes, the taking of these bulls would not have had a direct and immediate effect on the food supplies of the nursery pods.

[19] By the account of Matthews, *The Natural History of the Whale*, the pod would recruit a bull in the next breeding season in any case, and perhaps even in the same breeding season, if the attendant bulls were taken in that period. There is evidence that whalers have, in fact, taken more males than females. See Frost, *The Whaling Question*, 103–4, and Friends of the Earth, *The Whaling Manual*, 153, which show that substantially more than half of the recent sperm whale populations consists of females. These data, however, reflect modern hunting practices and modern rules. It should also be said that females are easier to take, because they are smaller and because they will not abandon their calves. Bull sperms are often pugnacious, as any reader of *Moby-Dick* is well aware. See the discussion of baleens later in this article.

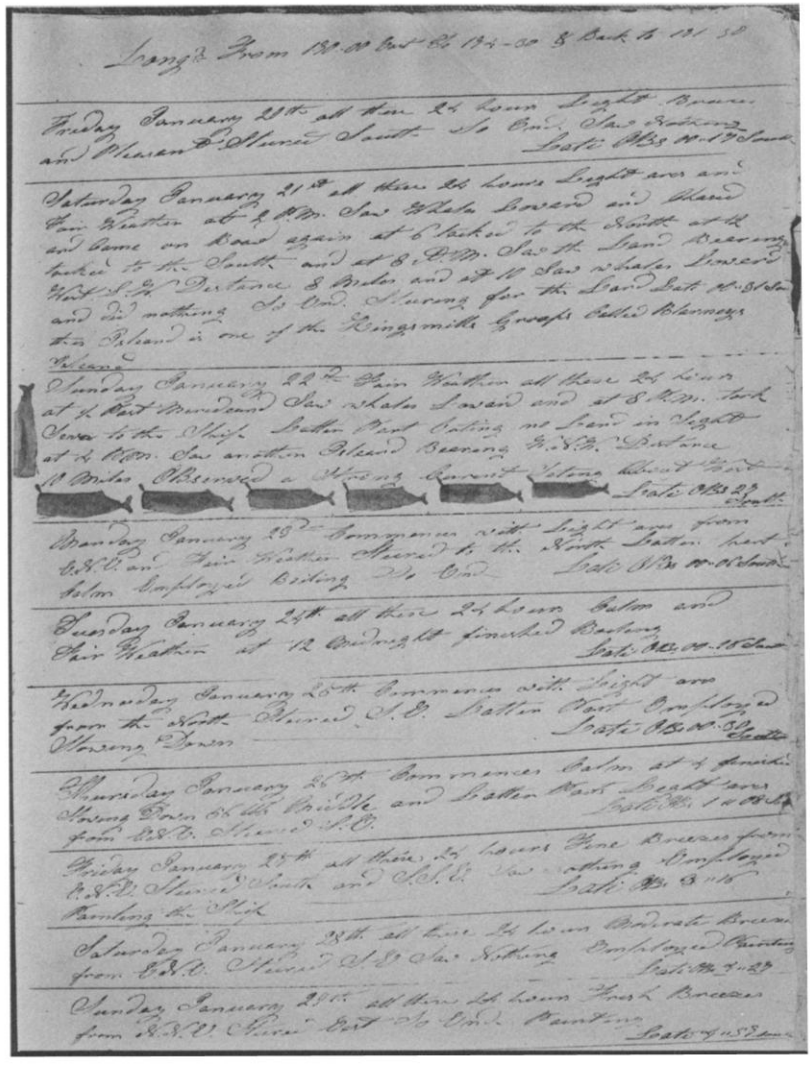
gathered together the records of nineteen sperm whaling vessels over the years 1800 through 1887, in which various bits of information about captured whales are given: in 13 instances, size or sex alone; in 98 cases, the yield in oil of each whale taken; in 129 cases, the number and total yield of the whales killed on a given day ("8 av 44 bbls @" or "5 whales 150 bbls total"); in still other cases, the recovery of dead whales ("stinkers," as the whalemen called them).[20] The last two classes of information are of doubtful usefulness for present purposes. Presumably some dead whales discovered floating in the sea by whalemen had died as a result of previous assaults by whalers, but not all. Consequently, information about stinkers should not be used to infer the choices hunters were making about the types of whales to be taken. The information concerning groups of whales is also of limited value, since in no case can the distribution of the catch among size classes of whales be unequivocally established.

The data on the yield of individual whales is, however, quite useful, since mature cows and bulls are of very different average sizes: mature cows weigh about 30 percent as much as bulls.[21] Yield was an increasing function of weight. A full-grown cow must have yielded about 25 percent as much as a full-grown bull. The largest bulls in the Wray and Martin sample—two or three only—are hundred-barrel bulls, from which we may infer that full-grown cows in this population (Western Indian Ocean) rarely topped twenty-five barrels. Of the 111 whales for which size, sex, or yield information is available, 42 percent seem clearly to have been bulls; that is, they were designated as "bulls," or as "large," or they yielded more than twenty-five barrels. Another 10 percent were twenty-five barrel animals, many of which must have been bulls. Indeed, of those below twenty-five barrels, many must also have been bulls, since nursery pods—the only groups from which cows could be taken—must have contained roughly equal numbers of immature males and females. In any case, the first datum recorded above—that 42 percent of the animals taken seem clearly to have been bulls, many identifiable as bulls on account of their size—suggests that whalemen did prefer to take the large animals available to them and that therefore they may not have unduly interfered with reproduction among the sperm whales.[22]

[20] Wray and Martin, "Historical Whaling Records," 236–39.

