Nineteenth-century Ship-based Catches of Gray Whales, *Eschrichtius robustus*, in the Eastern North Pacific

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Introduction

In a broad analysis of global whaling, Reeves and Smith (2006) identified no fewer than 22 different whaling "operations" that targeted gray whales, *Eschrichtius robustus*, in the North Pacific Ocean, ranging from aboriginal hunts that began many hundreds or even thousands of years ago, to the more recent factory ship activities using modern searching, killing, and processing methods. Among those 22 operations, they identified five American-style pelagic (or ship-based) operations that took gray whales (Dutch, French, German, Russian, and American; operation numbers 54–56, 61, and 64 in their Appendix). In addition, during this study, we have established that vessels registered in Great Britain and Hawaii also took gray whales (operation numbers 57 and 58 in Reeves and Smith, 2006). These seven operations, along with the other whaling on this species, had reduced gray whale numbers to an unknown, but apparently considerable, extent in both the eastern and western North Pacific by the end of the 19th century.

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The widely held view that the eastern population (often called the California population or stock) has recovered to its pre-whaling abundance was recently challenged by a study suggesting an average long-term abundance of about 96,000 gray whales in the North Pacific Ocean (Alter et al., 2007). This figure is several times higher than the number of gray whales estimated alive today. If the DNA-based estimate were considered accurate and were applied to the period just before large-scale commercial exploitation began in the 1840's, it would imply that a far greater number of animals had been removed from the California population by whaling than generally assumed. Even without that DNA-based estimate, however, there are concerns about the accuracy of the catch record used in population modeling of eastern North Pacific gray whales (IWC, 1993; Butterworth et al., 2002: Table 2). Wade (2002:85–86), for example, stated:

> "An unresolved issue regarding the eastern North Pacific gray whale is that it has not been possible to reconcile the catch history from the 1800s with the recent time series of abundance data in a simple way. Several attempts have been made to project population models

ABSTRACT—The 19th century commercial ship-based fishery for gray whales, Eschrichtius robustus*, in the eastern North Pacific began in 1846 and continued until the mid 1870's in southern areas and the 1880's in the north. Henderson identified three periods in the southern part of the fishery: Initial, 1846–1854; Bonanza, 1855–1865; and Declining, 1866–1874. The largest catches were made by "lagoon whaling" in or immediately outside the whale population's main wintering areas in Mexico—Magdalena Bay, Scammon's Lagoon, and San Ignacio Lagoon. Large catches were also made by "coastal" or "alongshore" whaling where the whalers attacked animals as they migrated along the coast. Gray whales were also hunted to a limited extent on their feeding grounds in the Bering and Chukchi Seas in summer.*

Using all available sources, we identified 657 visits by whaling vessels to the Mexican whaling grounds during the gray whale breeding and calving seasons between 1846 and 1874. We then estimated the total number of such visits in which the whalers engaged in gray whaling. We also read logbooks from a sample of known visits to estimate catch per visit and the rate at which struck animals were lost. This resulted in an overall estimate of 5,269 gray whales (SE = 223.4) landed by the ship-based fleet (including both American and foreign vessels) in the Mexican whaling grounds from 1846 to 1874. Our "best" estimate of the number of gray whales removed from the eastern North Pacific (i.e. catch plus hunting loss) lies somewhere between 6,124 and 8,021, depending on assumptions about survival of struck-but-lost whales. Our estimates can be compared to those by Henderson (1984), who estimated that 5,542–5,507 gray whales were secured and processed by ship-based whalers between 1846 and 1874; Scammon (1874), who believed the total kill over the same period (of eastern gray whales by all whalers in all areas) did not exceed 10,800; and Best (1987), who estimated the total landed catch of gray whales (eastern and western) by American ship-based whalers at 2,665 or 3,013 (method-dependent) from 1850 to 1879.

Our new estimates are not high enough to resolve apparent inconsistencies between the catch history and estimates of historical abundance based on genetic variability. We suggest several lines of further research that may help resolve these inconsistencies.

forwards from the1800s assuming the population was at carrying capacity prior to the start of commercial whaling in 1846, but such projections cannot produce a trend that agrees with the recent abundance estimates, which indicate the population roughly doubled between 1967 and 1988 … . The catch history and current trend can only be reconciled through fairly dramatic assumptions, such as an increase in the carrying capacity from 1846–1988 of at least 2.5 times, an underestimation of the historic commercial catch from 1846–1900 of at least 60%, or annual aboriginal catch levels prior to 1846 of at least three times the level previously thought (Butterworth et al. 2002)."

In a separate paper in this issue, Reeves and Smith (2010) reviewed and reanalyzed the history of commercial shore-based whaling for gray whales and humpback whales, *Megaptera novaeangliae*, along the coast of California in an initial attempt to address Wade's (2002) "dramatic assumption" that the historic commercial catch has been substantially underestimated. This paper considers another aspect of the gray whale's catch history that bears on the same assumption. Thus, we review commercial 19th century ship-based whaling on gray whales in the eastern North Pacific and evaluate the extent to which previous compilations have led to underestimation of removals by that component of the overall whaling effort on this species.

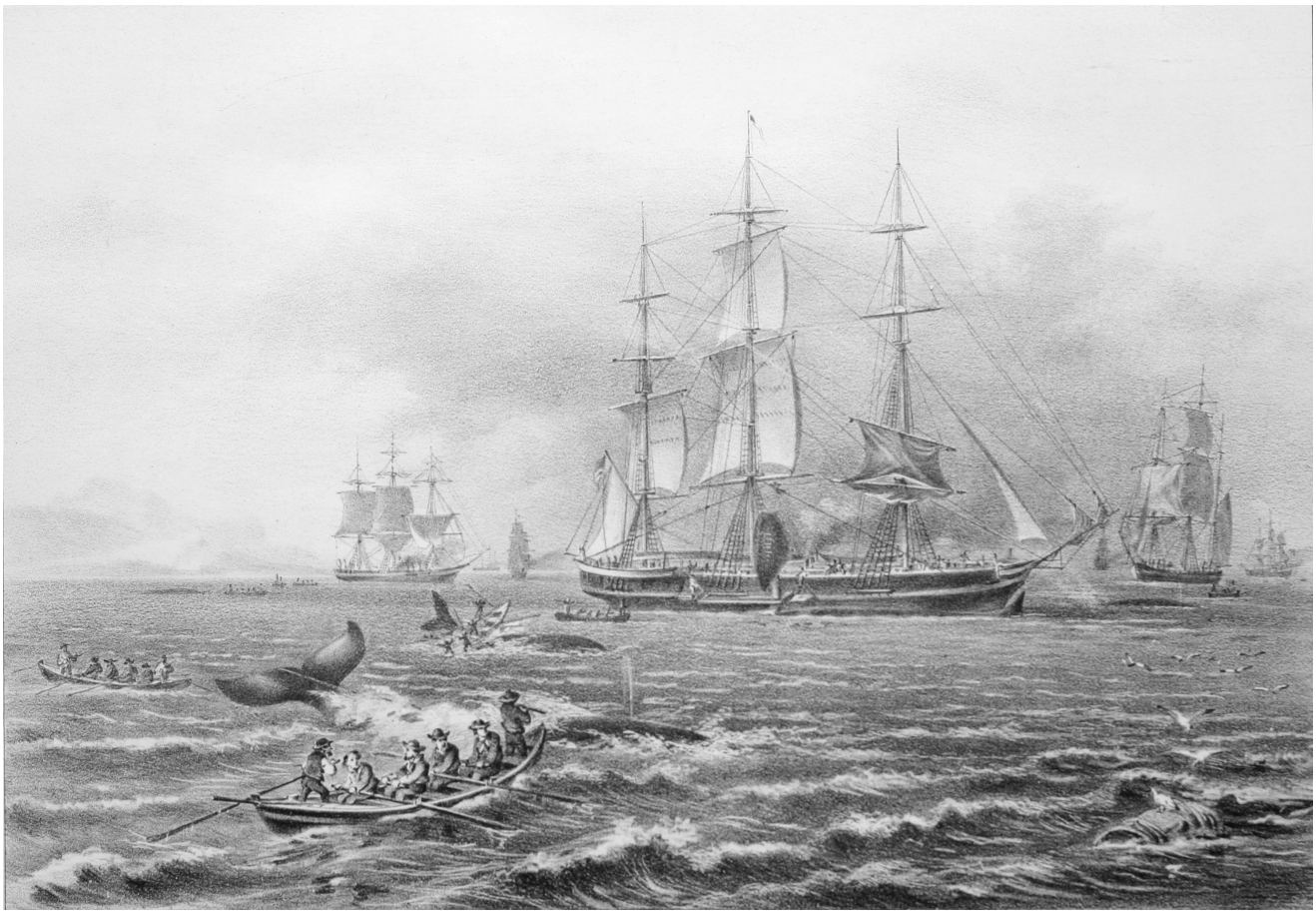
Figure 1.—Whole plate ambrotype of the New Bedford whaleship *Saratoga*, labeled "1856 Frederick Slocum, master." The photographer and his location are unknown. Depending on where it was taken, New Bedford or Honolulu, this image would be the oldest or second-oldest known photographic representation of a whaleship. At the time, *Saratoga* was part of the fleet of vessels engaged in whaling for gray whales in Mexico during the winter season. Courtesy of New Bedford Whaling Museum.

Previous Gray Whale Catch Estimates in the Eastern North Pacific

By ship-based whaling we mean the whaling by crews of ships (rigged as brigs, schooners, barks, or ships) that went to sea from a home port and hunted whales using this main vessel as a "mother-ship," pursuing the whales from small boats and towing their catch back to the main vessel (or in some scenarios to a "tender" vessel) for processing (Fig. 1). Although ship-based whaling was usually a pelagic activity, in some circumstances, for example when hunting gray whales in their breeding and calving lagoons, the ships were anchored near shore or in a bay while the boats scouted for and caught the whales. Such whaling is sometimes called "bay whaling," a term that is not, however, without ambiguity. For example, Dall (1872 as quoted in Scammon, 1874:22) referred to what has been called shore whaling at Monterey, Calif. (Sayers, 1984; Reeves and Smith, 2010), as "the bay-whaling of that locality." Scammon (1874:23), in contrast, referred to the start of "bay-whaling" for gray whales in 1846 in a clear reference to the start of ship-based whaling in Magdalena Bay, Baja California. Although gray whales were taken in the eastern North Pacific by both offshore or alongshore whaling and by bay whaling, the latter apparently was responsible for the bulk of the removals.

Scammon (1874:23) estimated that no more than 10,800 California (i.e. eastern Pacific) gray whales had been "captured or destroyed" by whalers between 1846 and 1874. Given his estimate of 2,916 killed by shore-based whalers, this would imply that about 7,900 were killed during that period by the lagoon, alongshore, and offshore commercial whalers and aboriginal whalers, combined.

Henderson (1984:169, his Table I) estimated lower total removals (including hunting loss) of gray whales from the "California herd" by commercial whalers (i.e. taking no account of catches by aboriginal whalers): 8,044–8,099 from 1846 to 1874. Of that number, 2,592 were killed by shore whalers, leaving roughly 5,500 (5,452–5,507) to have been taken by ship-based whalers operating in the lagoons (3,235–3,290), alongshore (1,678), and in northern areas (539). Henderson (1972:260), in compiling



Lithograph of a northern whaling scene from Scammon (1874).

his catch record, had deliberately tried to err "on the side of exaggeration" because he was concerned that his estimates were lower than Scammon's. Although Henderson appears to have redressed that bias to some extent in his 1984 reanalysis, the net overall effect of the changes between his 1972 and 1984 estimates was, in his estimation, negligible (Henderson, 1984:166).

Best (1987) estimated even lower catches of gray whales by American ship-based whalers throughout the North Pacific between 1850 and 1879. One of his estimates was based on oil production (2,665 whales landed) and the other on logbook-recorded catch per voyage (3,013 whales landed). However, these estimates are difficult to compare to those by Scammon and Henderson as they include whales taken from the western North Pacific population and do not include catches by non U.S. vessels.

Three related estimates of the catches of eastern North Pacific gray whales over time have been used in modeling the status of the population. Reilly (1981) divided the commercial whaling era into three periods, defined according to the nature of his sources: 1846–1874, 1875–1911, and 1912–1981. For the first period, which is the main focus of this paper, Reilly relied principally on Henderson (1972). The second catch series, compiled by Lankester and Beddington (1986, their Appendix 1), benefited from the comprehensive review and analysis of ship-based whaling by Henderson (1984). Cooke (1986) used the Reilly (1981) catch series in his analysis, noting that it was "very similar to more recent compilations by Henderson (1984) and Lankester and Beddington (1986)." The third series was produced (by Butterworth et al., 1990, 2002) for a special meeting of the IWC Scientific Committee in 1990 to assess gray whales. The commercial component (at least) of that catch series was "based primarily upon Lankester and Beddington's (1986) table" (IWC, 1993:243). Although the Butterworth et al. (1990) catch series was considered the "best available" at the time of the special meeting, participants suspected that it was incomplete and that the commercial catches could have been underestimated by up to 1.5 times (IWC, 1993).

The IWC special meeting agreed (based on Mitchell, 1993) that although Henderson's (1972, 1984) studies of American ship-based whaling for gray whales off Mexico and California had been definitive in some respects, at least two things deserved reconsideration

(IWC, 1993). One was Henderson's use of 35 barrels (bbl)/whale as an average yield for converting oil production statistics into gray whales secured and processed. The other was the smallness of the loss rates (i.e. whales struck but lost as a fraction of the total killed) applied by Henderson (1972, 1984).

A number of additional issues that were not cited in the IWC report deserve attention. One is the possibility that some gray whales taken by non-American ships operating in the North Pacific, including the Mexican lagoons and the Bering Sea, were not accounted for in Henderson's published work. Another is the possibility that the oil returns used by Henderson to estimate catches were not complete. A countervailing (positive) bias might have come from the inclusion of oil from humpback whales, blackfish (mainly pilot whales, *Globicephala macrorhyncha*), and occasionally right whales, *Eubalaena japonica*, fin ("finback") whales, *Balaenoptera physalus*, and blue (sulphur bottom) whales, *Balaenoptera musculus*, in the whale oil returns of vessels visiting the gray whale grounds along the Mexico and California coasts. We have attempted to address all of these concerns, with varying success, in this study.

