A Preliminary Estimate of the Reduction of the Western Arctic Bowhead Whale Population by the Pelagic Whaling Industry: 1848-1915

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Introduction

Today the bowhead whale, *Balaena mysticetus*, population of the Bering, Chukchi, and Beaufort Seas is at the center of a controversy about the effect of the Alaskan Eskimo hunt on its numbers. Although many observers believe the population has not recovered significantly from the low level at which it probably stood in 1915, hitherto no thorough attempt has been made to estimate the number of bowheads that were taken by the pelagic whaling industry. Based on primary resources (logbooks and maritime newspapers), this report presents the results of the first systematic endeavor to reach an estimate of the annual bowhead kill.

Although a few bowheads may have been taken between 1843 and 1847, these whales were not deliberately sought until 1848. In that year Captain Thomas Roys sailed into seas unknown to whalemen and discovered the great whaling grounds beyond Bering Strait where the bowheads, oil-rich, baleen-laden, and docile, were found in numbers. Roys quickly filled his ship and returned to Honolulu to broadcast his success. Word of these new whaling grounds spread quickly, and in the following year more than 40 vessels sailed north and enjoyed equally successful cruises. In succeeding years the news of the 1849 season increasingly lured other vessels, and in 1852 more than 200 whale ships operated in the Bering Strait region[1].

The whalers quickly established a routine that they would vary only slightly for the next 60 years. Leaving New England in the autumn and rounding Cape Horn in the southern summer, they would fit out at Hawaiian ports or San Francisco, sailing for the Arctic in late March to reach the pack ice of the central Bering Sea a month later.

They took a few whales as they worked their way north toward Bering Strait through the melting floes, but by early June most of the whales had passed them and gone deep into the safety of the ice on the migration to their summer feeding grounds in the Arctic Ocean. The whalemen would not see their quarry again until late July when the ice allowed the ships to approach the north coast of Alaska and intersect the whales traveling from the Beaufort Sea to their autumn feeding grounds near Herald Island in the Chukchi Sea. The ships often cruised near Herald Island until the violent weather and encroaching ice of early October drove them back to ports in the Pacific Ocean.

The whalemen usually repeated these summer voyages once or twice more before returning to their home ports. Some alternated their summer hunts among cruises to the Arctic, the Okhotsk Sea, or the Gulf of Alaska, depending on where the best catches were being made; nevertheless, they rarely visited more than one of these areas per year.

The intensity of the hunting in the early years of the fishery quickly reduced the bowhead population. It is possible that the whales themselves responded to the threat for the catches of 1853 and 1854 were poor enough in comparison with previous years, and the fleet virtually abandoned the Bering Strait region in 1855, 1856, and 1857, turning its attention to the bowheads of the Okhotsk Sea. It too was soon overhunted, and the whalemen returned to the Bering Strait in 1858 to cruise there regularly for the following half century.

In the spring, once the ships reached lat. 57° or 58°N, the whalemen began to watch for bowheads; for the next 5 or 6 months they generally kept themselves in constant readiness to lower their boats. When they saw whales, if the seas were not too rough, four or five boats usually went after them. If the men were lucky, a boat got close enough to strike a whale with a harpoon. The whale would then run, towing the line and a boat after it and eventually becoming sufficiently exhausted so that it could be killed with a lance. But frequently whales escaped into the ice, towing lines and gear. In response to these losses the whalemen, after about 1860, increasingly used darting guns (which were fixed to the harpoon shaft and fired a small bomb into the whale at the moment of striking) as well as shoulder guns (27-pound, brass, smooth bores that fired a similar bomb from a distance and thus generally replaced the lance).

Once the whale was dead, or if a dead whale were found, the carcass was towed to the ship, where the crew took the baleen aboard and stripped off and "tryed out" (rendered into oil) the blubber. As a rough average, a moderate-sized bowhead yielded 100 barrels of oil (a barrel was 31.5 U.S. gallons) and 1,500 pounds of baleen.

By 1866 the hunting pressure had put the bowhead population in steep decline, and to offset poor catches the whalemen began taking walruses, *Odobenus rosmarus*, and gray whales, *Eschrichtius robustus*, in the "middle season" between their spring and autumn encounters with the bowheads. A decline in oil prices soon ended this; by 1880 oil prices were so low that profits could only be made by taking baleen,

[1]For the purposes of this report I define the Bering Strait region as the waters of the Bering and Chukchi Seas between approximately lat. 60° and 72°N

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287 WHALEMEN'S SHIPPING LIST AND MERCHANT