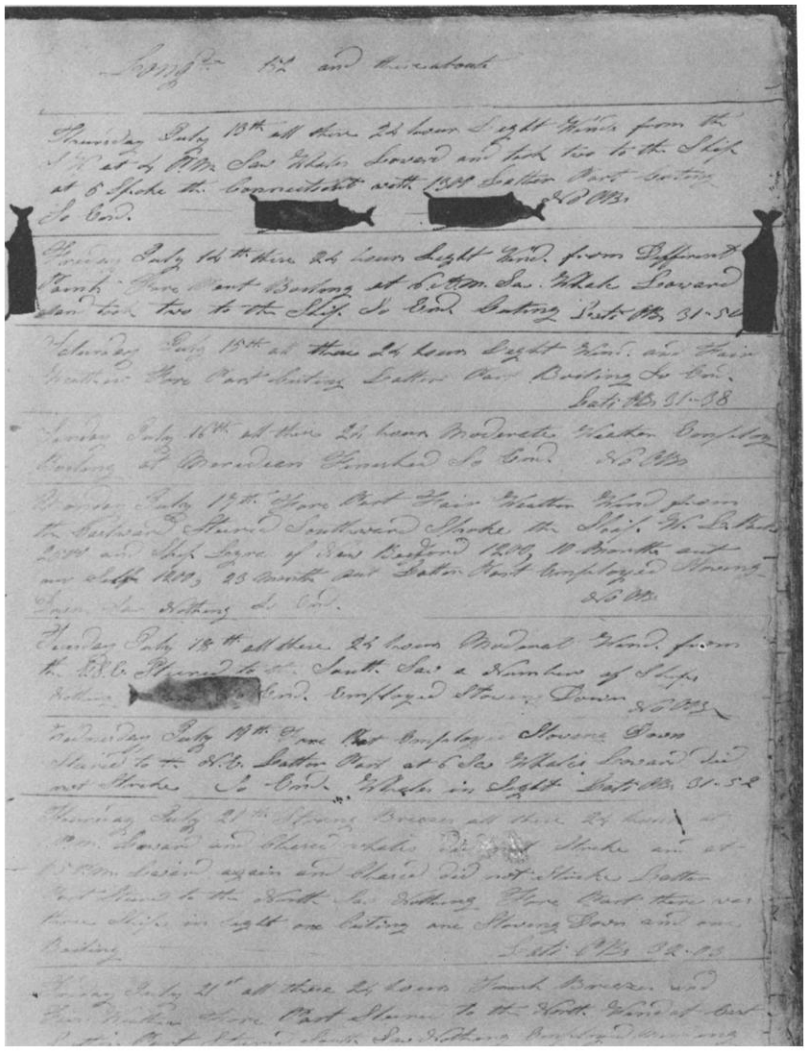
[21] Stephen Leatherwood and Randall R. Reeves, *Whales and Dolphins* (San Francisco, Calif., 1983), 82.

[22] Wray and Martin, "Historical Whaling Records," 236–39. Best's work more or less confirms the reasoning in the text. Best does identify a few cows that yielded more than twenty-five barrels, but his research was not confined to the hunting ground studied by Wray and Martin, the Western Indian Ocean. (According to Wray and Martin, the Indian Ocean sperm whale population consisted of relatively small whales.) Best, "Sperm Whale Stock Assessments," 52. That yield was an increasing function of weight may be inferred from Best's Table 8. If the fifty-five foot whales in that table were hundred-barrel whales, and if the thirty-foot whales were of a size equivalent to mature cows, then the table also allows one to infer that mature cows averaged twenty-five barrels. In fact, the whales described in the table are mainly bulls. Cows are said to be more slender than bulls. Consequently, the twenty-five barrel average is probably an upper bound on the true average value. Dropping the limit to twenty barrels would raise the share of large bulls in the total of all sperm whales taken to 56 percent.



LOG ENTRIES FROM A WHALING EXPEDITION

These two pages reproduce excerpts from the log of the ship Stanton, *under Captain Howland, out of New Bedford to the Pacific, 1824–27. The first page, recording 20–29 January 1826, describes taking seven whales on 22 January; the drawings indicate whales killed and secured. The next several days were spent boiling down the blubber and stowing the oil, 66 bbls. worth, and then the crew was "Employed Painting the Ship." The second page, for 13–21*



July 1826, records four whales taken and reports that the following days were spent cutting in the whales and boiling and stowing the oil. Entries indicate many other whales seen and chased, but none killed. The Stanton *also reports seeing three other ships, "one Cutting one Stowing Down and one Boiling." (Reproduced from MSS: 252 in Baker Library Manuscripts and Archives, Harvard Business School.)*