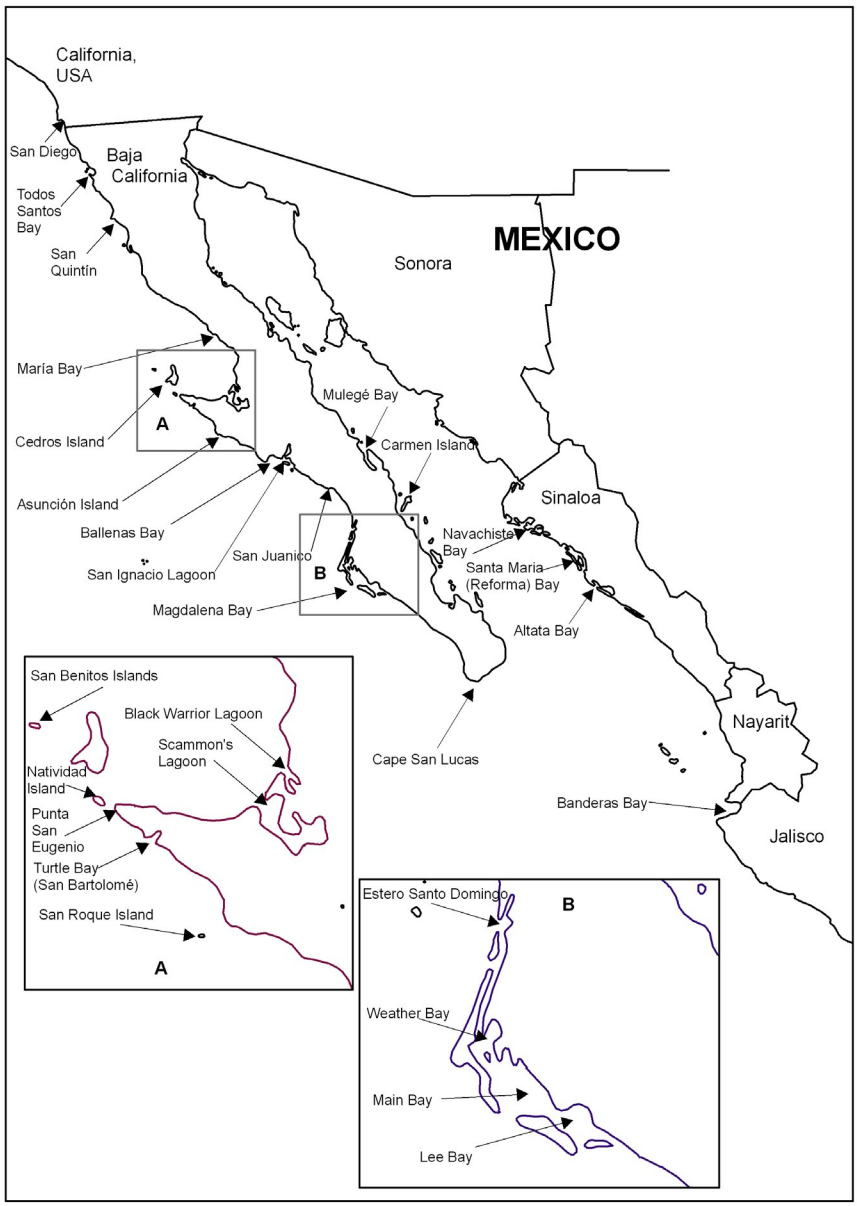


Figure 2.—Map of Baja California and Mexican mainland gray whaling region, with insets of Scammon's Lagoon (A) and Magdalena Bay (B).

Review of Ship-based Gray Whale Fishery

Henderson's Work

A central feature of the present study was a detailed examination of Henderson's published work (1972, 1984) and his extensive notes and files held by the library of the New Bedford Whaling Museum. We reviewed how Henderson made his estimates and attempted to evaluate their accuracy and completeness. The new estimates of catches and removals presented herein are based to a considerable extent on the Henderson material, supplemented by data from our own searches of logbooks, newspapers, and customs records.

Henderson's (1972) monograph on the fishery for gray whales in the eastern North Pacific focused on Scammon's Lagoon (Fig. 2) but included consideration of the entire species range. It was one of the earliest attempts to reconstruct a whale population's catch history from logbook and other data. He used, in particular, period newspapers such as the *Seaman's Friend and Temperance Advocate* and the *Pacific Commercial Advertiser* (Fig. 3), both published in Honolulu, Hawaii, the *Whalemen's Shipping List and Merchants' Transcript*, New Bedford, Mass., and various California newspapers, including the *San Francisco Alta California*, *San Francisco Chronicle*, *San Francisco Bulletin*, *San Diego Herald*, and *San Diego Union*.

In a follow-up study, Henderson (1984) reconsidered his earlier estimates. For his overall catch summary for the eastern Pacific population (his Table I, p. 169), he appears to have relied on a combination of newspaper reports, the Dennis Wood Abstracts (Wood, N.d.),

Figure 3.—Right: List of arrivals at Honolulu port, *Pacific Commercial Advertiser*, 5 April 1860. This illustrates some of the challenges of interpreting ambiguous data. For example, vessels that clearly visited the gray whaling grounds in Baja California in the winter of 1859–60, judging by the "From" column, had been at sea for many months, in some cases almost three years, and had given as their original destination ("Where Bound" column) Arctic, Ochotsk (Okhotsk Sea), or Kodiack (Gulf of Alaska). Much of the whale oil returned by such voyages (the "Wh." column under "Season's Catch") would have been from gray whales taken in the Mexican lagoons and alongshore.

Spring Fleet of Whalers.

ARRIVAL.	SHIP'S NAME.	CAPTAIN.	FROM.	MONTHS OUT.	SEASON'S CATCH Sp.	Wh.	Bn.	WHERE BOUND.	SAILED.
January 28	*Hibernia	Booker	Huahine	27	45	....	.....	Condemned	
February 11	*George Washington	Brightman	Off Hawaii	28	....	....	.....	Arctic	Feb. 28
13	*Republik (Bremen)	Sayer	Society Islands	16	....	....	.....	Arctic	Feb. 28
14	*Omega	Sanborn	Tahiti	28	....	....	.....	Arctic	March 19
19	America	Bryant	Cape St. Lucas	28	....	40	.....	Arctic	Feb. 22
21	*Comet (Oldenburg)	Wilhelm	Bremen	6½	....	....	.....	Ochotsk	March 14
27	*Majestic	Chester	Marguerita Bay	31	....	50	.....	Ochotsk	19
27	*Monmouth	Ormsby	Marquesas	30	....	....	.....	Ochotsk	12
March 1	*J. D. Thompson	Crosby	Coast of California	18	....	75	.....	Kodiack	19
1	*Republik (Bremen)	Sayer	Sea, mutiny on bo'rd	16	....	....	.....	Arctic	12
3	*Lewis	Neal	Marguerita Bay	31	....	....	.....	Arctic	20
5	Electra	Brown	New London	6	....	70	.....	Kodiack	5
9	Montezuma	Homan	Coast of California	30	....	120	.....	Ochotsk	13
11	Alice	Beebe	Line	16	90	....	.....	Ochotsk	14
12	Julian	Winegar	Line and Tahiti	18	25	....	.....	Kod'k & Arc.	21
13	Congress 2d	Stranburg	Marquesas	18	90	....	.....	Ochotsk	16
15	Coral	Sisson	Line	17	....	....	.....	Ochotsk	15
16	Phillip 1st	Hempstead	Lahaina	18	....	....	.....	Ochotsk	19
18	Marcia	Billings	Line	30	96	....	.....	Arctic	27
19	*Eliza Adams	Thomas	Marguerita Bay	30	....	700	.....	Arctic	In port
20	Cambria	Pease	Coast and Line	17	....	....	.....	Ochotsk	March 23
21	Florida	C. P. Fish	Home	7	40	120	700	Arctic	23
21	Callao	Fuller	Line	19	....	....	.....	Kamschatka	21
21	*Planet (Oldenburg)	Dallman	Bremen	5	....	....	.....	Ochotsk	In port
22	Jeannette	Winslow	Gallipagos	17	....	....	.....	Ochotsk	March 27
23	*George Howland	Pomeroy	Marguerita Bay	29	....	800	.....	Ochotsk	28
24	Navy	Sarvent	Home	7½	180	....	.....	Arctic	26
25	Hercules	Athearn	Marquesas	30	26	36	.....	Arctic	25
25	Martha	Dailey	Coast of California	20	....	....	.....	Arctic	25
25	Onward	Allen	Marguerita Bay	18	....	750	.....	Ochotsk	27
25	John Wells	Woodbridge	Coast of California	29	....	....	.....	Ochotsk	28
25	Constantine (Russ'n)	Lindholm	Scammon's Lagoon	20	....	160	.....	Ochotsk	27
25	*L. C. Richmond	Hatheway	Marguerita Bay	29	....	700	.....	Ochotsk	In port
26	Nimrod	Howes	Gallipagos	30	....	....	.....	Ochotsk	March 28
27	Thomas Nye	Holly	Line	29	....	....	.....	Ochotsk	28
27	*Henry Kneeland	Kelly	Scammon's Lagoon	21	....	350	.....	Arctic	In port
28	*Ripple (bark)	Morgan	Scammon's Lagoon	30	....	500	.....		In port
29	Helen Mar	Worth	Line	38	....	....	clean	Arctic	March 29
29	*Tempest (bark)	Fish	Scammon's Lagoon	34	....	550	.....		In port
30	*New England	Hempstead	Scammon's Lagoon	30	....	480	.....		In port
April 1	General Williams	Fish	California Coast	30	....	1000	.....		Outside
4	Rebecca Simms	Howes	Gallipagos	28	....	30	.....	Arctic	
4	Oliver Crocker	Cochran	Marguerita Bay	17	....	700	.....	Ochotsk	

Vessels marked (*) entered the harbor. Those not marked, simply touched outside.

Left: Article in *Pacific Commercial Advertiser*, 1 April 1862, with relatively detailed information on activities of various Honolulu-based vessels in the winter 1861–62 whaling season. Note that for some, the catch is given as whales landed and for others, as barrels of whale oil. Reference is made to activities in all three of the main gray whaling lagoons: Ballenas (San Ignacio), Scammon's, and Margarita (Magdalena) Bay.

MEMORANDA.

Report of brig Victoria, Dauelsberg.

Left Ballenas Bay, 13th March, with 450 brls this season. Reports the following vessels:

Brig Kohola, Brumerhop, Feb. 3d, at Scammon's Lagoon, with 11 whales. Brig Comet and schooner Kalama, at same place and date, with 21 whales between them.

At Margarita and Ballenas Bays—Ship Harvest, 37 whales; bark Harmony, 1000 brls.; schooner Emma Rooke, 500; ship C. W. Morgan, 14 whales; ship John Howland, 19 whales; bk Carib, 340 brls; bark Sarah Warren, 300 brls.

☞ Ship *General Teste*, Lopes—Left Honolulu, October 5. Cruised on the coast of New Zealand. In lat. 46° S., long. 160° W., fell in with immense quantities of field ice and very large islands of ice; was four days in going through. Left N. Z. Jan. 22; touched at Marquesas on the passage back, and saw there the Am. sperm whale bark *Sunbeam*, with 400 brls. sperm. Spoke the *General Scott* off New Zealand Jan. 10—he had taken nothing since leaving Honolulu.

☞ Ship *Reindeer*, Raynor, reports—Left Honolulu Dec. 4, and arrived at Margarita Bay on the 26th. Took the first whale on the 5th Jan., but did not fairly commence whaling till the 10th. Found whales most plentiful about the middle of January. Left the Bay February 28, put into Man-o'-War Bay for firewood, and sailed again March 5th. First three days, had light westerly winds, after that strong trades all the way. Arrived at Honolulu March 18, with 1,125 brs. oil this season, having been absent only 3½ months. Reports the following vessels:—In Margarita Bay, March 5, ship Harvest, Manchester, with 1000 brls. oil this season. Heard from, Feb. 22:

Bark Harmony, Molteno.....15 whales.
Schooner Emma Rooke, Wilbur.....11 "
Brig Maria.....3 "

Bottom: Brief, but informative, squib in *Pacific Commercial Advertiser*, 12 April 1860. Note that nearly all of the vessels mentioned here, *Sharon*, *Harmony*, *Ocmulgee*, *Fabius*, *George and Mary*, *Fortune*, *Delaware*, and *Lark*, are not included in the "Spring Fleet of Whalers" listed in the same newspaper a week earlier (see above). This example demonstrates the importance of combining multiple sources of information for a comprehensive accounting of catches.

☞ Capt. J. H. Swift, of ship *Sharon*, of Fair Haven, from Coast of California, with 450 brls oil, reports—Arrived at Scammon's Lagoon Jan. 2d; took the first whale on the 3d, and last one the 1st of March. Left on the 6th in company with ship New England, of N. L., and bark Harmony, of Honolulu; arrived at Turtle Bay the 7th; saw a number of whales until the 13th, when they became scarce. Left Turtle Bay on the 15th, in company with ship Ocmulgee and bark Harmony, both bound to the islands. Left at Turtle Bay, ship Fabius, Smith, of N. B., 500 brls this season; barks George & Mary, of N. L. 400 brls, Fortune, Comstock, of N. L., 400, Delaware, Kenworthy, of N. L., 550, Lark, of N. L., 600. The Lark leaves on the 20th for Marguerita Bay, to take the bark Ripple's oil home for her; all the other ships will touch at the islands.

logbooks, and a few published sources. He probably also consulted *The Polynesian*, a Honolulu-based newspaper that provided sometimes-detailed reports on whales taken per vessel, referring to the "California Coast" and at least occasionally to specific locations such as Turtle Bay or Magdalena Bay (Fig. 2). For the northern kills, Henderson used unpublished data provided by John Bockstoce (Bockstoce and Botkin, 1983). Henderson's final conclusion (1984:166) was that his earlier estimate of the total kill of eastern gray whales for the period 1846 to 1874 had been about right, i.e. ca. 8,000 gray whales, even though some of the details differed between his 1972 and 1984 analyses.

Henderson's 1972 book included the identities of the specific vessels that whaled in Scammon's Lagoon in each season from 1857 to 1873. His later book chapter (1984) had a broader focus, encompassing gray whaling in additional lagoons and bays in Mexico between 1846 and 1874, but without specifying the vessels and seasons. His summary totals of whaling vessel visits, which he termed cruises and which we term vessel-seasons, and his associated text led us to conclude that he had identified most, and probably nearly all, of the gray whaling activity in Mexico. We therefore assumed that, by scrutinizing his published work (Henderson, 1972, 1984) and his unpublished notes and files, we would be able to identify most of the vessel-seasons of whaling on the gray whaling grounds, including specific lagoons, bays, and "alongshore" areas.

Henderson's material included references to roughly 300 apparently uniquely named vessels that whaled for at least one season in Mexico beginning in 1846, for a total of roughly 500 vessel-seasons.[1] These vessel-seasons included many that were gray whaling, but also some that were taking sperm whales, *Physeter macrocephalus*, humpback whales, or elephant seals, *Mirounga angustirostris*, either exclusively or in addition to gray whales.[2] Some of the vessel-seasons proved to be spurious because a vessel's name had been spelled differently in different sources; this variation included instances where the appropriate Roman numeral was present in one source but missing in another (e.g. *Congress* vs. *Congress II*). Moreover, for some vessel-seasons, we were unable to determine the species targeted.

Henderson (1972:81) believed that gray whales had been largely or entirely "unmolested" by commercial whalers from 1795, when they were first observed and reported by Captain John Locke of the British whaleship *Resolution* ("the first captain to engage in a genuine whaling venture in the eastern North Pacific Ocean": Henderson, 1972:17, also see Henderson, 1975), to 1846, when, according to Scammon (1874), gray whaling began in Magdalena Bay. This large lagoon complex of smaller bays and channels had been visited by sperm whalers well before 1846, but apparently there is no record of a single gray whale having been taken before then, even though they must have been available in relatively high densities in winter. Henderson (1984:163) concedes that some whalers "chased" gray whales but he concludes that "so far as the record shows they never caught any."

General Characteristics of the Fishery

Henderson's extensive examinations of logbooks and newspapers allowed him to define the typical seasonal rounds, or itineraries, followed by the North Pacific whaling fleets. The ships usually sailed from the Hawaiian (Sandwich) Islands to the summer sperm, right, or bowhead, *Balaena mysticetus*, whaling grounds to the north and returned to Hawaii in the autumn and thence to one or more southern grounds, e.g. off New Zealand or Chile, along The Line (the equator), in the Marianas, or along the Coast of California, which mainly meant the western coast of Baja California (Henderson, 1984:162). Although there is little evidence that ship-based whalers hunted gray whales in low latitudes in the western Pacific as they did in the east (Henderson, 1990), considerable numbers of gray whales were taken in the Sea of Okhotsk (Reeves et al., 2008). This meant that on a given voyage, a vessel may have pursued eastern gray whales in the lagoons or alongshore Mexico and California in the winter, and western gray whales in the Sea of Okhotsk in the summer. In his synthesis, Henderson (1984) appears to have maintained the distinction and included in his Table I (1984:169) northern catches only from the "California herd," i.e. the Bering and Chukchi Seas. Therefore, there is no systematic compilation of gray whale catches by ship-based whalers in the Sea of Okhotsk (see Henderson, 1984:176, footnote 14; Kugler, 1984:157, footnote 6) although these are implicitly included in the estimates by Best (1987).