VESSELS' NAMES	ton	MASTERS	AGENTS	SAILED	BOUND	LAST REPORT.	OIL.
NEW BEDFORD.							
Abigail	310	Drew	Wm G E Pope	Aug 24, 52	N Pacific	Sept 18, 52, at Fayal	clean
A H Howland	414	Pease	Abraham H Howland	Aug 18, 51	N Pacific	Mch 29, 52, at Maui	90 sp
Ab'm Barker	400	Norton	Abraham Barker	Sept 19, 50	N Pacific	Aug 52, in Bherings sts wanting 1 wh	
Active, bark	333	Morrison	Cook & Snow	June 1, 52	Indian Ocean	Aug 11, 52, at Fayal landed 84 sp	
Adeline	329	Carr	I Howland jr & Co	Sept 21, 50	N Pacific	June, 52, off Cape Thadeus	unk
Addison	426	Cash	Isaac B Richmond	Sept 20, 52	Pacific		
Alexander	421	Ryan	John A Parker	June 11, 51	N Pacific	Aug 1. 52, off Bh'ngs sts 8 whs this sea	
Alex Coffin	381	Purrington	Jonathan Bourne jr	Nov 13, 51	N Pacific	June 1, 52, in Bherins sts 1 wh this sea	
Alice Frazier, bk	406	Taber	Lemuel Kollock	Sept 10, 51	N Pacific	No date in Bherings sts	5 whs
Alice Mandell	413	Wing	C R Tucker & Co	Sept 10, 51	N Pacific	Apl 10, 52, at Oahu for Arctic	50 sp
Alto, bark	236	Carr	Richmond & Wood	Sept 8, 51	Atlantic & Ind	Abt Jan 4, 52, off River Platte	150 sp
Alfred, sch	184	Gifford	Wm. G. E. Pope	June 12, 52	Atlantic	Sept 10, 52, at Fayal landed 35 sp	
Alfred Gibbs	425	Jenney	Wood & Nye	Nov 13 51	N Pacific	Apl 3, 52, off Oahu, bd N. 25 sp on bd	
America	418	Fisher	I Howland jr & Co	June 25, 51	N Pacific	Aug 1, 52, off Bh'ngs sts 6 whs this sea	
America, bark	257		Joseph A Beauvais	In port		Arrived Oct 2, 52, 450 sp	
Amethyst	359	Howes	John A Parker & Son	Sept 28, 50	Pacific	Aug 23, 52, at Tombez	750 sp
Anaconda, bark	383		Isaac B Richmond	In port			
Anadir, bark	615	Swift	Swift & Perry	Jan 2, 51	N Pacific	Aug 21, 52, off Bh'ngs sts 8 wh this sea	
Andrews, bark	303	Nye	Wm P Howland	June 3, 50	Pacific	Sept 20, 52, at Tombez 900 sp	
Antarctic	319	Bradbury	Wm P Howland	May 3, 52	Pacific	Sept 2, 52, at Fayal landed 15 sp	
Archer	322	Macomber	Edward W Howland	Oct 5, 52	Pacific		
Arnolda	360	Harding	James B Wood & Co	July 19, 52	Pacific	Sept 3, 52 at Fayal landed 22 sp	
Atlantic, bark	367	Luce	Hathaway & Luce	Oct 31, 51	Atlantic &c	Sept 25, 52, sld fm Fayal 440 sp landed	
Balæna	301	Dexter	J & J Howland	Sept 1, 49	Pacific	Sept 20, 52, at Tumbez 1300 sp	
Baltic, bark	395	Brooks	Alexander Gibbs	Nov 16, 51	N Pacific	June 21, 52, lat 56 N. lon 172 w	unk
Barnstable	373	Coon	William F Dow	May 6, 51	Pacific	Apl 9, 52, at Paita 200 sp on board	
Barclay	281	Taber	Henry Taber & Co	July 7, '52	Atlantic	Aug 17, 52, at Fayal landed 150 sp	
Bart Gosnold	356	Heustis	I Howland jr & Co	July 15, 51	Pacific	Aug 20, 52, off Bh'ngs sts 12 whs this sea	
Benj. Tucker	349	Sands	C R Tucker & Co	Nov 5, 51	N Pacific	Early in season in Arctic had done well	
Bevis, bark	214	Snell	Benjamin B Howard	June 4, 50	Indian Ocean	June 12, 52, off Johanna 640 sp	
Brandt	310		Alexander Gibbs	In port		Arrived Sept 12, 52, 1000 sp 140 wh	
Brighton	354	Weaver	James D Thompson	Oct 9, 50	N Pacific	Aug, 52, in Bherings sts clean	
Bragansp	470	Devoll	Wm G E Pope	Sept 10, 50	N Pacific	Aug 1, 52, off Bh'ngs sts 10 whs this sea	
Bramm	245	Childs	Gideon Allen	Sept 9, 51	N Pacific	Mch 14, 52, at Hilo clean	
Callao	324	Baker	Henry Taber & Co	July 27, 52	N Pacific	Sept, 52, at Fayal clean	
Cambria	362	Cott e	James B Wood & Co	Sept 3, 51	N Pacific	Mch 28, 52, at Maui clean	
California	398	Wood	I Howland jr & Co	Oct 22, 51	NPacific	Last of July heard from 7 whs	
Caroline	364	Gifford	William Gifford	Aug 3, 52,	N Pacific		
Carolina	395		S Thomas & Co	In port			
Catalpa, bark	260	Hamblin	I Howland jr & Co	Aug 12, 52	Atlantic & Ind	Sept 17, 52, lat 31 N. lon 42 w clean	
Canada	545	Ths West	Barton Ricketson	Oct 1, 51	N Pacific	Aug 1, 52, off Bh'ngs sts 6 whs this sea	
Canton	409	Wing	E Perry & W C N Swift	Aug 10, 52	N Pacific	Sept 14, 52, at Fayal clean	
Canton, 2d	280	Folger	C R Tucker & Co	July 31, 51	Pacific	Jan 7, 52, off Juan Fernandez clean	
Canton Packet	274	Howland	I H Bartlett & Son	Dec 28, 49	New Zealand	Dec 29, 51, cld at Oahu 20 sp 550 wh	
Chas W Morgan	351	Sampson	Edward M Robinson	June 5, 49	Pacific	April 20, 52, off French Rock 900 sp	
Chandler Price	441	Taber	Wm G E Pope	July 25, 51	N Pacific	First of season heard from unk	
Charles	290	Manchestr	Lemuel Kollock	July 25, 49	Pacific	May 27, 52, at Gallipagos Is 500 sp 700 w	
Champion	336	Waterman	James D Thompson	June 18, 50	N Pacific	Mch 20, 52, sld fm Hong Kong 240 wh	
Ch'n Packet, bk	184	Lewis	Tho's Knowles & Co	Apl 19, 51	Indian Ocean	June 1, 52, off Seychelle Is clean	
Chas Frederick	317	Haskins	John A Parker & Son	Aug 22, 50	Pacific	Aug 28, 52, off Ceros Island 900 sp	
				Aug 19, 51	N Pacific	Mch 28, 52, at Maui clean	