Thus it seems unlikely that even concentrated hunting would have depleted the stocks of sperm whales or greatly eroded their reproductive powers. In any case, the evidence indicates that hunting did not follow a pattern of local concentration. As American whaling expanded in the decades following the War of 1812, hunters very quickly moved into the South Atlantic and around Cape Horn and the Cape of Good Hope to the Pacific and Indian oceans and then into the Sea of Japan and the far North Pacific. The fact that whalers continued to hunt in all grounds provides substantial support for the argument that a ground was not hunted out before whalers moved on to a new one.[23]

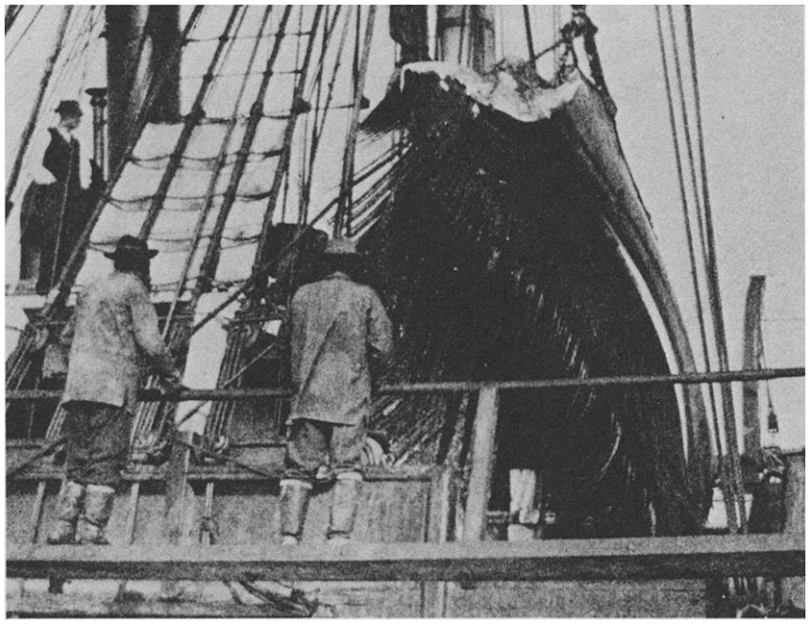
BALEEN WHALES

Quantitative evidence on baleens is generally much less complete and reliable than the information on sperm whales. Sydney Frost has data by sex and narrow geographic region for sperm whales, but such details are not generally available for baleens. There are estimates of the total stock of baleens (exclusive of whales in certain grounds), and of bowheads in Davis Strait, Hudson's Bay, Bering Strait, and the Okhotsk Sea. Gray whales still in existence in the early nineteenth century were chiefly concentrated off the coasts of California, Korea, and Japan. On the other hand, we have only incomplete information on the geographic distribution of rights and humpbacks.

By all accounts baleens were much less numerous than sperms. If we again take Frost's evidence, add Allen's data for North Pacific humpbacks and rights, substitute John Bockstoce and Daniel Botkin's figure for bowheads of the Western Arctic, and use James Scharff's and Allen's procedure to adjust the exploitable stock estimates to total population levels, the hunted baleens (exclusive of Spitzbergen whales) probably originally numbered at least 367,000 (compared with between 1.8 and 2.4 million sperms).[24] Once again, the estimates of whales killed drawn from Scammon's evidence must be adjusted. According to Scammon, the average baleen whale yielded about 60 barrels of oil. Following Charles Stevenson's figures, however, and assuming that different groups of whales were taken in proportion to their numbers, one reaches an average figure of 64 barrels. Even this figure is probably too low. The humpback was less widely hunted than were the other baleens. Assuming they were taken only a third as often as their numbers would predict, the average baleen yielded 73 barrels.

[23] See Davis, Gallman, and Hutchins, "The Structure of the Capital Stock."

[24] According to Scharff, "International Management," 332, the ratio of the total population of baleens to the exploitable population is 1.5 to 1. Allen, *Conservation and Management*, 19, puts the ratio at 1.3 to 1 for humpbacks.



CUTTING IN BOWHEAD WHALE JAW, c. 1890

Clearly visible in this photograph is the baleen, or whalebone, used in many industrial applications until the invention of spring steel. (Reproduced from Old Dartmouth Historical Society Sketch, *number 77, plate XXX, Baker Library.)*

Scammon also estimates that whalers killed and lost one-fifth as many baleens as they caught, a proportion that seems too high. According to Bockstoce and Botkin, bowheads killed and lost came to less than 15 percent of those caught. Since loss rates were particularly high for bowheads, and since bowheads lost were not infrequently recovered by other whalers, a loss rate of 10 percent for all baleens seems more reasonable for present purposes. If these revised assumptions are correct, it appears that whalers killed about 180,000 baleens in the nineteenth century.[25] This figure is likely to be a little too high, since it rests on output data that combine with baleen oil the oil taken from blackfish and walruses.

On the surface, then, it seems that baleen populations were more likely to have been depleted than were sperm whale populations. Furthermore, baleens are monogamous and may even form permanent sexual attachments, and the female baleen is larger than the male. Thus the natural factors that helped protect the reproductive capacity of sperms

[25] Scammon, *The Marine Mammals*, 244; Stevenson, "Aquatic Products," 192; Bockstoce and Botkin, "The Historical Status," 116. Again we assume that the American fishery was responsible for three-quarters of the catch.

from the depredations of hunters—the small relative size of the female, polygamy, and the easy substitution of one male for another in the breeding season—were absent in the case of baleens.