Henderson (1972:81) reported that American whalers arrived at the shores of Baja (Lower) California in Mexico and Alta (Upper) California in the Unites States in the early 19th century and that there was a "major movement of American whalers into the North Pacific from Hawaii after 1820." The vessels often provisioned at San Francisco and Monterey before heading to the Californias for winter sperm whaling. By the 1830's, scores of vessels were doing this. During 1846–47, the number of ships visiting Magdalena Bay for gray whaling rose rapidly from several to perhaps 50 (according to Scammon) or 20–25 (according to Henderson, 1972:83; 1984:165) in 1847–48. Apparently all of these represented "between the seasons" cruises by New England (especially Connecticut)

[1] Throughout this paper, a vessel-season is understood to encompass the period from late autumn one year to spring the next. Thus, 1846–47 would mean approximately November 1846 through April 1847. In some of the tabular material where vessel-seasons are identified by only one year, this refers to the latter part of the season and thus, in this example, it would be 1847 not 1846.

[2] As an example, *Cynosure* of San Francisco visited grounds between Cedros Island and Cape San Lucas, including Magdalena Bay, in the season 1855–56. The logbook makes no mention of gray whales but records the capture of one humpback whale (another struck/lost), 36 blackfish (pilot whales, *Globicephala* sp.), 22 elephant seals, and 20 turtles. In addition, the crew chased killer whales, *Orcinus orca*, unsuccessfully and struck but lost a blue whale. After a stopover in San Francisco from early February to late March, *Cynosure* returned to the Baja California and mainland grounds south to Central America, chasing right whales and humpback whales in April, and then only sperm whales and blackfish through the summer and autumn before returning to San Francisco in November 1856.

vessels or by foreign vessels (including some from French, Dutch, and German ports) that, in summer, had been engaged primarily in right whaling in the northern North Pacific.[3] There is a suggestion by Henderson that this phase of lagoon whaling was facilitated by the U.S.–Mexico war. As he put it, during the hostilities the Mexican government was "even less able to control, or benefit from, the whaling than prior to 1846" (Henderson, 1972:83).

Interest in gray whaling waned temporarily after 1848, a trend attributed by Henderson (1972:84, citing Williams, 1964; also Henderson, 1984:165) to "the inferior quality and low price of the dark-colored gray whale oil, the low quality and quantity of whalebone from the gray, and the dangers of lagoon whaling." In fact, lagoon whaling for gray whales stopped entirely for three seasons—1848–49, 1849–50, and 1850–51. A San Francisco ship (*Aquetnet*) whaled at Magdalena Bay in 1852–53 (Henderson, 1984:164), followed in the mid 1850's by, among others, the ship *Leonore* and schooner *Hopewell* (Henderson, 1972:84). As Scammon (1874:270) noted, "... Magdalena Bay whaling was resumed with ardor about the years 1855 and 1856, and was continued and extended along the whole coast of both Upper and Lower California." Many vessels returned to San Francisco after the winter season and then went back to Mexico for sperm and humpback whales in the summer.[2] It was not until 1861, when the barks *Sarah Warren* and *Carib* did so, that San Francisco vessels began to participate in the northern summer hunt for bowheads and right whales (Henderson, 1972:86).

By the early 1860's, a gray whaling circuit had been established, consisting of summer cruises out of Hawaii or San Francisco to the Gulf of Alaska, Bering Sea, Arctic Ocean, coast of Kamchatka, or Sea of Okhotsk principally for right whales and bowhead whales, followed by winter cruises to Baja California and along the mainland Mexican coast (Henderson, 1972:85). Some of the ships discharged their cargoes and refitted in Hawaii or San Francisco before going south while others proceeded directly to Mexico, often still carrying their cargo of northern oil and whalebone. Lagoon whaling for gray whales continued to be dominated by Hawaii and New England vessels operating out of Hawaiian ports. So-called "pick-up" cruises by small vessels out of San Francisco going for various whale species in addition to gray whales, plus elephant seals, sea turtles (probably mainly Cheloniidae), and even abalone (family Haliotidae) were also common in the late 1850's and early 1860's (Mulford, 1869; Henderson, 1972:94–6; 1984:171).

Henderson (1972, 1984) recognized three distinct contexts or phases of ship-based gray whaling: lagoon whaling, coastal or alongshore whaling (including kelp-whaling, where the boats were stationed in or near the kelp beds and waited for the whales to swim within shooting range; Scammon, 1874:26–27, 258–259), and pelagic whaling on the northern summering grounds. In his statistical scheme for organizing the catch history of eastern gray whales, Henderson (1972, 1984) divided the 19th century ship-based era into three periods, as follows: Initial, 1845–46 to 1853–54; Bonanza, 1854–55 to 1864–65; Declining 1865–66 to 1873–74.

Unfortunately, the lack of lists of the vessels and voyages included in Henderson's analyses seriously hampers attempts to trace his reasoning and verify his catch totals, which in any event are presented in his various published tables only as quasi-decadal aggregates. Following Henderson, we have organized our review according to three phases (lagoon, alongshore, pelagic), further subdivided by time intervals as appropriate.

Lagoon Whaling

Lagoon whaling was centered in three lagoons along the outer (Pacific) coast of Baja California: Magdalena (Margarita) Bay (a deep basin with appended lagoons and shallow margins where gray whales concentrated; Mulford, 1869; Henderson, 1972:30), San Ignacio (Ballenas) Lagoon (not to be confused with Ballenas Bay on the outside where alongshore whaling occurred), and Ojo de Liebre (Jack Rabbit Spring; see Henderson, 1984:183) Lagoon (now better known as Scammon's Lagoon; Fig. 2). Black Warrior Lagoon (Laguna Guerrero Negro), although named after the whaling bark *Black Warrior* of Honolulu, was not a significant whaling lagoon, and Henderson (in Scammon, 1970:38, note 52) concluded that it was only visited in 1858–59 when "the captains of the few vessels from Honolulu which entered the lagoon probably mistook the mouth for that of Scammon's Lagoon."

In the Initial Period, there was no lagoon whaling in 3 of the 9 years (1848–49, 1849–50, and 1850–51). The entire lagoon catch in this period was in Magdalena Bay, where ships sailing from Connecticut ports predominated, accounting for about half of the 50–60 vessel-seasons. Also, vessels from Havre (5 seasons), Bremen (1), and Amsterdam (1) visited Magdalena Bay and whaled for gray whales there. Presumably, Henderson's (1984:165, 169) estimate of the lagoon catch in this period (400–450 by 50–60 cruises) includes the activities of non U.S. registered vessels. He accounted for the downward revision of his earlier estimate of 500–550 for this period (Henderson 1972, his Table I) by suggesting that about 100 catches of sperm and humpback whales had been inadvertently included with the earlier tally (Henderson, 1984:165).

Henderson (1984:165) stressed that some vessels and crews were especially adept at gray whaling in the lagoons (and perhaps also alongshore) and took many whales, while others left the grounds "without a drop of oil." The difficulty of approaching and securing the whales could well have increased with time. Even by the mid 1850's, Mulford (1869) found, for example, that the gray whales in Magdalena Bay were extremely wary:

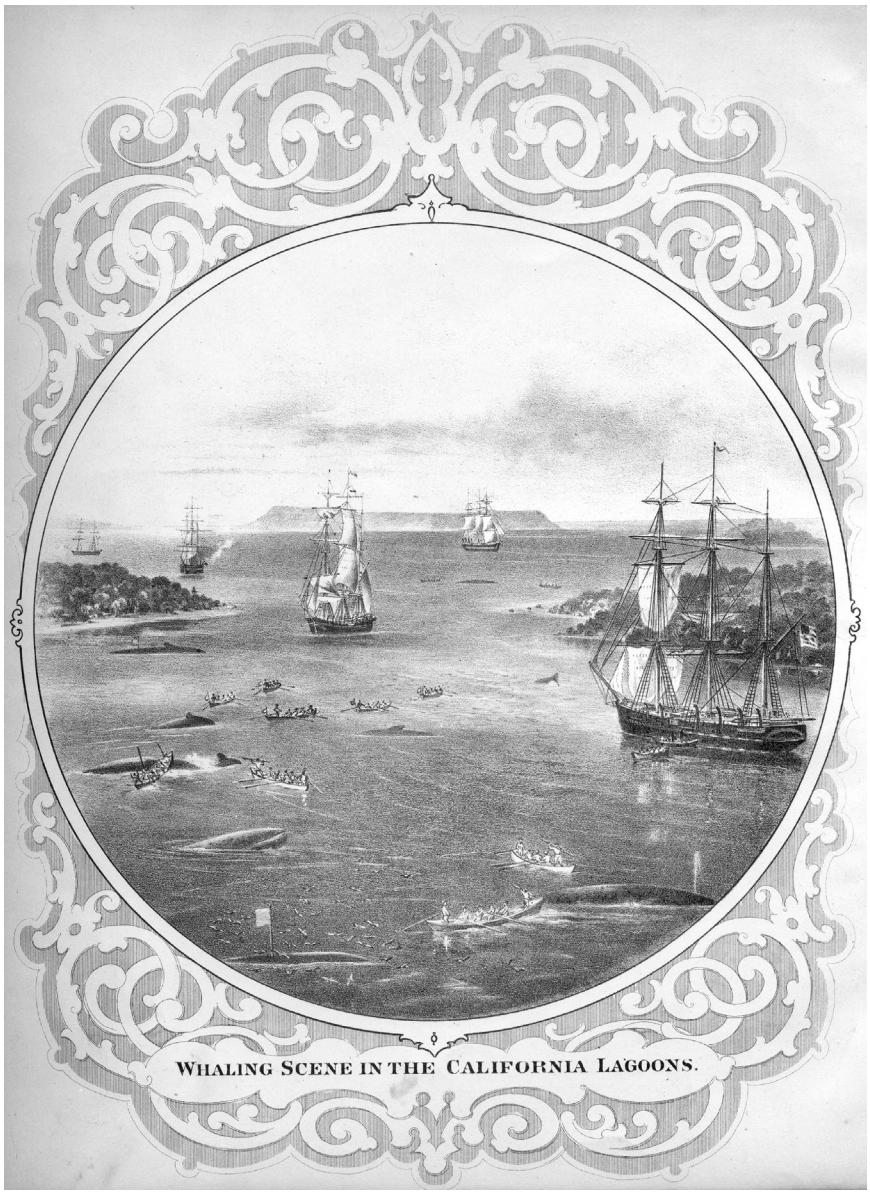
> "Near as the Graybacks came to the schooner, they were shy of the boats. They had been chased before and know something of our deadly intentions. Two hours

[3] In the 3 years from 1846 to 1848, 32 American, 4 French, and 2 Dutch vessels reportedly took 338 whales in Magdalena Bay (Henderson, 1972:83).

elapsed before we managed to creep up near one of the great fish. The oars were handled without noise; the men spoke not a word; they came within a few yards of the black mass; the suspense and half dread was akin to that experienced by the soldier in the hush before the battle."

Indeed, the literature (not just Henderson) consistently characterizes lagoon whaling for gray whales as a specialized endeavor that attracted only a particular subset of whalemen. Scammon (1874:268–269) claimed that lagoon whaling was not equally attractive to all who tried it. For example, many of the 50 ships that visited Magdalena Bay in the winter of 1848 left after only a few days, choosing instead to spend the between-seasons period sperm whaling in the open sea. This pattern described by Scammon may have changed to some extent in later years (the Bonanza period) when in some seasons a very high proportion of the Honolulu- and San Francisco-based fleets were engaged in lagoon (and alongshore) whaling for gray whales. Improved practices, techniques, and equipment, particularly wider use of the bomb-lance (see later), evidently made gray whaling in and outside the lagoons more feasible and less dangerous (Henderson 1984:171).

The catch (and kill) in lagoon whaling was strongly biased toward adult females and calves of the year. In Magdalena Bay, there was a distinct break in timing between the cow/calf season (approximately late December through mid February) and the season for "the bulls" (approximately the second half of February), and the two seasons were also spatially separate, with mothers and calves being hunted in Lee (Almejas) Bay and bulls in Weather or Main Bay (*Saratoga*, 1857–1858, logbook; Fig. 4). Some shifting of the center of whaling activity through the season also occurred in Scammon's Lagoon. For example, in the 1858–59 season, Scammon (1970:66–8) took most of his whales (apparently all cows and calves) in the inner lagoon in January and early February, then relocated toward the outer (Weather) lagoon in mid February where whaling continued into early March.



Lithograph from Scammon (1874).

Modern studies of gray whales in the Mexican lagoons (mainly centered in San Ignacio Lagoon) indicate that mother-calf pairs tend to remain inside the lagoons about three times longer than single whales (including males as well as females unaccompanied by calves) (Urbán et al., 2003). Calving females are among the earliest whales to arrive at the lagoons and the cows, with their calves, are the last to leave on the spring northward migration (Norris et al., 1983; Swartz, 1986). There is a sharp distinction between the cow-calf pairs and "courting" whales in how they use the lagoons. The former tend to occupy the very shallow channels deep inside the lagoons while the latter generally remain in and near the lagoon entrances. Also, although cow-calf pairs do circulate among the different lagoons to some

Gray whale in San Ignacio Lagoon. Photo: Sergio Martinez Aguilar.

Pair of adult gray whales in San Ignacio Lagoon. Photo: Sergio Martinez Aguilar.

Breaching gray whale in San Ignacio Lagoon. Photo: Sergio Martinez Aguilar.

Mother and calf gray whale in San Ignacio Lagoon. Photo: Sergio Martinez Aguilar.

Calf in San Ignacio Lagoon. Photo: Sergio Martinez Aguilar.

Calf riding onto the back of an adult gray whale, presumably its mother, in San Ignacio Lagoon. Photo: Sergio Martinez Aguilar.

extent, the turnover rate of courting animals appears to be higher.

For some years, there is precise information on lagoon catches. For example, at the end of *Paulina*'s 1858–59 season, its logbook entry for 21 February summarizes the Magdalena Bay catches to that date in two parts of the Magdalena Bay complex, as follows: in the outer or Main Bay—*L.C. Richmond* 12 whales, *Majestic* 6, *Benjamin Morgan* 6, *Paulina* 10, *Fortune* 6, *Hibernia* 3, *Hawaii* 1; in Weather Bay—*Reindeer* 8, *Rambler* 8, *Addison* 8, *Scotland* 5, *Massachusetts* (of Nantucket) 7, *Levi Starbuck* 5, *Benjamin Rush* (no report), *Euphrates* (no report), *Dromo* 8, *Tenedos* 6, *Hercules* 4. The *Paulina* log also notes that there was no definite information from vessels whaling in the upper lagoon, "but they are reported as doing extraordinarily well." If all of the whales taken in Main Bay and Weather Bay were grays, this would mean that well over 103 had been secured in the Magdalena Bay complex that season prior to 21 February.

Henderson (1984) assumed that in lagoon and alongshore whaling, one whale was killed and lost for every ten secured (loss rate factor: 1.1). This appears to have been intended to account for non-calf whales that were harpooned or shot but never secured and processed, and thus would not account for killed, injured, or orphaned calves (discussed later). According to Henderson (his Editor's footnote 86 in Scammon, 1970:68), "Scammon may not have bothered to record all of the calves killed or he may have instructed his men to stay clear of the calves in order to avoid infuriating the cows." *Ocean Bird*'s tally in 1858–59 consisted of 47 cows and 5 calves. "It would appear

that, after taking four calves with the first seven whales killed [in 1858–59], Scammon's boat crews had tried to avoid killing calves and thus enraging the cows, or that Scammon simply ceased recording the calves taken" (Henderson, in Scammon, 1970:57, Editor's footnote 74). In a later voyage on *Ocean Bird* (1860–61), Scammon "captured many calves along with their mothers" in San Ignacio Lagoon (Henderson, in Scammon 1970:68, his note 86; and see Henderson, 1972:138–139). "The calves, however, were not calculated in the catches of the gray whalers. Some very large calves killed at end of the season at the lagoon may have been counted as adult whales" (Henderson, Editor's footnote 86 in Scammon, 1970:68, citing *San Francisco Alta California* 1 January 1860:4).