VESSELS' NAMES	ton	MASTERS	AG
NEW BEDFORD.			
Ja's Andrews, b	275	Beetie	Charles F
James Arnold	393		Henry Ta
James Edw ard	434	R Luce, jr	George F
Java	278	Lawrence	Geo & Ma
Janus	321	Cornell	T & A R
James Maury	395	Whelden	C R Tuck
Jasper, bark	223	Rotch	Alexande
Jeannette	340	West	Isaac B B
Jireh Perry	435	Lawrence	E Perry &
John	308	Tilton	Frederick
John A Parker b	342	Taber	Henry F
John Howland	377	Taylor	James H
John & Edward	318	Cathcart	Wilcox &
John Wells	366	Cross	Tho's Kn
Joseph Butler, b	193	Mayhew	I Howla
Joseph Meigs	356	G Allen	George F
Julian	356	Cleveland	Hathawa
Junior	378	Hammond	David R
J E Donnell, bk	343	Earl	Swift &
Kathleen, bark	312	Allen	James H
Kensington	357	Clark	David B
Kutusoff	415	Pierce	Henry F
Lafayette, bark	341		I H Bart
Lætitia, bark	275	Alden	F & G R
Lagoda	341	Tobey	Jonathar
Lalla Rookh	323	Gardner	John A I
Lancaster	383	Almy	T & A R
Lancer	395	Lakeman	Richmon
Leonidas	231	Clark	Russell
Levi Starbuck	376	Ellison	Edward
Lewis	308	Clement	I H Bart
Lexington, bark	201		Benjamin
Liverpool	306	Barker	Abraham
Liverpool 2d	428	Swift	Thomas
Logan	302	Tucker	I Howla
Louisiana	297	Taber	T & A R
Louisa, bark	316	Wyatt	Swift &
L C Richmond	341	Cochran	James F
Magnolia	396	G L Cox	Wm G F
Malta, bark	151	Smith	Benjami
Manuel Ortez, b	351	C H Cole	Weston
Majestic	297	Percival	S Thom
Marengo	426	Devoll	Jonatha
Marcella, bark	210	Rounds	C R Tuc
Massachusetts	364	Bennett	William
March, brig	89	Reynolds	William
Marcia	315	Wing	Edward
Margaret Scott	307	Eldridge	Rodney
Maria, bark	202		Samuel
Maria Theresa	330	Taylor	T & A I
Mars, bark	270		

Figure 1.—Detail of page from *Whalemen's Shipping List*, 1852 (courtesy of New Bedford Whaling Museum).

the great flexible plates that hang from a bowhead's upper jaw and are used to filter food from the water. As the price of oil sank, forced down by petroleum products, the price of baleen began to rise dramatically, driven up by the call of the fashion industry for, among other uses, "whalebone" corset stays and skirt hoops.

In 1880 the western Arctic remained the major profitable whaling ground for the American fleet[2], and the rising price of baleen stimulated the development of steam-auxiliary whaling vessels. These immediately proved successful in pursuing the whales to the least accessible corners of the Arctic Ocean. In 1889 steamers reached the bowheads' summer feeding grounds off the Mackenzie River delta in Canada's Northwest Territories, and from then until 1915 the focus of the industry was concentrated largely on those waters. Changes in fashion and the introduction of flexible spring steel as a cheap substitute for baleen caused the market to collapse in 1908, dragging the industry with it. After 1915, although a few vessels cleared port as whaleships, they were in fact primarily on fur trading and freighting voyages, and only a few whales were taken by ships thereafter.

[2]Vessels of other nations had ceased whaling there in the 1870's.

Resources and Methods

The basic source for this study was the *Whalemen's Shipping List and Merchants' Transcript* (Fig. 1). Published in New Bedford from 1843 to 1914, it contains the most comprehensive documentation of the American whaling industry; weekly issues posted the latest information on all American whaling vessels throughout the world. The *Shipping List* (Fig. 2) was of particular use to this project because whaling vessels usually touched at a major port to refit, to take on fresh provisions, and to report their cargoes immediately before and after their half-year Arctic cruise; thus, their Arctic catch can usually be determined (expressed in barrels

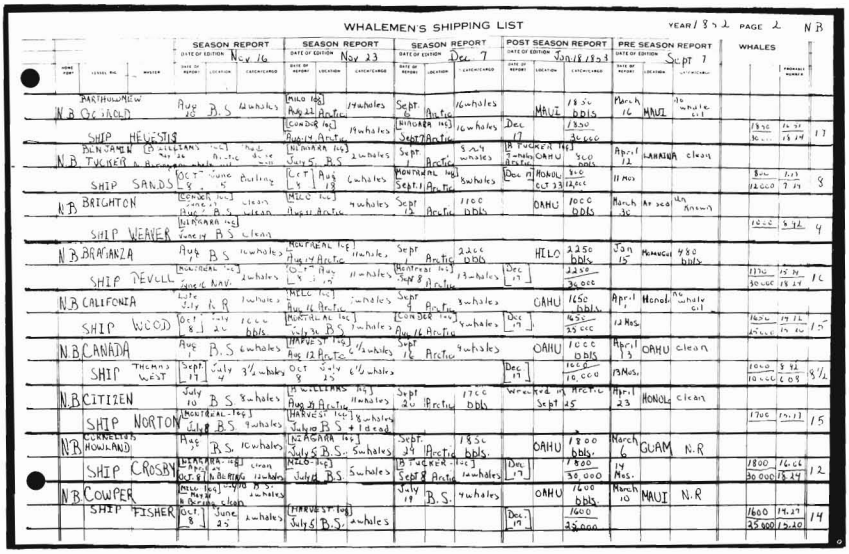


Figure 2. — One of the project's ledger sheets for New Bedford vessels, 1852 (courtesy of New Bedford Whaling Museum).

of oil and pounds of baleen) by subtracting the cumulative cargo listed in the spring from that listed in the autumn. Once in the Arctic, ships passing one another frequently reported their "season's catch" (usually expressed in the number of whales they had taken); this information, carried by ships leaving the Arctic, would also find its way to the pages of the *Shipping List*.

To organize these data I constructed a ledger sheet listing the following information from left to right: Column 1, the vessel's name, rig, captain, and home port; columns 2 through 4, successive seasonal reports; column 5, the postseason report; column 6, the preseason report. This information was gathered for each year and subdivided by home port.

The data from the *Shipping List* were augmented and corrected by adding information from other newspapers (principally from Honolulu's *Friend* and *Pacific Commercial Advertiser* and several San Francisco papers) as well as from scattered data in more than 500 printed books, magazine articles, manuscripts, government documents, and logbooks. This body of data was then spot-checked for accuracy against information compiled in the nineteenth century by Dennis Wood, a New Bedford insurance broker[3]. These resources allowed me to expand my purview beyond the American whaling industry to include vessels of the other nations operating in the western Arctic: Hawaii, Germany, France, and Great Britain (Australia). In all, more than 14,000 reports were tabulated.