On the other hand, the reproductive capacity of baleens is much greater than that of sperm whales. According to Frost, the pregnancy rate of adult sperm cows is about .19 per year (that is, a calf almost every fifth year) when the population is stable, and it can rise to as much as .25 (a calf every fourth year). Baleen cows calf every two years, however—a rate of .50.[26] Except for gray whales, which are bothered by killer whales, baleens have no more trouble with natural predators than do sperms.[27] D. W. Rice and A. A. Wolman have shown that the gray whales, when protected from hunting during their period of population recovery, maintained a rate of natural increase of 4.7 percent per year, even though their mortality rate is probably higher than the rate for large baleens.[28]

As we have indicated, whale populations adjust to the available feed. If populations are reduced by hunting, the age of sexual maturity falls, the birth rate goes up, and hunting losses are replaced, so long as they are not too large. The extent of the rise in the rate of natural increase depends on the disproportion between food supplies and existing whale stocks. In the case of baleens, the natural increase—expressed in absolute numbers—rises, as the population is hunted down, until the population has been reduced to about 60 percent of its maximum size. If the population is driven below that level, natural increase (again expressed in absolute numbers) will fall, and eventually the whole population will be put in jeopardy.

For the baleens of the nineteenth century, the original population was at least 367,000. If, to begin with, we treat the baleens as one population (a procedure not legitimate except for illustrative purposes), the population level at which the natural increase would have achieved its maximum level would have been about 220,200 (367,000 x .60). That

[26] Frost, *The Whaling Question*, 19; Gaskin, *The Ecology of Whales and Dolphins*, 309; E. J. Slijper, *Whales*, 2d ed., trans. A. J. Pomerans (Ithaca, N.Y., 1979), 389–90. Grays and fins bear every other year; blues, slightly less frequently; humpbacks, four years out of five. There is much less information on rights (including bowheads), but Frost's reference appears to cover them. According to Slijper, "Whales", 384–85, the gestation period for bowheads is 9–10 months and the lactation period 12 months. Rights have the same lactation period. Gaskin, however (D. E. Gaskin, *Whales, Dolphins and Seals* [Auckland, New Zealand, 1972], 88), puts the gestation period of the right whale at 11–12 months and the lactation period at 5–6 months. All of these figures appear to be consistent with the delivery of a calf every other year.

Biological information on whales is most full for those species recently hunted, both because many specimens were available to researchers and because strong efforts were made to enumerate these groups regularly. Of the populations that have not been hunted recently, scholars have the best information on the California gray whale, because the grays are particularly easy to observe. They breed in a few shallow-water areas off the coast of California and their migration route is within sight of land. Thus their breeding practices are relatively easily monitored and they are also easily enumerated. Bowheads and rights, however, are more difficult to observe and, since neither group is hunted extensively today, biologists have few specimens with which to work.

[27] David A. Henderson, *Men and Whaling at Scammon's Lagoon* (Los Angeles, 1972), 36.

[28] Rice and Wolman, *Life History*. The text statement about large baleens is based on Frost's evidence concerning sperms. Rates for these two groups are likely to have been similar.

is, only if the population had been reduced by about 147,000 whales (compare this with the total of 180,000 actually killed over the entire century) over a very short period of time would the maximum natural increase—the "maximum sustainable yield," in the language of the whale specialists—have been reached. Furthermore, if Rice and Wolman's findings about fertility are representative of baleens, the maximum sustainable yield, under these circumstances, would have been about 10,400 per year (220,200 x .047). That is, if the baleen population had been driven as low as 220,200, whalers could have taken as many as 10,400 baleens each year without jeopardizing the population. In fact, American whalers never took as many as 7,000 in any year, and in most years they took only a small fraction of that number.

Can the Rice and Wolman results be regarded as representative of baleens as a whole? Allen warns against extrapolating from one species to another, but he makes the point in the context of a discussion of overhunted groups. Allen points out that the gray whale may have recovered quickly because it employs only a limited number of breeding grounds, so that, even when the number of grays had dropped to a small fraction of their original number, population density on the breeding ground was always high enough to ensure successful breeding on a large scale. Allen suggests that other groups, such as rights, might not be able to recover so quickly.

In this article, however, we are not concerned with the issue of recovery from severe overhunting. We are interested in maximum sustainable yields, which are reached long before whale populations are put in danger. In this context, it seems safe enough to extrapolate from the experience of grays to other groups. Rice also seems to set the maximum sustainable yield for bowheads of the Western Arctic in the late nineteenth century at a maximum of 5 percent, or roughly at the level exhibited by the grays.[29]

DIFFERENCES AMONG BALEENS

Our calculations to this point have treated all baleens hunted by the American nineteenth-century fleet as though they were alike, as though they bred indiscriminately across groups, and as though they were hunted in the same way. These conditions were not met, of course, and we therefore must look at individual species separately.

Gray whales represent something of a special case, although their peculiarities were shared, in some measure, by humpbacks.[30] They produced inferior oil and bone, and relatively small amounts of them

[29] K. Radway Allen, in *The Whale Problem*, ed. William E. Schevill (Cambridge, Mass., 1974), 356–57; D. W. Rice, ibid., 189.