The detailed, legible logbook of *Saratoga* (1857–1858) provides further insights. Of 14 gray whales landed by *Saratoga* in the 1857–58 season in Magdalena Bay, 13 were "cows" and only one a "bull" (Fig. 5). In a number of instances, the logbook offers hints at how the whalers did, or did not, strike the calf to improve their chances of securing the cow. For example, on 20 January 1858 one of the boats passed between a mother and calf, and the calf was harpooned —"in an instant the cow stove the stern of the boat," then wreaked havoc. Two days later, a cow was taken whose calf was judged to be less than 24 hours old, and "way too small to fasten to, as an iron would have killed it and the cow then, would have made 'music' among the boats." The next day, one of *Saratoga*'s boats was "stove" (damaged) by a calf. On 29 January the logbook records that a boat from another vessel (*Splendid*) "struck a calf … and killed it instantly, the cow then left, before they could fasten to her, and they lost her." A day later, the crews from *Saratoga* and *Draper*, working together ("mated"), struck both members of a cow-calf pair but the lines fouled and "parted," and the whale (singular) was lost. The same approach was taken on 1 and 6 February, but these times successfully, with the cow secured and the fate of the calf not mentioned in the logbook. Also on 6 February, a *Saratoga* boat "fastened" to another calf but the iron "drew" and "they lost the cow." On 10 February *Saratoga* and *Draper* killed three cows but lost one of them, "the calf drawing the irons out of the cow, the lines being foul and she sinking." Yet another description was provided by Mulford (1869:64), who mentioned an incident in which a harpooned cow became enraged and smashed the whaleboat after her calf had "received the lance intended for the mother." Although it is impossible to be sure, it seems that in this instance the whalers had not intended to lance the calf.

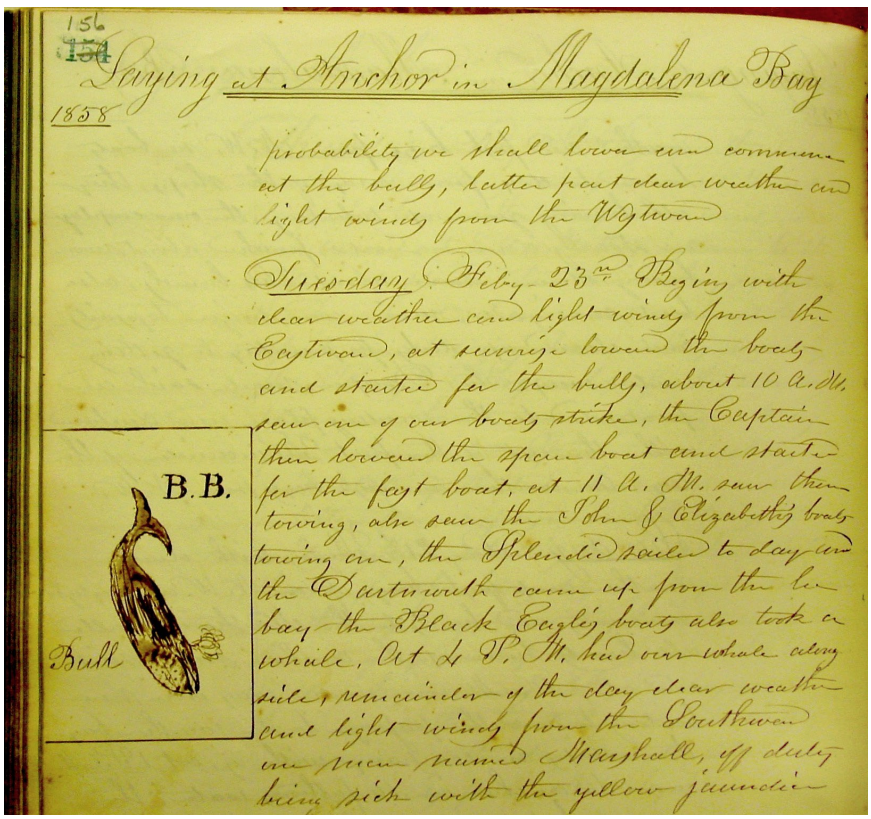

156
154
Laying at Anchor in Magdalena Bay
1858
probability we shall lower our commence at the bully, latter part clear weather and light winds from the Westward
Tuesday 23rd Feby Begins with clear weather and light winds from the Eastward, at sunrise lowered the boats and started for the bully, about 10 A.M. saw one of our boats strike, the Captain then lowered the spare boat and started for the first boat, at 11 A.M. saw them towing, also saw the John & Elizabeth's boat towing on, the Splendid sailed to day for the Dartmouth came up from the lower bay the Black Eagle's boats also took a whale, At 4 P.M. had our whale along side remainder of the day clear weather and light winds from the Southward one man named Marshall, off duty being sick with the yellow jaundice
B.B.
Bull

Figure 4.—Detail of a page from the logbook of the ship *Saratoga*, 22–23 February 1858, with the vessel initially at anchor in Magdalena Bay. *Saratoga* relocated from the Lee Bay to the Weather Bay on 21–22 February, with the logbook stating (top of this page), "… we shall lower and commence at the bulls." Indeed, "at sunrise [23 February] lowered the boats and started for the bulls." One bull was secured by *Saratoga*, as shown by the sketch in the margin, and other whales were taken in the same area by *John and Elizabeth* and *Black Eagle*. Courtesy of New Bedford Whaling Museum.

The notion that more calves were at least struck, if not killed outright, than is suggested in the tallies of whales killed, or indeed than is implied by the amounts of oil landed, was echoed by other authors, including Scammon himself. He stated (Scammon, 1874:259), "A cow with a young calf is usually selected, so that the parent animal may be easily struck." Although the usual practice was to avoid striking calves, they were lanced at least occasionally by accident when they got in the way at a critical moment during the capture of the cow (Scammon, 1874:29). Also, at times the whalers deliberately harpooned the calf instead of the cow. Scammon (1874:29) described two occasions when a particularly wary cow was taken only after the calf was harpooned and hauled into shallow water where the attendant

mother could be shot with a bomb-gun from the beach. The published journal of a whaleman's wife who spent the 1846–47 season in Magdalena Bay (Druett, 1992:177) states that gray whales "can only be taken when they have a young one which they [the whalemen] fasten to and by this means secure the mother who will never forsake it till dead. … When dead they tow the whale [i.e. the mother] to the ship. …"

Overall, Henderson (1984:178) found that tactics varied. "Whalers handled attacks on calves in two ways: some preferred to harpoon the calf first so that the cow would stay close by; others left calves alone out of fear that wounded and dying calves provoked the cows into more destructive behavior." Regardless of whether calves were struck, killed, or left alone by the whalers, however, their death was virtually certain, and therefore it is reasonable to infer that one calf was killed for every cow killed in the lagoons (Fig. 5). Again, Mulford (1869:42) provides a clear example of what must have been a typical outcome:

> "We towed the upturned carcass to our vessel. But the poor calf still followed the dead mother. It was playing about the body in the morning, ... and still after we had stripped from the carcass the blubber and turned it adrift to float up and down the lagoon … the poor, helpless, starving creature still swam by the dead mother's side."

Henderson (1972:132) observed:

> "… as the catch on the calving grounds consisted largely of cows, many of which had calves that were killed or died without their mothers, the current and future reduction of the population exacted in the calving waters was far greater than the actual reported catch there, which usually did not account for calves, would indicate."

Scammon (and presumably other whalers in the mid 19th century) regularly used explosives ("bombs") to hunt

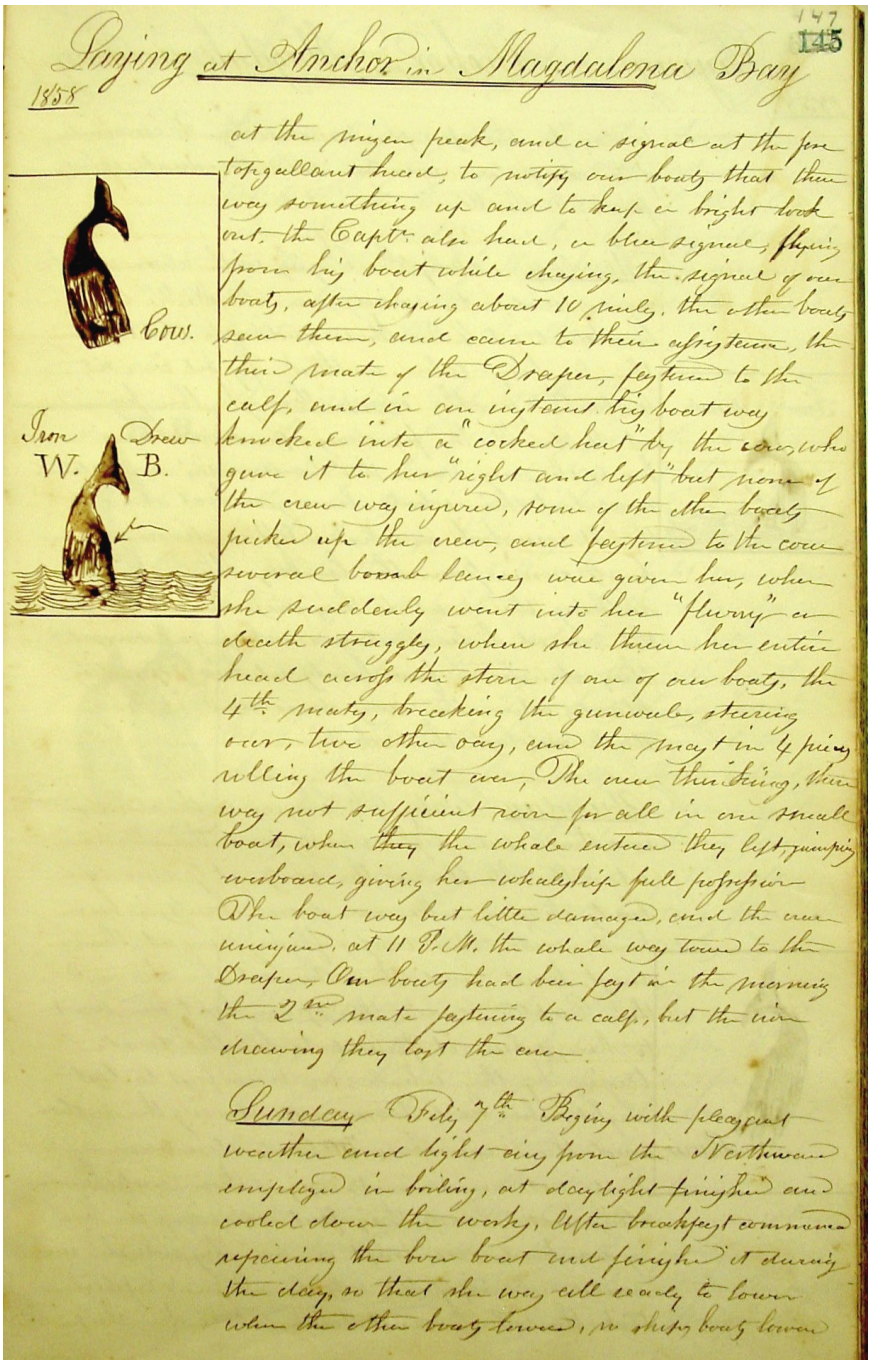


Figure 5.—A page from the logbook of the ship *Saratoga*, 6–7 February 1858, with the vessel at anchor in Magdalena Bay. The sketches in the margin indicate that one cow was killed and secured and another whale was struck but lost when the "iron drew." The text for 6 February refers to a boat from *Draper* having harpooned a calf, then being "knocked into a 'cocked hat' by the cow." The cow was finally killed and towed to the mother ship, but not until it had damaged two boats and forced their crews overboard. Earlier in the day a boat from *Saratoga* had harpooned another calf and then its mother, which was lost when the iron drew. Courtesy of New Bedford Whaling Museum.

gray whales in the lagoons (Scammon, 1970:31, 46; Henderson, Editor's footnote 41 in Scammon, 1970:30). A bomb lance was a small, metal cylinder filled with gunpowder and fitted with a time-delay fuse that allowed it to explode a few seconds after entering the whale (Bockstoce, 1986). It was fired from a shoulder gun. The use of bomb lances allowed the operation in Scammon's Lagoon to become a "shoot and salvage" operation (Reeves et al., 2002), with the whalers simply shooting the whales and hoping to retrieve the floating carcasses either soon afterward or the next day (Scammon, 1874:264; Henderson, 1984:178–179). This practice of shooting the whales without first fastening to them with a harpoon would have contributed to hunting loss although in lagoon whaling the prospects of recovering bombed whales that escaped or sank certainly would have been higher than in the open ocean (Henderson, 1984:166). Some whalers clearly fastened first and then fired bombs, but even then the whale could be lost. For example, in Magdalena Bay in 1861, boats from the Hawaiian schooner *Maria* reported having "fastened to another cow whale, and fired two bomb lances, which set her spouting thick blood, but unfortunately the iron drew and we lost the whale, being close to the passage at the time" (*Pacific Commercial Advertiser*, 18 April 1861, 5(42):2).

Within the confines of a lagoon, carcasses could be found "washed ashore or drifting . . . if the internal decomposition had generated gasses to float the whales" (Henderson, Editor's footnote 43 in Scammon, 1970:32). Sometimes the position of the carcass was marked with a buoy to aid in relocating it (Editor's footnote 49 in Scammon, 1970:34; Henderson, 1984:178). It seems consistent with both the circumstances (i.e. sheltered or enclosed conditions) and the evidence from logbooks to infer that the rate of recovery of gray whale carcasses was much higher inside the lagoons than outside.

At least one "shore party" was active in Magdalena Bay in the late 1850's (*Saratoga*, 1857–1858 logbook; also see Henderson, 1972:100, 126–127; 1975; 1984:170). On 18 January 1858 a trypot and three empty casks from *Saratoga* were towed to shore where a group of "Spaniards" had agreed to "take the oil from the carcasses, on halves." We interpret this to mean that the team on shore received whale carcasses after the blubber had been stripped for cooking aboard the vessel, and that for their efforts they were allowed to keep half of the oil produced from the flensed carcasses. On 23 January 1858 the *Saratoga* logbook notes:

> "The shore party of Spaniards came off and assisted us [in cutting in a gray whale taken the day before]. They try out the carcasses for us and two other ships on halves. . . . They keep a sharp look out on shore with a telescope and when they see either of the three ships cutting, immediately put off in their boat, and when we have finished cutting, tow the carcass on shore to their works."

On 31 January, the logbook records that *Saratoga* received 6 bbl of oil and "settled up" with the shore party, as did the other two ships. The shore camp was dismantled on 19 February but there is no further mention in the *Saratoga* logbook of oil received from the camp.

"Carcassing" (Henderson, 1972:127; 1984:170) complicates catch estimation for lagoon whaling in a number of ways. The returns of vessels whaling in Magdalena Bay were sometimes reported in terms of "body" oil versus "carcass" oil. For example, *Massasoit* was reported as "full" in April 1861 (*Polynesian*, 20 April 1861, 17(51):3), having taken 20 whales yielding 860 bbl of "body" and 93 bbl of "carcass" oil. The latter may refer to oil obtained from carcasses found and tried out by the crew of *Massasoit*. *Massasoit* reportedly also "bought 78 bbls besides," which could refer to oil obtained from carcassers.

In some instances, operations on shore seem to have been directly integrated with the ship's whaling strategy (as could be true of the *Saratoga* example, above, but it is impossible to know for certain). In 1860, when the Hawaiian schooner *Maria* arrived at Magdalena Bay on 3 December, the crew immediately went ashore, constructed tryworks and huts, and prepared a scow for transporting blubber to land (*Pacific Commercial Advertiser*, 18 April 1861, 5(42):2). From 24 December, when the first gray whale was observed, through the end of March, *Maria*'s crew, along with those from several other vessels, apparently deployed from the anchorage and took more than 65 gray whales.