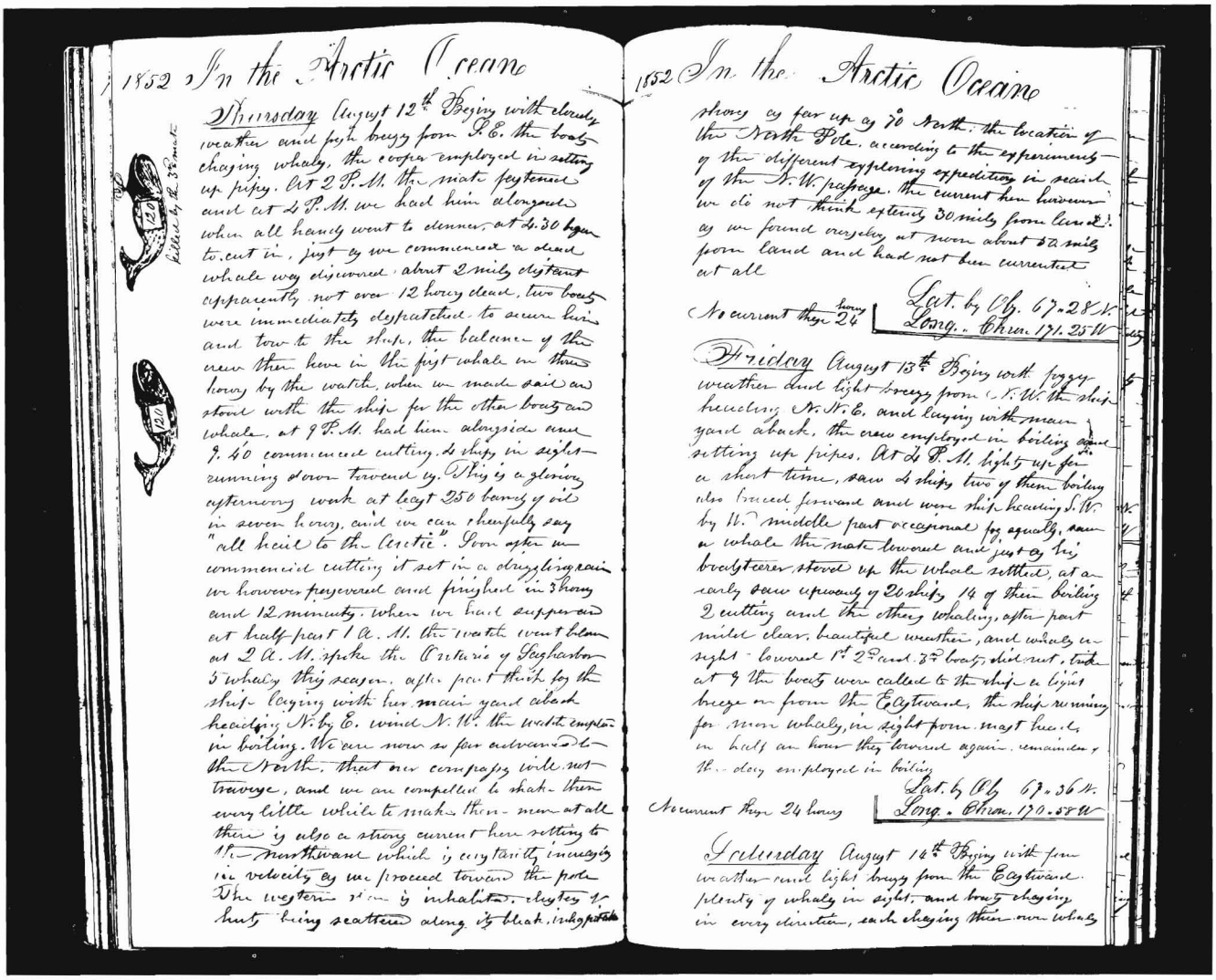
Of particular value was the information from logbooks and private journals (Fig. 3). After I had constructed the basic list of Arctic voyages from newspaper sources, I turned to the published checklists of the logbooks and journals that are now held in public collections. Using my list of Arctic voyages, I was thus able to identify the manuscript materials from this fishery. Of the more than 2,600 seasonal cruises, I found records of more than 600 in public collections. I then tried to examine a number of records equal to 5 to 10 percent of the Arctic cruises for each year. I extracted the following data from the logbooks and journals for each Arctic cruise: The number of lowerings for whales, the number of whales struck-and-lost, the number found dead, and the number taken, as well as the names of ships seen in the Arctic and their reported catches. These data allowed me to expand and correct my list of Arctic voyages and to appraise a number of other aspects of the whale kill that varied from year to year throughout the duration of the fishery (see Discussion section).

The logbook data also provided me with information on the total number of bowheads taken during a vessel's Arctic season and the combined yield of oil and baleen from those whales. From this information I derived a cruise average for the size of the whales captured (expressed in barrels of oil and pounds of baleen); and using this average as a rough guideline, I applied it to the figure for the products of each ship's seasonal catch to estimate the number of bowheads taken by that ship.

When coupled with an understanding of the changing tactics and economics of the whaling industry, these averages proved to be a useful analytical tool for exposing spurious additions of oil or baleen. For instance, once the figures for a ship's oil and baleen had been divided by the appropriate year's average, (and if a wide discrepancy were found between the number of whales indicated by each [Fig. 2]), then a high oil figure from a voyage in the 1870's might indicate the presence of walrus oil or gray whale oil in the cargo. Similarly, in the 1890's (when the price of oil was very low) a high baleen figure frequently indicated that little oil was being saved.

A note should be made about the sources that I intentionally did not consult. A number of compendia of data about whaling voyages exist, but an examination of each revealed serious deficiencies for my needs. Although Starbuck's (1964) and Hegarty's (1959) important works were based on the information in the *Shipping List*, these authors included only the cumulative results of the entire whaling voyage and hence were of little value for determining the annual bowhead catch; further-

[3]Wood's records are held by the New Bedford Free Public Library.