[30] Much of what follows is drawn from Henderson, *Men and Whaling*.

(their oil averaged about 35 barrels a whale). Initially they were not easily taken. Whalemen called them "devil fish" because they would attack the whale boats—very often successfully. At first they were hunted in the North Pacific by whalemen who were seeking rights and bowheads, but who would take grays if the opportunity presented itself. Relatively few grays were killed in these seas.

Hunting of gray whales changed when their calving grounds in the bays of the Baja Peninsula were discovered. Whalers then began hunting the grays in the winter, chiefly as an off-season activity while the pursuit of rights and bowheads in the north was impossible. Before the Baja grounds were discovered, whalers sailed south in winter to the New Zealand, Chilean, or California grounds to hunt sperm whales and humpbacks. Gray whaling became another off-season option after the mid-1840s. Very risky at first, gray whaling became an important activity after the whalers had learned to enter the bays successfully and had adopted the Greener harpoon gun (which kept them at a safer distance from their ferocious prey). According to David Henderson, the number of these whales killed on both the northern and calving grounds rose from between 700 and 800 in 1846–54 to 5,200 in 1855–65, and then fell to 2,100 in 1866–74, after which whalers effectively gave up gray whale hunting. The total killed in the nineteenth century thus came to about 8,200.[31]

According to Frost and Allen (see Table 1), the California herd originally numbered between 15,000 and 20,000. Scammon implies that it was nearer 50,000, but modern students of the subject discount this figure.[32] Following the line of argument adopted previously, 8,200 whales taken from an original population of 15–20,000 ought not to have destroyed the gray whale herds. Gray whaling, however, was a special case. Hunting was extremely concentrated, the gray whaling era lasting only about thirty years, and once the calving grounds were entered, virtually all of the whales killed and listed in Henderson's tally were females. The ability of the stock to reproduce was directly attacked. Furthermore, many of the females were pregnant, or left behind calves that were too young to feed themselves and starved to death. These calves—as well as those attacked and killed by whalemen to draw the mothers within range of hunters' harpoons—are not counted in Henderson's totals. The slaughter, then, was greater than Henderson's figures, alone, describe; it is a wonder that the California gray whale population survived at all. It did, however, and is today probably as large as it ever was.

How the grays survived is not entirely clear, although it is possible that the increased cost of capture due to diminished numbers, taken

[31] Ibid., 256–57.
[32] John R. Spears, *The History of the New England Whalers (New York, 1908), 190–91.*

together with weakening markets for oil—especially for the inferior oil yielded by the grays—led whalers to abandon the California grounds in time to save the remnants of the population. In any case, the American whale fleet did not end its days for lack of gray whales. Grays were never central to American whaling.

The bowheads of the Western Arctic constitute a second group for which there are good data. According to Bockstoce and Botkin, Arctic bowheads originally numbered at least 20,000 and perhaps as many as 40,000, but in all likelihood about 30,000. They began to be hunted commercially in 1848, and commercial whalers took about 18,700 before the First World War, or something more than 60 percent of the original population. Again, the slaughter was concentrated in a relatively short period of time, but it was not, as in the case of the grays, a destruction visited chiefly on females.

Bockstoce and Botkin have attempted a number of simulations of the bowhead population and have been able to reconcile their estimates of the original stock, the numbers killed by pelagic whaling, and the number remaining in 1915 only on the assumption that mortality from all sources other than whaling exceeded recruitment. The density/fertility mechanism presumably did not operate. The appropriate way to view the recruitment and survivorship ratios is that they represent values influenced by hunting. Bockstoce and Botkin argue that one bowhead feeding ground after another was hunted out and that the whales were forced to withdraw into always more limited feeding grounds. Under these circumstances, hunting would not set off a favorable density/fertility mechanism, since the relevant feed/whale ratios would not rise. The model recruitment and survivorship ratios may therefore be reasonable.[33] Bowheads, with their relatively confined feeding grounds, may have been in greater danger of extermination than were rights, sperms, and humpbacks.[34]

Whatever the mechanism, the evidence suggests that the bowhead population had been reduced to about 3,000 by 1915. That the final collapse of the bowhead population occurred while U.S. whaling was still otherwise viable, however, and that the collapse contributed importantly to the end of U.S. whaling are not so clear. The fleet had been in decline since the beginning of the Civil War and was dramatically so after the mid-1870s, periods during which bowheads must still have been relatively numerous. The estimates of kill-per-unit-of-effort assembled by

[33] Bockstoce and Botkin, "The Historical Status," 137. But see also Michael F. Tillman, Jeffrey M. Breiwick, and Douglas G. Chapman, "Reanalysis of Historical Whaling Data for the Western Arctic Bowhead Whale Population," 145, and J. M. Breiwick and E. D. Mitchell, "Estimated Initial Population Size of the Bering Sea Stock of Bowhead Whales (Baleena mysticetus) from Logbook and Other Catch Data," 150, 151, both in *Scientific Reports of the International Whaling Commission*, 145.