Floaters or "stinkers" that were found by a ship's crew or a shore party may have yielded lower-than-average amounts of oil, whether due to putrefaction and leakage or to scavenging by sharks. Best (1987:417) noted that in Townsend's (1935) sample of logbook data, 11 of the gray whales processed had been found dead (representing 4.4% of the total listed as landed). Best considered this an underestimate of the true proportion and assumed that most found carcasses were of whales that had died as a result of whaling-related injuries (as opposed to natural causes). "If so, this fact should be borne in mind when corrections are applied to the landed catch to account for whales struck and lost that subsequently died" (Best, 1987:417). On one occasion when *Saratoga* (mated with *Draper*) lost a cow in Magdalena Bay due to sinking, the carcass was secured two days later "but was so much blasted that it was a stinker in every sense of the word" (*Saratoga*, 1857–1858, 12 February 1858 logbook entry). Still, the whalemen managed to make 40 bbl from it. Scammon made no mention of shark damage, but Henderson (Editor's footnote 43 in Scammon, 1970:32) cited evidence from other whalemen that this could be a serious problem (e.g. in Banderas Bay and in Estero Santo Domingo at the northern end of Magdalena Bay).

Coastal or Alongshore Whaling

Whaling outside the lagoons but along continental or island coasts was generally a mixed-species hunt: humpback whales and sperm whales were as or more likely to be taken than gray whales (humpbacks were also taken in

Magdalena Bay). Henderson (1984) estimated that only 25 grays were taken alongshore in five vessel-seasons during the 9-year Initial period (1845–46 to 1853–54). However, the intensity of alongshore whaling increased greatly thereafter, with Henderson (1984:168) estimating about 900 grays taken in 80 vessel-seasons during the 11-year Bonanza period (1854–55 to 1864–65). Referring to the seasons of 1858 and 1859 (presumably meaning 1857–58 and 1858–59), Scammon (1874:270) stated:

> "... not only the bays and lagoons were teeming with all the varied incidents of the fishery, but the outside coast was lined with ships, from San Diego southward to Cape St. Lucas. A few vessels of this fleet cruised near the shore by day, standing a little way off at night; but by far the largest number anchored about the islands, points, and capes, wherever the animals could be most successfully pursued."

Henderson (1972:97) concluded that 1860–61 was the peak year of alongshore whaling for gray whales.

The principal places for alongshore whaling included: San Quintín, Natividad Island, Punta San Eugenio, Turtle Bay (San Bartolomé), San Roque Island, Asunción Island, San Juanico, Cape San Lucas, and the near-shore waters off and inside Todos Santos, Ballenas, and María Bays (Henderson, 1972:97). Some gray whales may have been taken near the San Benitos Islands and Cedros Island as well (Henderson, 1984:168). Although generally not viewed as part of the main theater for gray whaling, several bays along the mainland Mexico coast of Sonora, Sinaloa, and Jalisco were used by gray whales and were visited by the whalers. These included Altata (Scammon, 1970:16, his note 10), Navachiste, Santa María (Reforma), and Banderas Bays (Henderson, 1972:31; also see Gilmore et al., 1967).

One additional area where gray whales were hunted, but which has not been mentioned by previous authors, is Mulegé Bay on the eastern coast of the Baja California peninsula. The New Bedford bark *South America* hunted gray whales (referred to as "devilfish" and "ripsacks") in the bay for most of January and February 1858, taking two large whales (27 January, 2 February; Fig. 6). The 27 January whale was taken "in company" with the New Bedford bark *Sarah Sheafe* and therefore at least one other vessel was hunting gray whales in Mulegé Bay that season. The logbooks of both *South America* and *Saratoga* provide insights on the apparently opportunistic nature of some coastal gray whaling. In early December 1857, *South America*, *Saratoga*, *Sarah Sheafe*, the bark *Islander* of Nantucket, and the bark *Tybee* of Stonington were all "endeavoring to work up the Gulf [of California]." Working in company until mid December, *South America*, *Saratoga*, and *Sarah Sheafe* reached as far north as Carmen Island (lat. 25°57′N, long. 110°50′W), where the crew of *Saratoga* went ashore and interrogated local people concerning whales. On 16 December, the logbook of *Saratoga* states: "... giving up all further intention of proceeding up the gulf and starting for Magdalena Bay." In contrast, *South America* and *Sarah Sheafe* continued sailing northward and stayed in the gulf, coming to anchor in Mulegé Bay in the third week of December and remaining in the area until 27 February. Time was spent on shore—fishing, clamming, and gathering wood—from their arrival in the bay until mid January. Humpback whales were sighted "bound up the bay" on 6 January (*South America* log), but no effort was made to chase them. On 13 January, the log notes, "waiting for whales, expect them any day," implying that the whalers had come to Mulegé Bay for the explicit purpose of hunting gray whales. More humpbacks were seen on 23 and 25 January, and then "a few California grays" were chased on the 26th.

After taking their second gray whale (on 2 February), *South America*'s crew saw whales on only four more days before leaving the bay on about 20 February. Two of those sightings were of humpbacks, one of which was chased without success. *South America* sold 372 gallons of oil and 7 barrels of "slush"[4] locally—the oil being a reminder that catch estimates based on oil returns may be negatively biased. While working out of the Gulf of California (en route to Hawaii, where it arrived at the port of Wohoo on 21 March), *South America* struck but lost a "sulphur bottom" (blue whale). Also, the boats were lowered for humpbacks as the bark passed Cape San Lucas on 2 March.

Henderson (1972:166, also his Table I) seems simply to have guessed that about 150 grays were secured between southern Sonora and Banderas Bay during the Bonanza period, and the same number again during the Declining period. He noted that the whalers who whaled there were interested primarily in sperm and humpback whales—they "probably took gray whales only when sperms and humpbacks were scarce or absent" (Henderson, 1972:166). Without explanation, Henderson (1984:174) concluded that the gray whale catch along the Mexico mainland during the Declining period was only 50 (in 10 vessel-seasons), rather than 150 as he had estimated earlier (Henderson, 1972, above). A recent study of gray whale usage of these mainland sites found that calving no longer occurs there, and that this situation is unlikely to change given present levels of fishing activity and maritime traffic in the region (Findley and Vidal, 2002). We are unaware of recent investigations in Mulegé Bay and therefore cannot comment on whether some gray whales still visit that area.

As mentioned earlier, some coastal whaling was described as "kelp-whaling," where the boats were stationed in or near the kelp beds and waited for the whales to swim within shooting range. In later years of the fishery, when the whales had become wary of the whaleboats, small 2-man boats were used, with one man to scull and the other to

[4] Slush was the fatty residue left from boiling salt horse (dried beef and/or pork). It was allotted to the cook in his contract and he was able to sell it for added profits to himself. Later, that term was used for the grease that was used to grease the mast and spars.

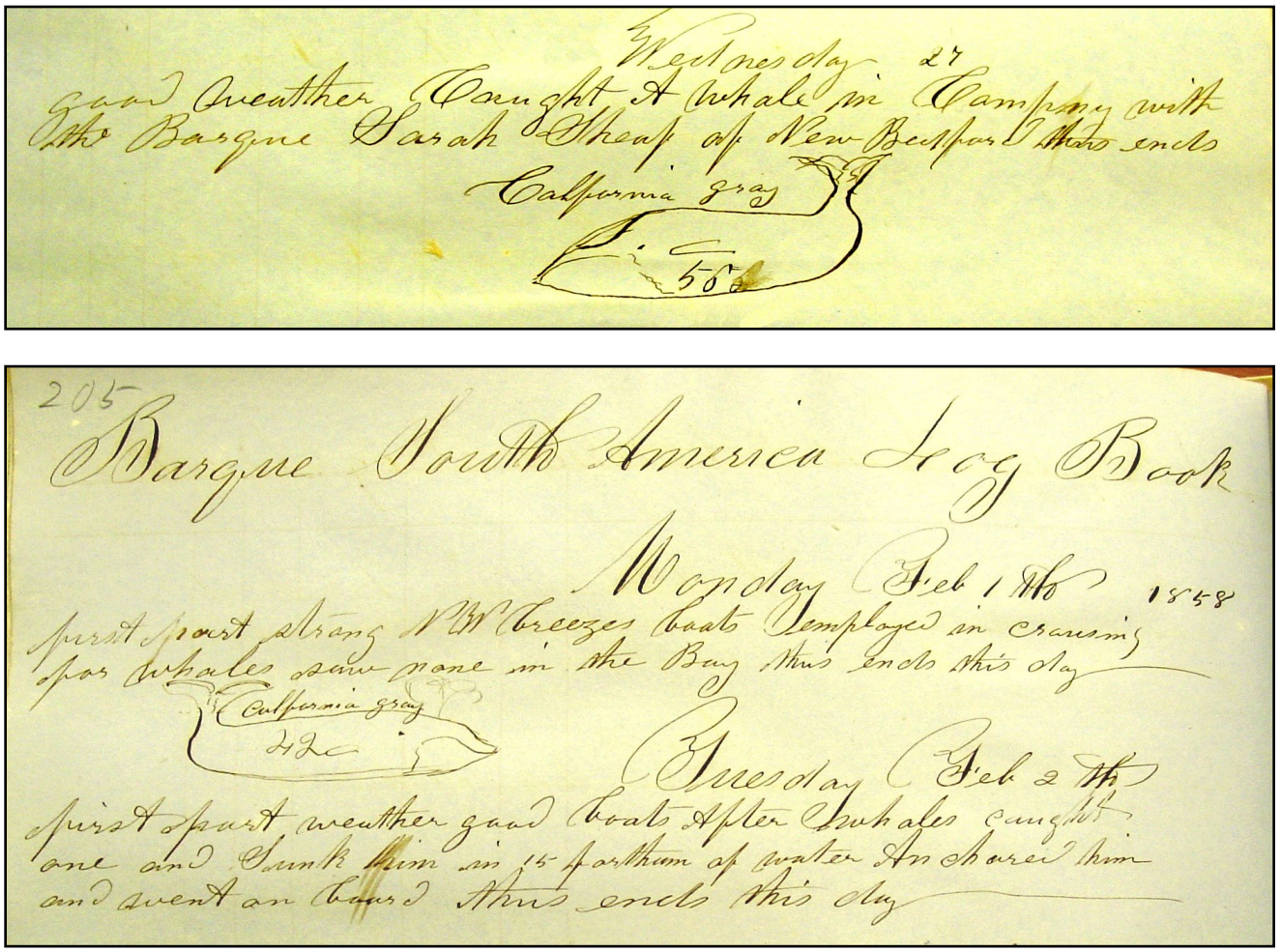


Figure 6.—Top: Detail of a page from the logbook of the bark *South America* for 27 January 1858, while in Mulegé Bay on the east coast of Baja California, describing the taking of a large (55 barrel) gray whale "in Company with" the bark *Sarah Sheafe.* Bottom: Another page from the logbook of *South America*, referring to the capture of a "California gray" in Mulegé Bay, Gulf of California, this one on 2 February 1858. Courtesy of New Bedford Whaling Museum.

shoot. Still later, as the whales passed farther offshore, the whaleboats were anchored outside the kelp, chasing the whales as they passed inshore. Evidently, much of the whaling was "shoot-and-salvage." Even if a line was secured before the whale died, the carcass often sank and would only be secured after it rose to the surface as much as a day later. Sometimes the blubber was tried out in "pots set for that purpose upon the beach" although most often the flensing was conducted alongside the ship. Scammon described another variant of coastal whaling for gray whales as "whaling along the breakers" (Henderson, 1972:96).

As indicated above, Henderson (1984) used the same loss rate factor for adjusting catches in alongshore whaling as in lagoon whaling even though he acknowledged that the chances of eventually securing a struck/lost whale were better inside a lagoon or embayment than outside in the open ocean. Our own findings in this regard are discussed later.

Pelagic Whaling

Almost no whaling for gray whales occurred in offshore waters of Mexico and California, presumably because the whales themselves tended to remain close to shore and congregated mainly in bays or lagoons. Most of the pelagic catch therefore centered in high latitudes, particularly in the Bering and Chukchi Seas. Although whalers searching for right whales in the Gulf of Alaska chased gray whales occasionally (Henderson, 1972:26), there is no evidence to suggest that they made significant catches there. Henderson (1984:166), with unaccounted-for precision, gave "probably … only about 52" as the number taken in 20 vessel-seasons on the northern grounds in the Initial period, followed by about 175 (80 vessel-seasons) in the Bonanza period, and 175 (40 vessel-seasons) in the Declining period for a total catch of 402

(539 killed) over the entire period from 1845–46 to 1873–74 (1984:169). He further stated (1984:170–171) that on the northern grounds, many gray whales were lost under the ice or in foggy conditions and that "more whales were lost [there], relative to those caught, than in any other sector of the gray whale fishery."

Bockstoce (1986:72–73, 132) estimated that about 500 gray whales were taken over the entire life of the ship-based commercial fishery for bowheads in the Bering Sea and Arctic Ocean (1848–1914), and that about 300 more were killed but lost (implying a loss rate factor of 1.6, as compared with 1.34 implied by Henderson's numbers [539/402]). In considering why so few gray whales were taken, Bockstoce (1986:72–73, 132) noted that 1) they lacked commercially valuable baleen, 2) they yielded comparatively little oil, which in any event was priced at about 5 cents less per gallon than "whale" oil, 3) they were both difficult and dangerous to subdue, and 4) most importantly (according to Bockstoce), by the mid 1860's their numbers had been reduced considerably by the lagoon whaling in Mexico.

Regarding the difficulty of capturing gray whales, noted whaling captain Thomas Welcome Roys described them as fast swimmers that "generally could not be taken with hand harpoons from open boats" (Schmitt et al., 1980:25). Further, according to Roys (in Schmitt et al., 1980:64), gray whales, along with humpback whales and blue whales, "will not generally allow a boat to come nearer than three or four rods of them, hence the difficulty of fastening."

Bockstoce and Burns (1993:568) stated that by 1866 the bowhead whale population in the Bering and Chukchi Seas was in "steep decline" owing to nearly two decades of intensive commercial whaling. As a result, the American whalers tried to "offset poor catches" by hunting walruses, *Odobenus rosmarus*, and gray whales during the "middle season" between late spring and autumn. Elsewhere (Bockstoce and Botkin, 1982:184), it was suggested that most of the walrus hunting took place between mid June and early August, at a time when the bowheads were "generally inaccessible to the whaleships."

In their analysis of the walrus kill, Bockstoce and Botkin (1982) extrapolated from logbook data covering 516 complete cruises, or about 19% of the total number of whaleship cruises to the western Arctic from 1849 to 1914. No similar extrapolation to estimate the total kill of gray whales has been published, but Bockstoce and Burns (1993) stated that the kill amounted to "about 840 . . . , of which 539 were captured (Bockstoce in Henderson, 1984: Table I) and another 300 were lost (Bockstoce 1986:73)." Those authors' statement is not consistent with Henderson's (1984) conclusion (his Table I) that only 402 gray whales were "captured" on 140 cruises to the "Northern Summer Grounds" from 1845 to 1874, the total killed (including hunting loss) amounting to 539. Nowhere is it made clear whether the values of 402 and 539 refer to numbers of gray whales recorded in the logbooks of 516 cruises examined by Bockstoce and Botkin (1982, 1983), or instead are extrapolations meant to account for the whales taken on those plus the other 81% of the total cruises to the western Arctic between 1849 and 1914.

Non-American Whaling Vessels

As mentioned earlier, whaleships from countries other than the United States visited the coasts of Baja and Alta California during the 19th century. The British whaler *Toward Castle* wrecked on the Malarrimo coast just southwest of the mouth of Scammon's Lagoon in 1836 (Henderson, Editor's footnote 16 in Scammon, 1970:20; but see Henderson, 1984:182, footnote 18). The French ship *Valiant* of Havre wrecked near the entrance of Magdalena Bay at the end of December 1847 with 600 bbl of oil on board (*The Friend*, 1 April 1847, as quoted in Druett, 1992:184, footnote 33). Some of *Valiant*'s oil (200 bbl) was salvaged by *J.E. Donnell* of New Bedford and is presumably subsumed within that vessel's returns (which included 3,066 bbl of whale oil for its voyage of 1845–49; Starbuck, 1878:422–423).