1852 In the Arctic Ocean

Thursday August 12th Begins with cloudy weather and light breezy from N.E. the boats chasing whales, the cooper employed in setting up pipes. At 2 P.M. the mate pertenced and at 4 P.M. we had him alongside when all hands went to dinner at 4.30 began to cut in, just as we commenced a dead whale was discovered about 2 miles distant apparently not over 12 hours dead, two boats were immediately dispatched to secure him and tow to the ship, the balance of the crew then here in the first whale in three hours by the watch, when we made sail and stood with the ship for the other boats and whale, at 9 P.M. had him alongside and 9.40 commenced cutting. 4 ships in sight running down towards us. Ship is employed at least 250 barrels of oil in seven hours, and we can cheerfully say "all hail to the Arctic". Soon after we commenced cutting it set in a drizzling rain we however persevered and finished in 3 hours and 12 minutes. when we had supper and at half past 1 A.M. the watch went below at 2 A.M. spoke the Ontario of Sagharbor 5 whales this season, after part with by the ship laying with her main yard aback heading N. by E. wind N.W. the watch employed in boiling. We are now so far advanced to the North, that our compass will not traverse, and we are compelled to shake them every little while to make them move at all there is also a strong current here setting to N. Northward which is constantly increasing in velocity as we proceed towards the pole The western shore is inhabited, Esquimaux Huts being scattered along its bleak inhospitable

1852 In the Arctic Ocean

shore as far up as 70 North. the location of the North Pole, according to the experiments of the different exploring expeditions in search we do not think extends 30 miles from land. from land and had not been current at all

No current these 24 hours

Lat. by Ob. 67-28 N.
Long. Chron. 171. 25 W

Friday August 13th Begins with foggy weather and light breezy from S.W. the ship heading N.N.E. and laying with main yard aback, the crew employed in boiling and setting up pipes. At 4 P.M. lights up for a short time, saw 4 ships two of them boiling also braced forward and were ship heading S.W. by W. middle part occasional fog squalls, saw a whale the mate lowered and just as his boatsteerer stove up the whale settled, at an early hour upwards of 20 ships 14 of them boiling 2 cutting and the others whaling, after part mild clear, beautiful weather, and whales in sight - lowered 1st 2d and 3d boats, did not take at 9 the boats were called to the ship a light breeze up from the Eastward, the ship running for more whales, in sight from mast head, in half an hour they lowered again. remainder of the day employed in boiling

No current these 24 hours

Lat. by Ob 67-36 N.
Long. Chron. 170-58 W

Saturday August 14th Begins with fine weather and light breezy from the Eastward. plenty of whales in sight, and boats chasing in every direction, each chasing their own whale

Figure 3. — Journal of *Montreal*'s 1852 cruise (courtesy of New Bedford Whaling Museum).

more there were some omissions and errors in each. Townsend (1935) devoted a section of his report to the bowhead whales of the North Pacific, but he segregated them neither geographically nor chronologically; consequently bowheads from the Okhotsk Sea and the western Arctic are listed together under the total number taken on an entire whaling voyage — not for each season. In addition, a spot-check of his data revealed that occasionally gray whales and right whales, *Balaena glacialis*, were counted as bowheads and that some bowhead captures were overlooked. Although Clark (1887) listed seasonal reports for voyages to the western Arctic from 1868 to 1884, he omitted some vessels known to have operated there and included others that did not; his figures for each vessel's seasonal products frequently included walrus oil, gray whale oil, right whale oil and baleen, or bowhead baleen that was obtained in trade from the natives. Estimates of the bowhead kill that are based on these sources should be treated with skepticism.

Discussion

If the number of whales that a ship took in the Arctic was not recorded, then it was necessary to determine the average size of the whales taken in that year (expressed in barrels of oil and pounds of baleen) and then to apply this average to the ship's cargo of oil and baleen (Table 1). The averages were computed from information that was extracted from logbooks, journals, and those newspaper reports that included both the total number of whales taken

Table 1.—Preliminary information: Average size of whales taken.

Year[1]	No. of ship's returns used	Average size of whales taken	
		Oil (barrels[2])	Baleen (pounds)
1848	(12)	(132.43)	(1,644.06)
1849	12	132.43	(1,644.06)
1850	6	119.87	(1,644.06)
1851	9	117.04	(1,644.06)
1852	24	112.05	1,644.06
1853	11	113.07	1,509.61
1854	(11)	(113.07)	(1,509.61)
1855	(11)	(113.07)	(1,509.61)
1856	(6)	(97.74)	(1,516.12)
1857	(6)	(97.74)	(1,516.12)
1858	6	97.74	1,516.12
1859	16	111.21	1,469.69
1860	8	93.58	1,597.22
1861	5	113.33	1,733.33
1862	2	106.25	1,562.50
1863	6	106.17	1,419.75
1864	13	93.22	1,388.88
1865	13	98.13	1,526.08
1866	26	90.07	1,616.93
1867	30	86.95	1,383.06
1868	6	82.85	1,385.71
1869	22	88.20	1,464.00
1870	7	77.84	1,150.53
1871	(10)	(102.61)	(1,488.37)
1872	10	102.61	1,488.37
1873	4	95.90	1,568.18
1874	2	86.36	1,590.90
1875	6	97.09	1,327.27
1876	(6)	(97.09)	(1,327.27)
1877	2	125.00	1,568.18
1878	(5)	(118.05)	(1,527.77)
1879	5	118.05	1,527.77
1880	(5)	(118.05)	(1,527.77)
1881	(7)	(110.00)	(1,543.75)
1882	(7)	(110.00)	(1,543.75)
1883	7	110.00	1,543.75
1884	(11)	(96.98)	(1,149.31)
1885	11	96.98	1,149.31
1886	7	95.11	1,546.51
1887	9	91.70	1,403.25
1888	17	89.23	1,548.35
1889	13	83.17	1,403.57
1890	27	75.73	1,413.37
1891	20	88.97	1,212.02
1892	11	88.54	1,556.36
1893	8	86.95	1,521.73
1894	4	93.33	1,690.47
1895	3	92.50	1,260.00
1896	3	87.50	1,425.00
1897	3	122.33	1,461.11
1898	—	—	—
1899	5	102.08	1,503.21
1900	—	—	—
1901	—	—	—
1902	—	—	—
1903	—	—	—
1904	3	82.45	1,390.36
1905-15	—	—	—

[1]If data is insufficient, another year's average, shown in parentheses, is used for further computations.
[2]One barrel is 31.5 U.S. gallons.