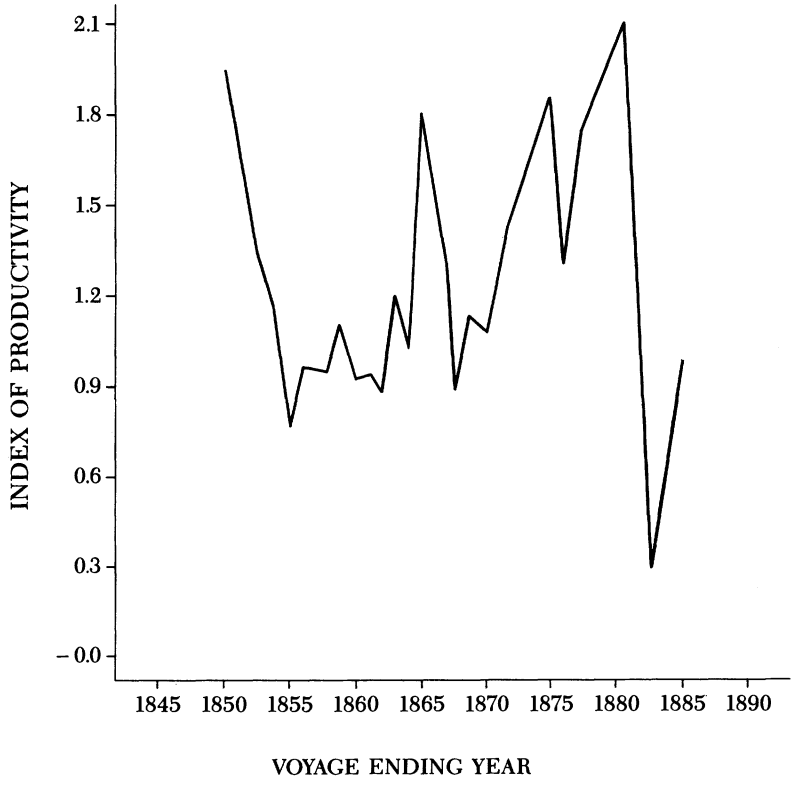
[34] Slipjer, *Whales*, 395.

Bockstoce and Botkin show neither a decline between the early 1850s and the early 1880s nor a dramatic decline thereafter.

Our index of total factor productivity of New Bedford whalers (sailing vessels only) in the Western Arctic (see Figure 1 and note 5) shows no unequivocal long-term drop before the early 1880s, at which point there were practically no New Bedford whalers left in the Western Arctic. These indexes do not provide conclusive evidence of changes in the stock of whales, of course, since factors other than the availability of whales

FIGURE 1

INDEX OF TOTAL FACTOR PRODUCTIVITY
NEW BEDFORD WHALING VOYAGES ENDING 1851–1885
ARCTIC FISHING GROUNDS



influenced productivity.[35] It is highly unlikely, however, that factors leading to improved productivity were powerful enough to offset the unfavorable influences of a drastic reduction in the stocks of bowheads. If the American fleet was being forced to contract because of sharply rising costs associated with the depletion of the bowhead population, the kill-per-unit-of-effort and the total factor productivity indexes should both fall. At least down to 1880 neither index does decline markedly. One may therefore doubt that the fleet was driven to extinction by a shortage of bowheads.

Data on the remaining groups of baleens hunted in the nineteenth century are much less complete. We know that the humpbacks were actively sought, although they had characteristics that made them less desirable than most other types of hunted whales.[36] Their oil and bone were less valuable than the oil and bone of rights, and they are much smaller than rights, averaging about 55 barrels per whale taken, compared with perhaps 100–120 barrels for rights. They were also difficult to catch—fast and quick to change direction. Although by no means ferocious, they have long flippers, and in their death throes they sometimes smashed whale boats. Moreover, unlike the typical right, they sank when killed. When this happened in shallow water—which is where the humpback was typically hunted—they could be raised with relative ease, or they could be marked and picked up later, when they eventually rose to the surface from natural causes. There was the risk in this case, of course, that they would be consumed by sharks. In deep water, the humpbacks could be neither successfully raised nor marked, but if they acted quickly, whalemen appear to have been able to keep them afloat (holding them by lines to the whale boats).[37]

Although humpbacks have been heavily hunted in the twentieth century, they survived the nineteenth century in large numbers.[38] How many

[35] Bockstoce and Botkin, "The Historical Status," 130, 131. The total factor productivity index displayed in the figure is described in Davis, Gallman, and Hutchins, "Productivity," and in footnote 5, above. Among the developments almost certainly affecting productivity importantly were a deterioration in the quality of seamen in whalers and various technical improvements, such as the darting gun and the steam-powered whaler (the latter influencing the Bockstoce and Botkin estimates, but not the Davis, Gallman, and Hutchins figures, which cover only sailing vessels). The former tended to reduce productivity, the latter to raise it. The Bockstoce and Botkin average weighted kill-per-unit-of-effort indexes are: 1849–59: .179; 1860–69: .147; 1870–79: .111; 1880–89: .159; 1890–99: .083. Dropping 1849 and 1850 reduces the average for the first period (now 1851–59) to .120.

[36] For accounts of humpbacking, see Dulles, *Lowered Boats*, chap. 20; Nordhoff, *Whaling and Fishing*, chap. 10; Clifford W. Ashley, *The Yankee Whaler* (Boston, 1938), 65. According to Dulles, it was common for New London whalers to spend two summers and a winter at Desolation Island, hunting rights and humpbacks.