German and French whalers, as well as one Russian vessel (from Finnish Russia, captained by a Swede), participated in lagoon whaling for gray whales between 1854–55 and 1864–65 (Henderson, 1984:172). Henderson (1972, his Table II, p. 261–263) included in his list of vessels whaling in Scammon's Lagoon between 1857–58 and 1872–73 the following foreign vessels: bark *Cleopatra* from New Granada (presumably present-day Colombia; probably sailing out of San Francisco with New Granada as a "flag of convenience" according to Henderson, 1984:184), brig *Stoofursten Constantin* of Russia, brig *Comet* from the German port of Oldenburg (purchased in Honolulu and put under the Hawaiian flag in 1868), and a variety of vessels from Honolulu—four barks (*Faith*, *Metropolis*, *Harmony*, *Cynthia*), two schooners (*John Dunlap*, *Kalama*), and two brigs (*Victoria*, *Kohola*). *Kalama* was a tender to the brig *Comet* at Turtle Bay in 1862.

There is ambiguity concerning the rig and name of the so-called *John Dunlap*, which apparently also cruised as a brig under the name *Alice*, but in any event it whaled for gray whales at Scammon's Lagoon in at least the 1858–59 season (Henderson, Editor's footnote 68 in Scammon, 1970:50). Some gray whales may have been taken by French whalers between 1842 and 1868 (Du Pasquier, 1986:274). In Du Pasquier's (1982) list of voyages, 15 are identified as having visited locations in California or Mexico where they could have taken gray whales between 1843 and 1864. At least three of those voyages included visits to Magdalena Bay (Ste-Marguerite or Baie Ste-Marguerite) and at least one to Lower California (Basse Californie). The voyage of *Valiant* of Havre, which wrecked in 1847 as noted above, is not among the 15.

The ship-based fisheries for right whales in the North Pacific Ocean and Bering Sea and for bowhead whales in the Bering Sea and Arctic Ocean were both dominated by vessels from the United States. Scarff (2001:266), however, estimated that non-U.S. ships might have constituted as much as 15–20% of the fleet on the right whale

grounds, whereas Bockstoce (1986:94) referred to ships from Bremen, Havre, Nantes, and Hobart (Tasmania) as having flocked along with the American fleet to the Bering Strait in 1850 immediately after discovery of the bowhead whaling grounds there. According to Bockstoce and Botkin (1983:110), the western Arctic fishery included vessels from the United States, Hawaii, Germany, France, and Great Britain (Australia). Some foreign vessels stopped to recruit crew and obtain provisions at Hawaiian ports, primarily Honolulu and Lahaina. Beginning in the early 1850's, some of these vessels were purchased by a small number of foreign residents in Hawaii. This burgeoning Honolulu-based fleet included vessels that continued to sail under foreign flags. By 1856, many vessels in this fleet began to be placed under the Hawaiian flag, including some whose owners did not meet the legal requirements for obtaining Hawaiian registry.

Oil Returns and Average Yield

As mentioned earlier, concern has been expressed that the average oil yield used by Henderson to estimate catches from oil production data may have caused him to underestimate the number of gray whales taken (Mitchell, 1993). A large proportion of Henderson's (1972, 1984) catch estimates was derived from oil returns. However, the idiosyncratic nature of his catch tallying method makes it impossible, in many cases, to determine whether the catch attributed to a given voyage represents a count of whales taken (e.g. as reported in the voyage logbook) or instead an estimate made (after the fact) by converting an amount of oil on board or returned to port.

Often, the latter was clearly true, and therefore the average oil yield used by Henderson as the denominator for his conversions takes on particular importance. He recognized that some oil was shipped from the whaling grounds on cargo vessels or "sent home" on a different vessel, and he attempted to account for this in his compilation of catches (Henderson, 1972:259). He nevertheless cautioned that reports emanating from the whaling grounds (e.g. as a result of message exchanges between vessel captains) tended to exaggerate the amounts of oil inboard (we have not been able to corroborate this statement by Henderson).

Another consideration is whether oil inboard or returned by a given vessel came from gray whales rather than from one or more other species. The oil inboard a "gray whaler" obtained from sperm whales, elephant seals, and other seals was, according to Henderson (1972:259), "regularly distinguished," but so-called polar oil from right or bowhead whales taken in the previous summer season, humpback oil, and oil from other balaenopterids (such as fin and blue whales) "usually was not distinguished from the gray whale oil." In Henderson's view, this meant that oil-based estimation of gray whale catches are inherently positively biased. However, there must have been an economic incentive to mix gray whale oil with that of other species as, according to Scammon (1874:269), it was "of an inferior quality." Therefore, it would have been more profitable to adulterate other oils with gray whale oil rather than vice versa.

In our own reading of one logbook, it was noted that when *Mary and Helen II* had taken and processed three gray whales in the northern Sea of Okhotsk, the logbook entry for 24 September 1885 stated, "... stowing in lower mainhold the oil of the last Bowhead taken and what we have boiled of these last [gray or "ripsack"] whales mixed together." In this instance, without checking the logbook, the whale oil returned by the voyage would be considered to have come entirely from bowhead (and right?) whales as there would be no way to distinguish the contribution made by gray whales.

Mixing gray whale oil with other more valuable oils that would be reported and landed as such would tend to bias the data toward underestimation of the gray whale catch. At the same time, however, humpback whales, in particular, were hunted along the coast of Baja California and even inside Magdalena Bay during the gray whale season (Henderson, 1972:89; *Josephine*, 1863–1867, 5 January 1866 logbook entry), and they were at least seen in San Ignacio Lagoon in May and June (Henderson, 1972:195). This creates the potential to overestimate gray whale catches if it is assumed that all whale oil from a given cruise in the Mexican whaling grounds came from gray whales.

Henderson (1972) noted that "coast oil," at least in the context of San Francisco-based whaling in the mid 19th century, generally meant oil from gray whales. For example, the bark *Carib* of San Francisco returned to port in April 1859 after 10 months at sea with 800 bbl of coast oil, 50 bbl of sperm oil, and 300 bbl of humpback oil, and Henderson (1972:89) explicitly considered the coast oil to be from gray whales. In his catch compilations, Henderson (1972) sometimes corrected what he assumed were reporting errors. For example, the New London barks *Tempest* and *Ripple* were reported as returning 550 and 500 bbl, respectively, of humpback oil to Honolulu following a 1859–60 cruise to Scammon's Lagoon, but Henderson (1972:265) concluded that "the kind of oil ... must have been in error," noting that "no other vessel was ever reported to have taken humpback whales" in this lagoon. In another instance, Henderson inferred that a newspaper report of 400 bbl of sperm oil returned to Honolulu by the New London bark *Pearl* (1863–64) "may have been erroneous" because this vessel had been reported at Scammon's Lagoon with 190 bbl of oil (unspecified) on board two months earlier. He assigned a gray whale catch of "5+" to *Pearl* for that season.

Scammon's *Ocean Bird* returned to San Francisco in 1859 with a cargo of 1,600 bbl of oil from 47 gray whales (all "cows"), which led Henderson to conclude that 35 bbl/whale was a reasonable average yield (Scammon, 1970:68). One whale secured by Scammon in December 1858 yielded 55 bbl (Scammon, 1970:37), and one large cow taken in Magdalena Bay by *Saratoga* yielded 62 bbl, another 63½ bbl, both in January 1858 (*Saratoga*, 1857–1858, logbook). Scammon (1874), who had

extensive first-hand knowledge of gray whales and the ship-based whaling industry, gave the average yield of gray whales as 20 bbl, with males sometimes producing up to 25 bbl (1874:21) and "some individuals" as much as 60–70 bbl (1874:20).

Rice and Wolman (1971:35) observed that the mean body weights and yields of oil, meal, and meat from southbound gray whales were 2.5–3.0 times those of northbound whales. As summarized by Sayers (1984:123), gray whales taken during the "going down" season (December–February) were "fat, well nourished, and rendered a fine quality of oil," whereas those taken during the "going up" season (February–April) were much leaner as a result of fasting and, in the case of adult females, nursing their calves. In addition to the variability in oil yield due to seasonal changes in body condition, towing distance, shark scavenging, sea conditions, and various other circumstances could affect processing efficiency.

Bockstoce (1986) considered the average yield of gray whales on their northern feeding grounds to be 25–30 bbl (1986:72), 25 bbl (1986:132), or 30 bbl (1986:95). Henderson (1972, 1984), who was convinced that 35 bbl/whale was a good overall average for gray whales, acknowledged that yields tended to be lower on the northern grounds, reasoning as follows (1972:137):

> "Captures of small, young gray whales probably were more common on the northern summer grounds than along the coast of California, where the few slaughtered calves were not usually counted as part of the catch, and where rapidly growing young whales, returning to their place of birth, were at least a year old."

The question of average oil yield becomes relevant in the present context only, or at least primarily, if it is to be applied in catch estimation. In one of the earliest efforts to estimate whale catch from both oil returns and logbook data, Ross (1974:95) ended up averaging the "conflicting figures [on bowhead whale catches by American whalers in Hudson Bay] obtained by different methods . . . , there being no satisfactory criteria for choosing either one or the other." Similarly, Mitchell and Reeves (1983) presented estimates from both "oil yield" (from Starbuck, 1878 and Hegarty, 1959) and "catch-per-voyage" (from logbooks), and then arbitrarily used midpoints of the two in their table of annual catches of humpback whales in the West Indies attributed to the ship-based American fishery. Both Bockstoce and Botkin (1983) and Smith and Reeves (2003) employed data on oil returns to stratify vessel-seasons and to guide logbook sampling, but in the end used only average numbers of whales landed per vessel-season (mainly from logbooks and newspaper accounts) as the basis for estimating catches of bowhead whales and humpback whales, respectively. Finally, in his multispecies study of the American 19th century ship-based fishery for baleen whales, Best (1987) estimated catches in 5-year intervals using both production (oil averages to 1879 and whalebone thereafter until 1909; all from Starbuck, 1878 and Hegarty, 1959) and whale catch per voyage (1805–1914, from Townsend, 1935). He made no attempt to reconcile the two alternative sets of estimates but instead simply reported them as a range, such as 2,665 ("based on oil production") to 3,013 ("as calculated from the catch per voyage") gray whales taken over the period 1850–1879 (1987:416). Best found that the two approaches gave "somewhat similar" results, differing by less than 10% in all cases except three: for South Atlantic right whales, *E. australis*, and humpback whales, the overall production-based estimates exceeded the catch per voyage estimates by 13% and 29%, respectively, and for gray whales, the overall catch per voyage estimate exceeded the production estimate by 13% (as indicated above).

Although Henderson (1984) appears to have depended primarily on oil returns to estimate gray whale catches, our own extensive experience with production data has led us to share the skepticism expressed by Bockstoce and Botkin (1983:110), who note the difficulty of allocating quantities of products to vessel-seasons (as opposed to entire voyages) and the risk that oil from multiple species (especially humpback whale and pilot whale oil in the present context) has often been included in whale oil returns. Therefore, like those authors, we consider data on numbers of whales taken, as recorded in logbooks and newspapers, to provide a more direct and reliable basis for interpolation and extrapolation, as explained in the following section.

New Catch Estimates from Voyage and Vessel-season Analyses

Our review of the literature and of Henderson's files and notes in the library of the New Bedford Whaling Museum (described earlier) led us to an approach for producing a more detailed alternative catch series. Rather than adopting Henderson's method of tracking and evaluating the intricacies of whale oil reports, newspaper snippets, and logbook entries in a largely opportunistic and ad hoc fashion, we chose to rely primarily on two sets of data sources for estimating the ship-based catch of gray whales.

First, we used the catch data in a sample of voyage logbooks (including some also checked by Henderson) and newspaper sources to estimate the average number of gray whales taken (both secured/processed and struck/lost) per vessel-season in Mexico. Second, we used the information from a broad search of published and unpublished sources to identify and count the vessels that whaled for gray whales in Mexico (and to a limited extent southern California) each year beginning in the winter of 1845–46.

Together, these two sets of sources allowed us to estimate the number of gray whales taken each year by the ship-based fishery in the winter season. Because the greatest catches of gray whales were made in Mexico on the whales' calving and breeding grounds, we focused our logbook sampling and catch estimation on the winter portions of voyages spent there rather than on portions of voyages in the northern

summering areas. For the ship-based catches in northern waters, we had no reason to believe that we could improve significantly on the gray whale catch and removal estimates (approximately 400–500 and 800, respectively; see earlier) presented by Henderson (1984) and Bockstoce (1986).

Logbook and Newspaper Sampling

Photocopied sections of some logbooks were available in the Henderson material in New Bedford, and these were examined for information on numbers of whales secured. We also checked (either directly or on microfilm) the relevant sections of additional logbooks selected to make the overall sample as representative as possible, especially over time. For those logbooks that provided sufficient detail, we also extracted the information on "condition" of whales that escaped (e.g. whether the harpoon iron drew, the line broke, the whale sank or was "spouting blood" when it escaped), the sex of caught whales, and the presence and fate of any calves mentioned.

To supplement that logbook sample, we used 1) Townsend's (1935) worksheets containing logbook data for about 800 voyages by vessels with names beginning with the letters A through J and 2) data that we had collected in previous studies from logbooks of about 160 voyages. Further, we used gray whale catch data found in 19th century Hawaiian newspapers. In a few cases, the same vessel-seasons were represented in two of the four types of sources, allowing us to check for consistency. For example, the numbers of gray whales indicated on three Townsend worksheets (5, 46, 10) were both higher and lower than those indicated in newspaper entries (4, 47, 14, respectively). Similarly, the Townsend data, which normally include only landed whales, were generally consistent with the more detailed data (catch, struck/lost whales, daily positions) taken directly from logbooks.

In some instances, logbook entries fail to identify whales to species. Where possible, we inferred the species from the circumstances surrounding the whaling activity or from the described behavior or other characteristics of the whales. Unless there was a marked change in whaling pattern or location, the other catches (including struck/lost) for that vessel-season were assumed to have been gray whales. For unidentified whales tried out during vessel-seasons for which catches of both gray whales and humpback whales were reported, we prorated the unidentified whales according to the ratio of grays and humpbacks reported in the logbook for that vessel-season.

Data on landings were available for 94 unique vessel-seasons. Of that number, 51 were covered by logbooks read specifically for this analysis, 18 were covered by the Townsend worksheets, 17 were covered by newspaper accounts, and 8 were covered by logbooks read for our previous studies. Seventy-seven of the 94 vessel-seasons involved gray whaling while the other 17 focused entirely on other species, notably humpback whales, sperm whales, and pilot whales. The mean number of gray whales taken (i.e. secured and processed) per vessel-season for the 78 vessel-seasons that involved gray whaling was calculated for four time periods selected to reflect the varying intensity of the fishery (without regard to Henderson's Initial, Bonanza, and Declining periods, noted earlier), and ranged from 14.0 down to 7.9 whales. The rates were higher in the earlier periods (Table 1).

Some information on the sex and maturity status of struck whales was obtained for a portion of the vessel-seasons covered by logbooks read specifically for this study. As expected, given the information summarized from the literature (above), 32 of the 35 whales (92%) for which sex was identified were cows. Although, as noted earlier, whaling inside the lagoons often involved calves, this was mentioned only 11% of the time (52 of 460 logbook entries). The subsample of logs with entries referring to calves included 18 vessel-seasons, and the percentage of strikes involving calves for those vessel-seasons averaged 29.7%, with a range from 6.2 to 100%. The logs of three vessel-seasons indicated that more than 60% of the strikes involved calves. The fates of 40 of the 52 calves (76.9%) were reported, with 39 of them struck or killed but apparently only one of them processed for its oil. Although this information from logbooks on sex of adults taken and the involvement of calves is clearly incomplete, it reinforces the general understanding from the literature (see above) that lagoon whaling in Mexico focused primarily on adult females and that calves were involved, often dying as a result.