Table 2.—Average catch and effort per vessel.

Year[1]	No. of logs consulted	Lowerings per vessel	Whales struck and lost per vessel	Whales found dead per vessel	Whales taken alive per vessel	Whales taken alive and dead per vessel[2]	Percentage of alive whales to total catch	Effort: Lowerings per whale taken alive
	A	B	C	D	E	F	G	H
1848	0	(30)	(1)	(0)	(11)	(11)	(100)	(2.72)
1849	1	30	1	0	11	11	100	2.72
1850	5	31	1	0	5	5	100	6.20
1851	11	22	3	1	7	8	87	3.14
1852	13	39	4	1	14	15	93	2.78
1853	7	34	3	2	5	7	71	6.80
1854	4	18	3	0	2	2	100	9.00
1855	2	41	3	0	4	4	100	10.00
1856	1	16	2	0	3	3	100	5.33
1857	1	(18)	0	1	(2)	3	66	8.00
1858	6	18	2	0	2	2	100	9.00
1859	5	19	2	0	3	3	100	6.33
1860	6	13	2	1	4	5	80	3.25
1861	3	15	1	0	6	6	100	2.50
1862	2	20	3	0	7	7	100	2.85
1863	5	27	2	0	14	14	100	1.92
1864	5	20	1	1	5	6	83	4.00
1865	6	24	2	1	7	8	87	3.42
1866	4	26	2	0	5	5	100	5.20
1867	4	27	1	0	8	8	100	3.37
1868	3	20	0	1	5	6	83	4.00
1869	7	21	1	1	9	10	90	2.33
1870	9	24	1	0	12	12	100	2.00
1871	6	11	1	0	3	3	100	3.66
1872	6	16	1	1	3	4	75	5.33
1873	4	14	1	0	3	3	100	4.66
1874	2	46	2	0	5	5	100	9.20
1875	4	15	1	0	9	9	100	1.66
1876	1	4	0	0	2	2	100	2.00
1877	3	23	2	0	9	9	100	2.55
1878	2	11	2	1	2	3	66	5.50
1879	1	27	9	2	7	9	77	3.85
1880	3	36	2	0	20	20	100	1.80
1881	1	33	0	0	17	17	100	1.94
1882	2	8	1	0	4	4	100	2.00
1883	2	7	0	0	2	2	100	3.50
1884	2	15	1	0	4	4	100	3.75
1885	4	20	2	0	6	6	100	3.33
1886	1	6	1	0	2	2	100	3.00
1887	2	30	1	0	6	6	100	5.00
1888	4	17	1	0	1	1	100	17.00
1889	3	8	0	0	1	1	100	8.00
1890	4	13	0	0	5	5	100	2.60
1891	5	16	1	0	6	6	100	2.66
1892	3	15	1	0	5	5	100	3.00
1893	4	11	0	0	5	5	100	2.20
1894	4	15	1	1	4	5	80	3.75
1895	4	17	1	0	4	4	100	4.25
1896	3	2	0	0	2	2	100	1.00
1897	3	19	1	0	5	5	100	3.80
1898	4	20	3	0	8	8	100	2.50
1899	3	24	0	0	15	15	100	1.60
1900	3	16	1	0	8	8	100	2.00
1901	3	6	0	1	3	4	75	2.00
1902	2	30	2	0	10	10	100	3.00
1903	2	19	1	0	5	5	100	3.80
1904	1	4	0	0	2	2	100	2.00
1905	2	18	2	1	8	9	88	2.25
1906	1	1	0	0	1	1	100	1.00
1907	1	16	1	0	5	5	100	3.20
1908	0	(16)	(1)	(0)	(5)	(5)	(100)	(3.20)
1909	1	5	0	0	2	2	100	2.50
1910	1	14	0	0	4	4	100	3.50
1911	2	18	1	0	7	7	100	2.57
1912	0	(18)	(1)	(0)	(7)	(7)	(100)	(2.57)
1913	0	(18)	(1)	(0)	(7)	(7)	(100)	(2.57)
1914	0	(18)	(1)	(0)	(7)	(7)	(100)	(2.57)
1915	0	(18)	(1)	(0)	(7)	(7)	(100)	(2.57)

[1]If data is insufficient, another year's average, shown in parentheses, is used for further computations.
[2]This figure is the total of columns D and E in this table.

on an Arctic cruise and the amount of oil and baleen they yielded. Because these averages were obtained from a relatively small sample, I restricted their use to that of a rough guide and coupled them with other information (Resources and Methods section and Fig. 2) to estimate the number of whales taken by each vessel in a particular year. For those years in which insufficient data were available the average I used for computations was drawn from another year, close in time, with a reliable data base. For the years after 1897, when the total number of whales taken by each ship was frequently reported, it was often unnecessary to construct averages.

To determine the average annual catch and effort per vessel (Table 2), the following information was extracted from the logbooks: The number of times a ship lowered its boats to chase whales, the number of whales struck-

and-lost, the number found dead[4], and the number taken alive. These data, in turn, allow an estimate of the effort expended per caught whale by computing the average number of lowerings per live whale taken. Because the technology of the fishery was altered somewhat with the introduction of steam auxiliary vessels, it would have been interesting to segregate these data into sail and steam categories; unfortunately the size of my data base would not allow me to do this with confidence. I plan to carry out such an analysis in a future project (see Future Research section).

Similarly, although it would have been desirable to collect information on the number of boats that were lowered during each encounter with whales (thus providing a better estimate of the effort per caught whale), this information rarely appears systematically in logbooks. It is likely that a larger body of data, collected with greater refinement, will allow this analysis (see Future Research section).