[37] Robert Ferguson, *Harpooner: A Four-Year Voyage on the Barque Kathleen, 1880–1884*, ed. Leslie Dalrymple Stars (Philadelphia, Pa., 1936), 130–31, 145–48. The accounts in these pages apparently refer to hunting humpbacks in deep water.

[38] According to Edward Mitchell and Randall R. Reeves, "Catch History, Abundance, and Present Status of Northwest Atlantic Humpback Whales," 160, 161, in *Scientific Reports of the International Whaling Commission*, 4,053 humpbacks were killed in the western North Atlantic (including Iceland) in the forty-one years 1850–1890, and 4,810 in the next period of like duration, 1891–1931.

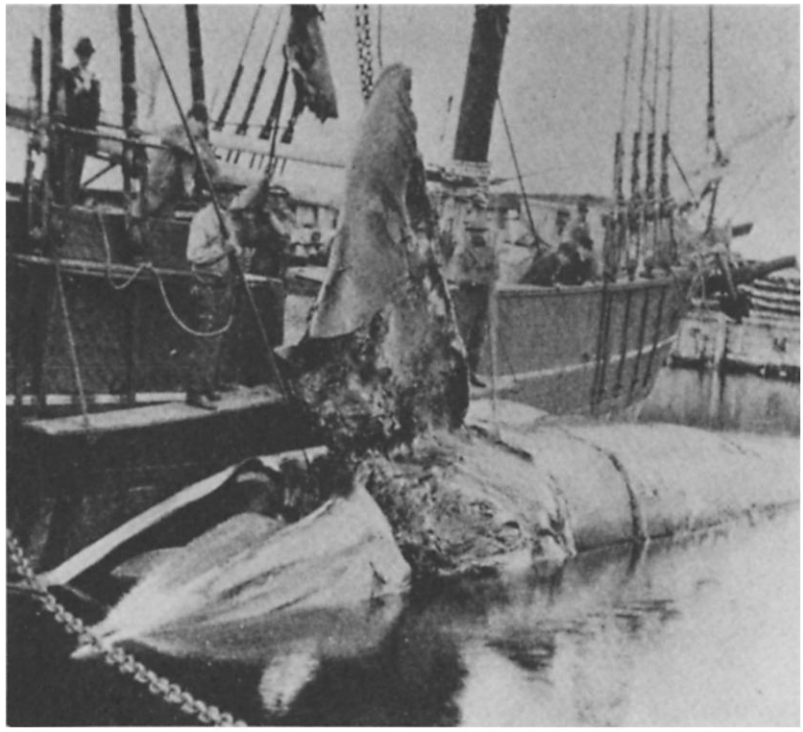
were killed in the nineteenth is by no means certain. In computing the average size of baleens, above, we assumed that humpbacks were taken only a third as often as their relative numbers would lead one to expect—a guess, no more. A guess of some kind is required, however, if we are to get some idea of the extent to which the remaining baleens—chiefly rights—were under assault. Accepting this guess allows the following computation:

Total number of baleens killed (thousand):		180.0
of which:		
bowheads of the Western Arctic	18.7	
California grays	8.2	
humpbacks, perhaps	35.0	
Total of three above		61.9
Leaving rights, Atlantic bowheads, Japanese and Korean grays, blackfish, the odd fin or sulfur bottom		118.1

The original stocks of rights and North Atlantic bowheads amounted to about 177,000. About 70,800 could have been taken before these populations were at the maximum sustainable yield level, a level at which perhaps 5,000 animals could be taken each year without jeopardizing the stock. Remember that American whalers never took as many as 7,000 baleens annually, a figure that includes, of course, bowheads, humpbacks, and grays. Remember also that the 118.1 thousand figure is a residual, based in part on oil taken from animals other than rights and bowheads: Japanese and Korean grays, fins (a few), blues (a few), walruses (many), blackfish (many), and others.

Rights had become scarce by the 1930s, when the whaling nations agreed to a convention to protect them from all hunting, for fear that they would be exterminated. Whether this condition was a legacy of the period when U.S. whaling was important, or was a product of late nineteenth- or early twentieth-century hunting is not entirely clear, since data on twentieth-century hunting of rights is fragmentary.[39] The lack of reported kills might in itself lead one to believe that twentieth-century hunting was not intense: If right populations had been hunted down in the twentieth century, data on whales killed would likely not be fragmentary. That conclusion, however, is not necessarily correct. Hunting records of the twentieth century were not well kept before the 1930s, particularly with respect to the distribution among species. Rights are likely often to have been counted with the more numerous rorquals,

[39] Tønnessen and Johnson, *Modern Whaling*, 736, 751.



CUTTING IN A FINBACK WHALE

This photograph shows the simple staging in use before 1860. Men employed hooks, knives, and other implements to reduce the usable parts of the whale carcass to manageable size. (Reproduced from Old Dartmouth Historical Society Sketch, *number 77, plate XXXI, Baker Library.)*

which could explain the fragmentary nature of direct evidence of the number of animals killed.