Using a subset of the logbook data for 36 vessel-seasons for which sufficient detail was recorded, we estimated the proportion of struck animals that were lost. The 408 struck whales were each assigned to one of three classes: 1) landed and processed, 2) escaped when the harpoon drew or the line parted, and 3) either escaped spouting blood (interpreted to mean the whale was mortally wounded) or actually died and sank before being secured by the whalers. The proportion lost when the harpoon drew or the line parted was much higher than that for animals that escaped spouting blood or sank (28% and 6%, respectively; Table 2). This makes it difficult to estimate total removals. Although it can be assumed that the 5% of struck animals that were lost because they sank or escaped spouting blood were effectively dead, at least some of the 24% of the struck animals that escaped when the

Table 1.— Mean numbers of gray whales landed per vessel-season (WPV), their standard errors (SE), and numbers of vessel-seasons sampled (N) from logbooks (directly or via Townsend worksheets) and newspapers.

Period	WPV	SE	N
1846–1854	14.0	3.32	7
1855–1860	14.0	2.28	23
1861–1865	10.1	1.14	30
1866–1874	7.9	1.36	18

Table 2.— Proportions (P) of 408 struck gray whales that were reported lost under different conditions: when the harpoon drew or the line parted (Drew-Parted), when the animal sank or escaped spouting blood (Sank-Bleeding), and combining those two conditions. Also shown are the standard errors of the proportions (SE(P)), the ratios of the number struck to the number landed (loss rate factor, LRF), and their standard errors (SE(LRF)).

Conditions	P	SE(P)	LRF	SE(LRF)
Drew-Parted	0.24	0.021	1.32	0.037
Sank-Bleeding	0.05	0.011	1.06	0.012
Combined	0.29	0.023	1.42	0.050

harpoon drew or the line parted probably survived, considering that wounds and scars from previous encounters with whalers have been observed on some caught whales (Jordan, 1887; Starks, 1922). We have no basis for estimating the proportion that survived.

Following Henderson's suggestion that the loss rate was higher in alongshore gray whaling (i.e. "outside" rather than "inside" the bays or lagoons), we also classified the reported vessel locations for strikes reported in the logbooks according to whether they were "inside" or "outside" and computed the respective loss rate factors. The alongshore Drew-Parted (DP) LRF (1.41, SE = 0.080) and the Sank-Bleeding (SB) LRF (1.08, SE = 0.027) were both larger than the corresponding "inside" LRF's (DP: 1.26, SE = 0.043 and SB: 1.05, SE = 0.016, respectively). One-sided t-tests suggest that the outside Drew-Parted LRF was significantly greater than the inside (p=0.013), while the difference between the two Sank-Bleeding LRF's was not significant (p=0.084).

However, for most vessel-seasons we were unable, in the absence of the relevant logbook data, to distinguish catch locations on a sufficiently fine geographic scale to apply loss rate factors differentially. As Henderson (1984:168) noted, it was "sometimes difficult to determine if a particular ship captured a whale inside or outside the lagoon itself; only if one has logbook records at hand, rather than newspaper accounts, can he determine how many whales were taken inside or outside the lagoon." For example, the newspaper *Polynesian* reported (29 March 1862, 18(48):3) that the Hawaiian brig *Victoria* arrived in Honolulu in late February from the "coast of California" with 400 bbl of oil on board, having left Margarita (Magdalena) Bay 14 days earlier. The report indicates only that the oil had been obtained "in Bollnas [Ballenas] and Margarita Bays." In order to apply differential loss rate factors, it would be necessary to know or estimate the fraction of the 400 bbl obtained alongshore (i.e. in Ballenas Bay) rather than in the Magdalena Bay complex, which is classified as a lagoon-whaling site. Like Henderson (1984), then, despite the significant difference in loss rates, we had to use the same loss rate factor to estimate total kills from numbers secured in both lagoon and coastal whaling.

Number of Vessel-seasons

In addition to the vessel-seasons identified directly from the Henderson material, we made use of port and newspaper records concerning arrivals and departures of whaling vessels in Hawaii compiled by Lebo for this paper. The Hawaii data generally included the vessel's name (adjusted for obvious misspellings) and its dates of arrival and/or departure in Hawaiian ports. Most of the records also included the vessel's nationality of registry, master, and rig (e.g. schooner, bark, ship). In many instances, the records indicate where the vessel had come "in from" or where it was "bound for." Some of these geographical entries refer to specific places that are well known for gray whaling, such as Magdalena (more often given as "Margarita") Bay, but many are more general. These latter include the obvious and uninformative (e.g. "Pacific") and the somewhat more specific and informative (e.g. "South Pacific," "Japan," "Okhotsk"). Some entries are informative but difficult to interpret at first glance, such as "coast of cala," clearly meaning Coast of California but leaving open various possibilities other than the Mexican gray whaling grounds (e.g. humpback whaling around the Socorros or Revillagigedos Islands, sperm whaling off Cedros Island or in the Gulf of California, whaling for one or several species, including gray whales, along the coast of what is now the U.S. State of California).

For voyages with incomplete or conflicting information, we consulted the Dennis Wood Abstracts (Wood, N.d.),which include, for example, selected dates and specific locations where the vessel was known to have been during the voyage and the quantities of oil and whalebone on board at the time.

We combined the Hawaii arrival and departure records with those obtained from the Henderson material (and supplemented by any relevant details found in the Dennis Wood Abstracts) into a single list of vessel-seasons of whaling in Mexico, using a stepwise procedure as follows.

First, we used the Henderson material, maps, and our general understanding of the fishery to identify a set of geographical entries likely to represent whaling areas in the region. We then selected those vessels that arrived in Hawaiian ports late in or soon after the gray whaling season (i.e. between about February and May, or "spring") or that departed shortly before the season (i.e. between October and December, or "autumn"), with locations (either outgoing or incoming) indicative, or least suggestive, of time spent in Mexico. We did not try to account for vessels in the Hawaii records associated with only generalized geographical locations (e.g. Pacific or North Pacific), but see later discussion.

Second, we compared the two lists of vessel-seasons (one Henderson-based and one Hawaii-based) to two lists of whaling voyages, the American Offshore Whaling Voyage list (AOWV) (Lund et al., 2008; available through National Maritime Data Library, www.nmdl.org) and the French whaling voyages listed in Annex 7 of du Pasquier (1982:242–9; numbered in our system as 30,000 plus the numerical sequence). We thus attempted to identify specific multiyear voyages corresponding to each vessel-season, accounting for dates, master, and rig as available.

Because some vessels had the same name and because key information was missing from some records, it proved impossible to assign all of the vessel-seasons to their appropriate voyage with certainty. Also, we were hampered by the lack of systematic voyage lists from nations other than the United States and France. However, the registry information reported in the Hawaii arrivals and departures records, especially for the Hawaiian fleet, made it possible to identify the nationality for most of the non-American and non-French vessels.

Where more than one vessel had the same name, and especially in the few cases when such vessels were whaling

in Mexico in the same season, it was sometimes impossible to pin down and track the vessel-season with complete confidence. Newspapers and other sources proved useful for resolving some of these problems. For example, they allowed us to distinguish among the American *Maria*, the Hawaiian *Maria,* and the Chilean *Maria* in the 1861 and 1862 seasons. The latter two vessels were gray whaling in Mexico, while the first was on a sperm whaling voyage.

Third, we merged the Henderson and Hawaii lists, and this resulted in 660 unique vessel-seasons that were considered candidates for having involved some whaling in Mexican waters between 1846, when gray whaling began there, and 1875, by which time it had essentially ended there (although some killing of gray whales in the northern feeding areas continued into the 1880's). Of these 659, 480 were identified from the Henderson material and 179 from other sources only, especially the Hawaii port records. We then used the multiple sources of information available to classify each vessel-season according to the likelihood that it involved gray whaling in Mexico. For some vessel-seasons, we found no information that could be used as a basis for classification. For others, there was enough information to classify as definitely or likely gray whaling, definitely or probably not gray whaling, or possibly gray whaling. For analysis, we established four categories of the likelihood of gray whaling, as follows: Yes (definitely or probably gray whaling), Maybe (possibly gray whaling), No (definitely or probably not gray whaling), and Unknown.

The proportions of vessel-seasons that fell into these categories varied according to the source (Table 3), with, for example, 17% (82/478) of the vessel-seasons identified from the Henderson material judged as "definitely not" gray whaling compared to 29% (52/179) of those from the Hawaii port records. The proportions also varied over time, with, for example, a higher proportion Unknown after 1860.

Table 3.—Numbers of vessel-seasons according to the original sources of information and our judgments on the likelihood that they involved gray whaling.

Source	Yes	Maybe	No	Unknown	Total
Henderson	323	45	82	28	478
Hawaiian	54	32	52	41	179
Total	377	77	134	69	657

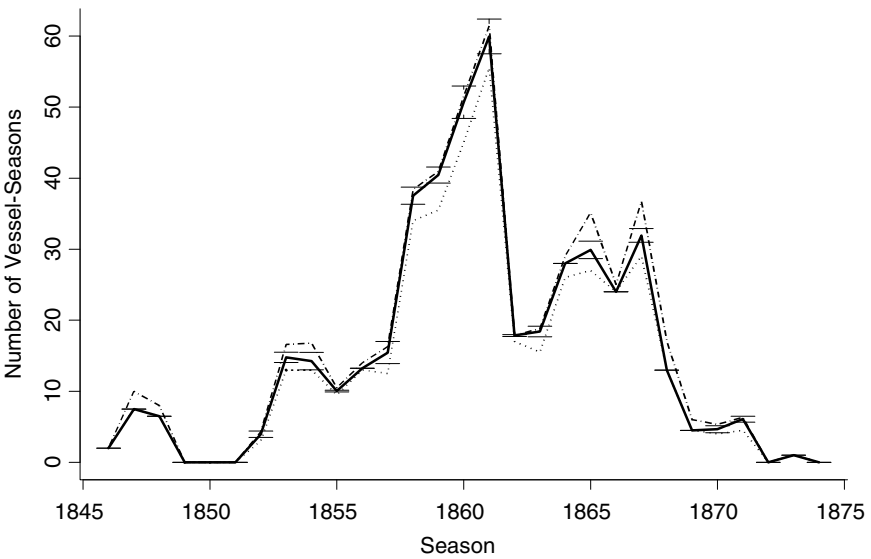


Figure 7.—Estimated numbers of vessel-seasons of gray whaling in Mexico from 1846 to 1874, by year, with three ways of accounting for uncertainty (as described in the text). Cases: low = dotted line, medium = solid line, high = dashed line. The 95% confidence intervals about the estimates are shown for the medium case.

To account for such differences, we addressed the uncertainties in the vessel-season data separately by source (i.e. Henderson vs. Hawaii) and by year. We addressed the uncertainty inherent in the Maybe and Unknown categories in two ways. First, we assumed that at least half of the vessel-seasons categorized as Maybe gray whaling were in fact gray whaling (i.e. we treated that half as Yes). Second, we prorated the number of Unknown vessel-seasons according to the frequency of Yes, Maybe, and No vessel-seasons.

We then considered three cases—low, medium, and high—to compute the total number of vessel-seasons. For the low vessel-season case, we took the total vessel-seasons to be the number categorized as Yes and half the number categorized as Maybe. For the high case, we took the total to be the sum of those categorized as Yes, those prorated to be Yes, and those prorated to be Maybe. Finally, for the medium case, we summed the number categorized as Yes and prorated as Yes, plus half of the number categorized as Maybe and half of the number prorated as Maybe. This procedure resulted in total numbers of vessel-seasons of 416, 466, and 489 vessel-seasons for the low, medium, and high cases, respectively, with standard errors due to the proportions used in the prorating. The numbers of vessel-seasons for the three cases for each year are shown in Figure 7, along with 95% confidence intervals for the medium case.

The identified vessel-seasons of whaling in Mexican waters are listed in the Appendix, which includes each combination of vessel name and season, the vessel's known or likely nationality, whether the vessel-season was identified from the Henderson material, and the likelihood that the vessel-season involved some gray whaling. Also included, where available, are the known or probable vessel and voyage identification numbers (see above). In some cases, we indicated a likely AOWV vessel number corresponding to the vessel name, even though a precisely corresponding voyage number could not be identified because the departure and arrival dates were not consistent with

the vessel's being in the gray whaling grounds at the appropriate season. It is possible that a few vessel-seasons are listed twice because of inaccuracies and inconsistencies in vessel names, although we tried to minimize this by evaluating the voyage records carefully to account for vessels with similar names.

Vessels with American registry were responsible for nearly 89% of the whaling activity, with 272 vessels involved in some 587 vessel-seasons. Hawaii-registered vessels were the next most common, with 17 vessels involved in 32 vessel-seasons, followed by French-registered vessels, with 6 involved in 10 vessel-seasons. In addition, vessels registered in German states (e.g. Bremen), the Netherlands, Russia, Great Britain, Colombia, and Chile were identified as having spent one or more seasons in the Mexico whaling grounds. Only 14 vessels were unidentified as to nationality, and they were responsible for 14 vessel-seasons.

Estimates of Gray Whale Catches and Total Removals

The number of gray whales taken (i.e. secured and processed) was estimated for each gray whaling season between 1846 and 1874 (Fig. 8; with, for example, the 1858–59 season denoted as 1859) as the product of the estimated number of vessel-seasons that were, or maybe were, gray whaling in the low, medium, and high vessel-season cases (Fig. 7) times the average number of gray whales secured per vessel-season in the respective time periods (Table 1). The standard errors of the estimated takes were computed from the corresponding sample standard errors of the number of vessel-seasons and of the mean gray whales landed per vessel-season for each of the three cases (Table 4). For the medium case, the estimated catch reflects a combination of differences in the average catch rates by period and the variability in numbers of vessels whaling each year, with the number of vessel-seasons rising to a peak in the early 1860's and then declining rapidly (Fig. 7).

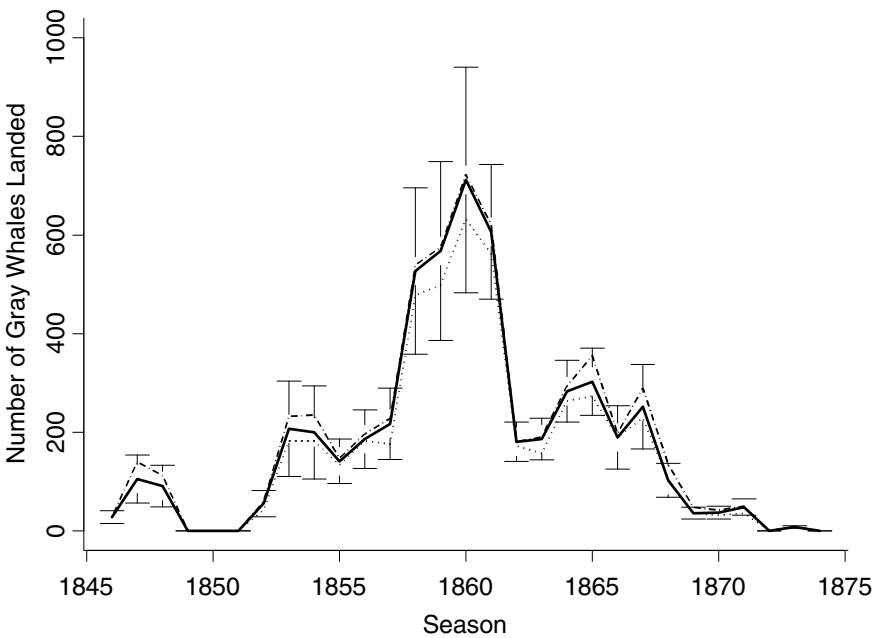


Figure 8.—Estimated numbers of gray whales landed in Mexico from 1846 to 1874, with the three cases for addressing uncertainty as to whether vessels were gray whaling (as described in the text). Vessel-season cases: low = dotted line, medium = solid line, high = dashed line Confidence intervals about the estimates (95%) are shown for the medium vessel-season case.