The information compiled in my ledgers yielded evidence of more than 2,600 whaling cruises to the Arctic. For the vast majority of these I was able to determine the amount of oil and baleen collected there and then to estimate the number of bowheads taken (Table 3) (see Sources and Methods section). The results of these computations appear in columns B and C of Table 3. I was, however, unable to determine the Arctic products of some of the ships; consequently I estimated their catches by using the figure for the average catch per vessel that we had established from logbooks and other reliable data (see Sources and Methods section and Table 2, column F). I estimated the annual total catch of whales (both alive and dead) taken by all known vessels (Table 3, column F) by combining the figures in Table 3, columns C and E. The estimated number of whales that were annually struck-and-lost (as defined for Table 2) was computed by applying the annual average (Table 2, column C) to the total number of known cruises in column A of Table 3.

Table 3.—Estimated number of whales taken and struck-and-lost by known vessels.

Year	Total no. of known vessels cruising in the Arctic A	No. of known vessels with recorded products B	Est. no. of whales taken[1] by known vessels with recorded products C	No. of known vessels without recorded products D	Est. no. of whales taken[1] by known vessels without recorded products[2] E	Est. no. of whales taken[1] by all known vessels[3] F	Est. no. of whales struck and lost[4] G
1848	1	1	15	0	0	15	1
1849	46	38	454	8	88	542	46
1850	110	94	1,358	16	80	1,438	110
1851	150	111	562½	39	312	874½	450
1852	220	211	2,585½	9	135	2,720½	880
1853	161	148	852½	13	91	943½	483
1854	42	35	78	7	14	92	126
1855	5	5	21	0	0	21	15
1856	13	13	49	0	0	49	26
1857	8	7	49	1	3	52	0
1858	101	99	442½	2	4	446½	202
1859	82	79	331	3	9	340	164
1860	47	46	267	1	5	272	94
1861	45	41	211	4	24	235	45
1862	17	16	111	1	7	118	51
1863	35	34	331	1	14	345	70
1864	80	77	373½	3	18	391½	80
1865	84	70	415	14	112	527	168
1866	78	77	660	1	5	665	156
1867	81	79	597	2	16	613	82
1868	59	58	458½	1	6	464½	0
1869	42	42	436	0	0	436	42
1870	54	53	601	1	12	613	54
1871	43	38	105	5	15	120	43
1872	34	31	196	3	12	208	34
1873	32	32	111½	0	0	111½	32
1874	17	16	134	1	5	139	34
1875	20	20	190	0	0	190	20
1876	19	18	140	1	2	142	0
1877	22	21	116½	1	9	125½	44
1878	24	13	43	11	33	76	48
1879	29	23	93	6	54	147	261
1880	23	20	252	3	60	312	46
1881	22	15	186½	7	119	305½	0
1882	34	31	177	3	12	189	33
1883	36	35	85	1	2	87	0
1884	38	35	174½	3	12	186½	38
1885	41	36	234	5	30	264	82
1886	33	32	161	1	2	163	33
1887	37	37	300	0	0	300	37
1888	39	36	147	3	3	150	39
1889	42	40	72	2	2	74	0
1890	39	37	133	2	10	143	0
1891	35	35	126½	0	0	126½	35
1892	45	44	243½	1	6	249½	45
1893	45	43	303	2	10	313	0
1894	33	32	111	1	5	116	33
1895	30	29	39	1	4	43	30
1896	26	25	91	1	2	93	0
1897	24	24	81	0	0	81	24
1898	20	20	152½	0	0	152½	60
1899	16	16	109	0	0	109	0
1900	16	11	81	5	40	121	16
1901	13	12	38	1	4	42	0
1902	12	12	68	0	0	68	24
1903	14	14	25	0	0	25	14
1904	17	17	57	0	0	57	0
1905	15	15	59	0	0	59	30
1906	14	14	25	0	0	25	0
1907	11	10	58	1	5	63	11
1908	10	10	25	0	0	25	10
1909	5	4	14	1	2	16	0
1910	4	4	8	0	0	18	0
1911	5	5	43	0	0	43	5
1912	4	1	2	3	24	26	4
1913	5	0	0	5	40	40	5
1914	4	2	11	2	14	25	4
1915	1	0	0	1	7	7	1

[1]Whales taken both alive and dead.
[2]Based on average from Table 2, column F.
[3]Total of columns C and E, this table.
[4]Based on Table 2, column C.

A note must be made about the "half" whales listed in columns C and F of Table 3. Occasionally whaleboats from two ships would assist one another in capturing a whale; in such a case the

[1]For the purposes of this report I have defined a struck-and-lost whale as one which could not be processed after being wounded, i.e., any live whale struck by a harpoon, darting gun, or bomb lance shouldergun. Hence, any whale that was struck and lost and later found dead by a ship would be counted under the dead whale category. The very few whales that died of natural causes and were found by ships are also included in the dead whale category.

products would be shared, and, correspondingly, a mid-season report might list "7½ whales." If, in column F of Table 3, a year's total for the estimated number of whales taken by known vessels included a "half" whale, this fraction was rounded off to the next whole number for use in further computations because, of course, it represented one whale kill.

It is obvious that more whales were killed than merely those that were captured: Some wounded whales escaped and died; others were killed, sank, and could not be recovered; others were killed, taken to the ship, and then lost during gales before they could be processed. If it is assumed that 50 percent of the whales that were struck-and-lost (as defined for Table 2) died of their wounds, I have the estimated kill given in column F of Table 4. On the other hand, taking into account the losses referred to above, it may alternatively be assumed that 100 percent of those struck-and-lost are added to the figure for whales taken alive (this figure is shown in column G, Table 4).

My estimate of the number of whales taken by known vessels (Table 3, column F) included both whales captured alive and those found dead. Therefore, to reach an estimate of the total mortality, it was necessary to reduce this figure to an estimate of the number of whales taken alive (Table 4, column D) before adding to it the estimated number of whales that died after being struck-and-lost. It was necessary to group my data into six periods to allow a more reliable data base for computing the percentage of live whales taken to the total taken (Table 4, column C).

I estimate that I identified 98 percent of all pelagic whaling cruises[5] to the Bering Strait region and western Arctic from 1848 to 1915. Thus, with 2,609 known cruises, it is likely that 2,662 cruises were actually made. If 17,597 whales were taken by those known vessels, and if between 18,759 and 21,020 whales were killed by known vessels, it is likely that between 19,142 and 21,448 whales were killed by all vessels (Table 5). Further research (see Future Research section) may well refine these estimates.