For what it is worth, the rorquals appear to have survived—although, in the case of the blues, just barely—a much more savage assault in the twentieth century than that to which the baleens hunted by the Americans were subjected in the nineteenth. According to J. N. Tønnessen and A. O. Johnson, 331,000 blue whales and 692,000 fin whales were taken in the Antarctic grounds alone between 1904 and 1978, while, according to Frost, the original populations of blues and fins in all of the southern hemisphere amounted to 270,000 and 607,000, respectively. That is, over a seventy-four-year period the numbers of these whales taken substantially exceeded the original populations. Both groups were damaged. By 1978, southern hemisphere blues probably numbered 7–8,000; fins, 130,000. A much smaller fraction of the original popula-

tion of rights was taken by nineteenth-century hunters, and hunting was spread over the much longer period of ninety-seven years.

The right whales have characteristics, however, that may have brought them more readily to the brink of extinction. Their numbers were not large to begin with. They were scattered over wide reaches of the oceans, and various population groups seem to have been largely independent. Concentrated hunting might have lowered population densities far enough to interfere with breeding. The slaughter of the rights may have opened the way for the expansion of the populations of whales that were not at that time being heavily hunted—the fin whales, for example. The only way for the right populations to recover from hunting would have been through a rise in fertility, occasioned by a fall in the age of sexual maturity, the latter due to an improved feed/whale ratio. But if the fins expanded into the space left by the rights, the feed-fertility mechanism of the rights would not operate, at least not with full effect. The calculations of the maximum sustainable yield exhibited above may, therefore, be too optimistic. Even so, the data do not suggest that the right whale stocks had declined so far by the 1870s that they served as a major check to the American whaling industry.

CONCLUSION

We conclude that the stocks of sperm whales and humpbacks were decidedly not running out. The number of sperm whales killed by whalers in the nineteenth century is very small when compared with the previously existing stocks of whales and their procreative ability. The same can be said of humpbacks. The picture with respect to rights, grays, and bowheads is not so clear. Hunting was certainly a heavier burden to these whale populations, but probably not heavy enough to make them all generally scarce by the time the American whaling fleet went into its steep decline. In short, the decline of American whaling antedated serious problems of whale numbers.

Supply-side pressures that would have led the whaling industry to contract may have emerged even in the absence of ecological disasters. It is possible that hunting affected the numbers and behavior of whales, even in cases where there is little evidence of overhunting. Hunting may have reduced population densities of some whales (even if the harvest never exceeded the maximum sustainable yield), making them less accessible and their capture more costly. Such reductions could explain the persistent search for new hunting grounds, even though old ones had not been hunted out. At the same time, and perhaps more likely, the whales may have learned to become wary. William Scoresby claims that, when the Spitzbergen grounds were opened, whales were so curious and unfearful that they "allowed themselves to be closely approached"

WHALING 1825

Despite its romanticized depiction of the scene, this painting captures the elements of a typical whale hunt, with harpooners balanced in their small whaling boats, riding the churning seas created by the spouting and diving pod of whales. (Reproduced from PM:252, an aquatint by Thomas Sutherland from a painting by William John Higgins, PM:252, Baker Library Manuscripts and Archives.)

by the whale boats, but in time they became timid. The same sequence was observed in Davis Strait and the Western Arctic.[40] As whales learned about men, hunting costs may have risen.

If population densities and the wariness of whales were important, however, one would expect to see some evidence of it in the analysis of whaling productivity. Our efforts so far have failed to turn up such evidence. Heavy hunting seems not to have been followed by declining productivity, other factors being equal (see note 7). These issues are nevertheless worthy of further exploration. Their resolution would help to settle the question of the causes of the decline of American whaling. At this stage, however, there is no persuasive evidence that U.S. whaling collapsed because the stock of whales was running out.

[40] William Scoresby, *An Account of the Arctic Regions with a History and Description of the Northern Whale Fishery*, vol. 2: *The Whale Fishery* (rpt.; Newton Abbot, England, 1969), 172–73, 183; Bockstoce and Botkin, "The Historical Status," 118, 119; Wray and Martin, "Historical Whaling Records," 226. Biologist Haven Wiley, of the University of North Carolina, Chapel Hill, writes (personal letter of 12 Dec. 1986): "Ecologists interested in predation worry a lot about whether prey *densities* correlate with prey *availabilities*, and clearly they often do not. With specific reference to whaling, it is perhaps important to consider whether increasing wariness by the whales might have had a significant impact on their availabiliy to whalers in sailing vessels."

WINTER 1988

Business History Review

FOCUS ON RESOURCE-BASED INDUSTRIES

- Resource depletion and American whaling
- Conservation vs. commerce in the lobster industry
- Technology diffusion in Pacific salmon-canning
- Medical screening among zinc and lead miners

PUBLISHED BY THE HARVARD BUSINESS SCHOOL

COVER: CUTTING IN A SPERM WHALE. This early twentieth-century photograph shows whalemen on platforms cutting apart the head, or case, of a sperm whale. The chain and pulley arrangement holding the whale to the ship can be seen in the center. (Photograph reproduced from George Francis Dow, *Whale Ships and Whaling: A Pictorial History of Whaling during Three Centuries.* [Salem, Mass., 1925], 405.) For an article examining the supply of whales in the nineteenth century, see pp. 569–595.