[5]I am excluding vessels used solely for trading, shore whaling, freighting, walrusing, or wrecking, although some of these vessels cleared port as whalers.

Table 4.—Estimated number of whales killed by known vessels.

Year	No. of logs consulted A	Est. no. of whales taken alive and dead[1] B	Percentage of alive whales taken to total taken[2] C	Est. no. of whales taken alive[3] D	Est. no. of whales struck and lost[4] E	Lower est. of total mortality of whales by known vessels[5] F	Higher est. of total mortality of whales by known vessels[6] G
1848-1859	56	7,536	91	6,858	2,503	8,110	9,361
1860-1869	45	4,068	94	3,824	788	4,218	4,612
1870-1879	37	1,873	95	1,779	570	2,064	2,349
1880-1889	24	2,032	99	2,012	308	2,166	2,320
1890-1899	37	1,428	97	1,385	227	1,499	1,612
1900-1915	19	660	97	640	124	702	764

[1]Taken from Table 3, column F.
[2]Taken from logbook data.
[3]Taken from columns B and C.
[4]Taken from Table 3, column G.
[5]Number is equal to 50 percent of column E plus column D.
[6]Number is the sum of adjacent numbers in columns D and E.

Table 5.—Estimated number of whales taken and killed by all pelagic whaling vessels.

Item		No.
A	Number of known cruises[1]	2,609
B	Estimated total number of cruises[2]	2,662
C	Estimated number of whales taken by known vessels[3]	17,597
D	Estimated total number of whales taken[4]	17,956
E	Estimated number of whales killed by known vessels[5]	50% rate: 18,759 100% rate: 21,020
F	Estimated total number of whales killed by all vessels[6]	50% rate: 19,142 100% rate: 21,448

[1]Total of Table 3, column A.
[2]Assuming column A, this table represents 98 percent of all cruises.
[3]Total of Table 3, column F.
[4]Assuming column C, this table represents 98 percent of the total number.
[5]Totals of Table 4: column F (50 percent rate), assuming 50 percent of struck-and-lost whales died; and column G (100 percent rate), assuming 100 percent of struck-and-lost whales died.
[6]Assuming column E, this table represents 98 percent of all kills.

Future Research

This work should be considered a reconnaissance. To quickly assess the reduction of the western Arctic bowhead population, I restricted myself to using those resources that were both convenient and accurate. Out of the constraints of time and budget, I limited my logbook research to a representative sample, extracting data on a relatively coarse level.

In the future I plan to expand my data base and to refine my methods of data extraction through a project to be carried out in association with the Marine Biological Laboratory (Daniel B. Botkin, Co-principal Investigator), Woods Hole, Mass. We plan to build on the research I have begun here, using logbooks as our primary source, extracting daily information and storing it in a computer-based retrieval system, and organizing the information under a number of topics (including date, latitude and longitude, weather conditions, number of whales seen, and the size of whales captured).

Coupled with modern mathematical techniques and theories, these records can provide estimates of former stocks, relative changes in populations, population distribution, migration patterns, and the depletion of the whales. These data will allow development and verification of mathematical models of the bowhead population. Such models may be useful to gain insight into present and future population trends and into the requirements for the successful protection of this and other species.

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Literature Cited

Clark, A. H. 1887. The whale-fishery. I.—History and present condition of the fishery. *In* G. B. Goode and staff of associates, The fisheries and fishery industries of the United States, Sect. V, Vol. II, p. 3-218. Gov. Print. Off., Wash., D.C.

Hegarty, R. B. 1959. Returns of whaling vessels sailing from American ports, 1876-1928. Old Dartmouth Hist. Soc., New Bedford, Mass., 58 p.

Starbuck, A. 1964. History of the American whale fishery from its earliest inception to the year 1876. Argosy-Antiquarian Ltd., N.Y., 779 p.

Townsend, C. H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica (N.Y.) 19, 50 p.

Minimal Historical Size of the Western Arctic Population of Bowhead Whales

L. L. EBERHARDT and J. M. BREIWICK

Introduction

The present size of the bowhead whale, *Balaena mysticetus*, population inhabiting the Bering, Chukchi, and Beaufort Seas is estimated to be at least 2,000 individuals (Braham et al., 1979). Estimates of historical levels were obtained by Breiwick et al. (In press), who used estimates of removals since 1848 and a range of values of certain parameters to reconstruct population sizes.

Two sources of concern about the trend in stock sizes since the beginning of commercial exploitation in 1848 seem worth exploration. The first concern is that the heavy exploitation may have reduced the stock to such low levels that its genetic diversity is seriously reduced. Commercial harvests effectively ended by about 1912 (Bockstoce, 1977); it is quite possible that the low point of the population occurred at about that time. If it is feasible to estimate a minimal population level, then such an estimate may permit evaluation of the issue of genetic diversity. The second concern is that the population may have continued to decrease since the cessation of commercial exploitation, due to a continuing take by Eskimos. The calculations that follow are intended to shed some light on these two sources of concern.

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Materials and Methods

The basic idea is to start from the presumed low point of the population and assume a population size at that time. We then simulate the course of the growth of the population to the present, subject to available estimates of removals, and tabulate the outcomes of a number of individual simulations (500). By repeating this process with various parameter combinations, we can suggest what sets of starting population sizes and parameters will result in populations in accord with the available recent estimates. The catch history used is that reported by Marquette and Bockstoce (1980), and the loss rates are those used in Breiwick et al. (In press).

Model

The underlying model parallels that of Breiwick et al. (In press), who assumed that the current population size could be modeled as:

$$P(t+1)=[P(t)-C(t)](1-M) + R(t) \qquad (1)$$

where $P(t+1)$ represents the current population size, which is equal to that of 1 year ago less the removals $[C(t)]$, reduced by mortality [$\exp(-M)$ approximately equals $1-M$], and increased by recruitment $[R(t)]$. Recruitment depends on population size T years before, reproductive rate, and survival to the present. Hence,

$$R(t)=rP(t-T). \qquad (2)$$

Because very little is known about these parameters in bowhead whales, the only course open at present is to assume a recruitment rate and a "lag" period. The lag period (T) is inserted to reflect the fact that current births depend substantially on the size of the population some years back; i.e., reproduction is a function of the mature