Table 4.—Estimated gray whale landings (whales) in Mexico from 1846 to 1874, with the three vessel-season cases (Low, Medium, High) to account for uncertainty regarding whether vessels were gray whaling. SE = standard errors of the estimates.

	Low Case		Medium Case		High Case	
Season	Whales	SE	Whales	SE	Whales	SE
1846	28	6.6	28	6.6	28	6.6
1847	105	24.9	105	24.9	140	33.2
1848	91	21.6	91	21.6	112	26.6
1849	0	0.0	0	0.0	0	0.0
1850	0	0.0	0	0.0	0	0.0
1851	0	0.0	0	0.0	0	0.0
1852	42	10.0	55	13.5	60	14.3
1853	182	43.2	207	49.4	232	55.3
1854	182	43.2	200	48.2	235	56.4
1855	133	21.7	141	22.9	147	23.9
1856	183	29.6	186	30.2	197	31.9
1857	176	28.5	217	37.0	228	38.6
1858	477	77.5	527	86.0	539	88.0
1859	499	80.9	568	92.6	575	93.7
1860	632	102.6	712	116.8	723	118.5
1861	561	63.5	606	69.7	621	71.4
1862	172	19.4	181	20.4	181	20.4
1863	157	17.7	186	21.4	190	21.8
1864	263	29.7	283	32.0	293	33.2
1865	273	30.9	303	34.8	355	40.6
1866	189	32.7	189	32.7	197	34.1
1867	229	39.5	252	43.7	290	50.1
1868	103	17.7	103	17.7	134	23.2
1869	36	6.1	36	6.1	47	8.2
1870	32	5.4	37	6.7	42	7.5
1871	36	6.1	48	8.5	50	8.7
1872	0	0.0	0	0.0	0	0.0
1873	8	1.4	8	1.4	8	1.4
1874	0	0.0	0	0.0	0	0.0
Total	4,789	199.5	5,269	223.4	5,624	234.7

There is a greater spread between the estimated landings for the three vessel-season case lines in some years than in others, especially during the middle years of the fishery, which are also the years that contribute most to the cumulative catch. In most of those years, the spread between the estimated landings for the three case lines is less than the width of the confidence intervals around the medium-case estimates (Fig. 8). In other words, the uncertainty in the estimated landings due to the standard errors (as reflected by the confidence intervals) is greater than the uncertainty due to the cases (as reflected by the spread between the case lines in the figure). We interpret this to mean that our estimation of landings would be improved most efficiently by reading more logbooks and not by simply trying to resolve more of the Unknown or Maybe gray whaling vessel-seasons.

The estimated total number of gray whales taken (secured and processed) by whalers in Mexican waters was 5,269 (SE = 223.4) for the medium vessel-season case, and ranged to roughly 9% lower and 7% higher for the low and high cases, respectively (Table 4). To estimate the total number of whales removed, an adjustment needs to be made to account for whales that were struck and lost (Table 2). At a minimum, a LRF of 1.06 can be applied to landings to account for the animals that were lost because they sank, because of poor weather, or because they escaped spouting blood (considered by the whalers as an indication of certain death). Alternatively, landings can be multiplied by 1.42 to account for all whales struck, regardless of their "condition" (Table 5).

Table 5.—Estimated numbers of gray whales removed by ship-based whalers in Mexican whaling grounds from 1846 to 1874 for the Low, Medium, and High cases for numbers of vessel-seasons and using the "Sank-Bleeding" or "combined" loss rate factor (LRF) (see Table 2), with standard errors (SE) accounting for the standard errors of both the landings and the LRF. See text for details.

Case	Low		Medium		High	
LRF	N	SE	N	SE	N	SE
1.06	5076	219.2	5585	245.1	5961	257.8
1.42	6800	371.1	7482	412.5	7986	436.2

Thus, actual removals would be at least 5,076 to 5,961, using the LRF of 1.06, although it is unreasonable to assume that no other struck whales died of their injuries. The estimated total number of struck whales would be between 6,800 and 7,986. However, it is also unreasonable to assume full mortality of all struck whales. Even though, as mentioned earlier, bomb lances were frequently used to subdue gray whales in the Mexican whaling grounds, not all bomb lances exploded. This is evidenced by the report from one California shore station where the equipment was said to be "of marginal quality" and "two thirds of the whales wounded were lost due to the harpoon's failure to explode" (Nichols, 1983:109, citing the diary of a judge who visited the whaling station at Ballard Point in 1860). In another example from the shore fishery (at Point Conception, California, 1879–80), all but one of 16 gray whales secured bore wounds attributed to previous strikes by bomb-lances (Jordan, 1887).

We are aware of two other studies that attempted to address the struck-lost issue in novel ways. Bannister et al. (1981), in their study of sperm whaling on the Japan Ground, sorted logbook records into three classes: whales tried out, whales struck and lost, and whales lost spouting blood. They then provided alternative LRF's, dependent on assumptions—one that only those lost spouting blood were "removed" (LRF: 1.20) and the other that all struck whales were removed (LRF: 1.61). This allowed them to offer two alternative estimates of total removals by year, essentially one high and one low, i.e. "a range within which total removals from the stock may lie during the study period …" (Bannister et al., 1981:830). Because their main interest was in trends in catches and catch per unit of effort, rather than in aggregate totals of whales removed (as here), Bannister et al. apparently saw no need to comment on which of their sets of estimates was likely the more accurate.

The other study (Mitchell and Reeves, 1983) assigned logbook records of humpback whale catches to six classes: 1) whales tried out, 2) whales known to have been killed but that were lost, 3) whales struck and lost but with no specific details on the circumstances, 4) whales struck and lost because the "iron drew," 5) whales struck and lost carrying gear, and 6) calves whose mothers were known to have been killed (i.e. they were orphaned on the calving grounds). These authors then developed a single LRF (1.86), based on the assumption that all of the whales in classes 1, 2, 5, and 6 and half of the whales in classes 3 and 4 were removed. They then used this single LRF to estimate removals from landings.

We are not able to evaluate in a meaningful way the potential of gray whales to survive various types of encounters with 19th century ship-based commercial whalers on the breeding grounds. Therefore, we have chosen to present multiple options according to assumptions, essentially following the lead of Bannister et al. (1981).

To account for the total effect of ship-based whaling on the gray whale population, the estimated 539 whales removed on the feeding grounds in the Bering and Chukchi Seas (Henderson, 1984) would need to be added.

Discussion

Comparisons to Earlier Estimates

Estimates of catches or total removals of gray whales by other authors have accounted for the various relevant whaling operations in different ways, and this makes it difficult to compare those estimates with ours. Henderson (1984) estimated that 4,466–4,516 eastern gray whales were secured and processed by ship-based whalers in Mexico between 1846 and 1874. This compares with our medium-case estimate of total landings of 5,269 (SE = 223.4). Henderson's estimates of landings were based largely on reported whale oil production, while ours are based on average landings per vessel-season. Our decision to consider the medium case for vessel-season uncertainty (Table 4) as providing our "best" estimates of total landings reflects our considered judgment concerning the many uncertainties surrounding the 19th century commercial catch history.

Henderson (1984) assumed that on the Mexican grounds, one whale was "mortally wounded" for every 10 secured, so his loss-adjusted estimate of total removals from those grounds was 4,913–4,968. Our medium-case estimate of total removals is 5,585 when we account only for whales that were lost due to sinking or escaped spouting blood and 7,482 if we assume (unrealistically) that all struck whales eventually died of their wounds. Thus, our medium-case estimate of removals in Mexico is somewhere between about 12 and 52% higher than that of Henderson (1984). We have made no attempt to investigate catches in the northern summering areas and therefore accept Henderson's (1984) estimate of an additional 402 eastern gray whales landed there, which he adjusted to 539 removed, assuming that in the north one whale was mortally wounded for every five secured. Adding that value to our range of Medium-case estimates suggests that a total of 6,124 to 8,021 gray whales were removed from the eastern North Pacific population.

Scammon (1874:23) stated: "From what data we have been able to obtain, the whole number of California Gray Whales which have been captured or destroyed since the bay-whaling commenced, in 1846, would not exceed 10,800." Because Scammon was well acquainted with whaling activities throughout the range of this gray whale population, we infer that his figure of 10,800 was meant to include all removals (catches plus hunting loss) by 1) ship-based commercial whalers in the Mexican breeding areas as well as in the northern feeding areas, 2) shore-based commercial whalers in California (Scammon, 1874:251), and 3) shore-based aboriginal whalers in northern latitudes (Scammon, 1874:29–32). We are not aware of any specific estimates of commercial ship-based catches by Scammon, but he gave the shore-based commercial catch between about 1850 and 1874 as "not less than 2,160," to which he proposed adding 20% to account "for the number of whales that escaped their pursuers, although mortally wounded, or were lost after being killed either by sinking in deep water or through stress of weather" (1874:251).

Scammon did not attempt to quantify the removals by aboriginal whalers but made a number of statements implying that he was aware of how widespread this whaling was and of its importance to some aboriginal communities. For example, in describing gray whale hunting by Indians of Washington and British Columbia and by Eskimos in the Arctic, he notes (1874:32) that in those northern latitudes the gray whale "is exposed to attack from the savage tribes inhabiting the sea-shores, who pass much of their time in the canoe, and consider the capture of this singular wanderer a feat worthy of the highest distinction." Given the incompleteness of information on how Scammon derived his estimate of total removals from the population, we cannot meaningfully evaluate the differences between his estimate of the ship-based commercial component and our own.

Finally, our estimates are considerably higher than those of Best (1987), who estimated landings on a voyage by voyage basis in two ways: 1) using published oil returns and Henderson's estimate of 35 barrels/whale for an estimate of 2,665 gray whales secured, and 2) using an average catch per voyage derived from Townsend (1935) for an estimate of 3,013 gray whales. He made no attempt to account for whales struck but lost. Moreover, he suggested that his catch estimates were 6–19% too low because he, unlike Henderson (1984), did not account for catches by non-U.S. registered vessels. Importantly, Best (1987) made no attempt to distinguish between eastern and western gray whales even though whales from both "stocks" were included in the oil data and the Townsend tabulations. It is unlikely that our inclusion of non-U.S.-registered vessels would account for the differences between our estimates and Best's estimates, considering that American vessels were responsible for 89% of the total ship-based gray whaling activity.

Uncertainties in the Estimates

Several of the uncertainties in our estimates of gray whale landings and removals are accounted for in the estimation variances, including the variability in the number of whales landed per vessel-season, the loss rate factor, and the prorating of the vessel-seasons for which we had no information about gray whaling activity. In sum, the width of the confidence interval for the medium-case estimate of total landings (4,811–5,726, Table 4), which reflects the sampling uncertainty, is 17% of the estimate. That percentage is similar to the difference between the low-case estimate and the high-case estimate (4,789 and 5,624, respectively), which is 15.8% of the medium-case point estimate and reflects the case variability.

We also explored the sensitivity of our estimates to the arbitrary assumption that half of the vessels in Mexican waters judged to have been "maybe" gray whaling actually were gray whaling. To do this, we computed estimates assuming that as few as one quarter or as many as three quarters of the "maybe" vessels actually were gray whaling. This resulted in differences of less than 5% in the estimated total landings. Thus, the magnitude of this uncertainty is small compared to that of uncertainty due to sampling variability and also small when compared to the differences among the three cases of numbers of vessel-seasons.

Another point to consider is that it was not always possible to distinguish vessels that gray whaled unsuccessfully (i.e. chased gray whales but made no catch) from those that pursued only other species (e.g. humpback whales or sperm whales). This inability to identify such "zero-catch" vessel-seasons would have biased our list of gray whaling vessel-seasons downward, but at the same time it would have biased our estimates of the average catch of gray whales per vessel-season upward. The two effects would tend to offset each other to an unknown extent, but the latter would likely be greater than the former because of the relatively small size of the sample used to estimate average catch per vessel-season.

Temporal Changes in Catch Levels

Gray whaling in the eastern North Pacific by 19th century ship-based

whalers was concentrated in a 3-decade period, with the bulk of the landings occurring between 1853 and 1863. Levels of both whaling activity (Fig. 7) and landings (Fig. 8) increased steadily over the decade beginning in 1853. Effort dropped abruptly in 1861, at the start of the U.S. Civil War, although it rapidly recovered to levels lying between the 1861 low and the pre-1861 high. Landings per vessel-season declined disproportionately as whaling became much less productive, with landings dropping by 45% from the peak level of 14.0 from 1856 to 1860 to a low of 7.9 from 1866 to 1874 (Table 1).

The decline in ship-based whaling activity paralleled the decline in shore-based gray (and humpback) whaling along the coast of California (Reeves and Smith, 2010). It is unlikely that the decline in either fishery was due to changes in the price of whale oil because, although the price declined briefly in the 1860's, it had recovered by the 1870's, even as gray whaling continued to decline. It is difficult to judge whether catch rates or effort to kill gray whales in the northern feeding areas also declined, given the relatively small catches there and the fact that the available tabulations (Henderson, 1972, 1984) provide only very coarse temporal resolution (i.e. totals approximately by decade).

The overall decline in gray whale catches in the 1860's was interpreted by some contemporary observers as a reflection of whale depletion. For example, when an American employee of a land-concessions company visited Baja California in 1866, he claimed that lagoon and alongshore whaling was no longer profitable and nearly abandoned, noting that two whaleships in Magdalena Bay had taken only two whales so far that season "though they had scoured the waters of the bay for two months" (Browne, 1966:60–61, as cited by Nichols, 1983:33). Scammon (1874:33) described the large bays and lagoons "where these animals once congregated, brought forth and nurtured their young" as "nearly deserted" by the early 1870's.

Gray whaling in the eastern North Pacific nearly ceased after the mid 1870's and until the early 20th century, except for aboriginal whaling (Mitchell, 1979; O'Leary, 1984; Mitchell and Reeves, 1990), small and sporadic catches by California shore whalers (Reeves and Smith, 2010), and occasional ship-based whaling on the feeding grounds (Bockstoce, 1986). Even if the eastern gray whale population was as depleted as suggested by first-hand observers in the late 1860's and 1870's, the lower intensity of whaling in subsequent decades should have allowed it to recover to some degree in the latter 19th and early 20th centuries. The extent of such recovery has not been revealed by assessment models that incorporate previous estimates of 19th century removals (as discussed above), which appear to be inconsistent with the population increases observed in the latter half of the 20th century.

Modern factory-ship whaling on gray whales began in 1914, and, by 1946, Norway, the United States, the Soviet Union, and Japan had taken a total of about 940 eastern gray whales in various parts of the population's range (Reeves, 1984). In addition, an uncertain number of gray whales (possibly several hundred) were taken in the 1930's off southern California by the U.S. factory ship *California* (Brownell and Swartz, 2007). The biological or population-level significance of these removals would have been considerable if the population was near extinction in the early 20th century as assumed by some contemporary observers (Andrews, 1916; Starks, 1922). The degree of depletion of eastern gray whales caused by 19th and early 20th century commercial whaling remains uncertain, but a recent assessment model, which incorporates 20th century population increases but uses only the record of removals since 1930, suggests that the population was on the order of a few thousand in 1930 (Brandon and Punt, 2009).

Implications for Population Assessment

We have no doubt that this effort of ours to build upon the legacy of David Henderson has provided a more complete and accurate picture than was previously available of the numbers of whales removed by ship whalers in the 19th century. The total estimates presented here for 19th century ship-based whaling in Mexico, along with those in our recent reanalysis of 19th century California shore-based gray whaling (Reeves and Smith, 2010), are not, however, substantially different from previously available estimates of removals by these two components of the overall commercial fishery.

Further, we are not aware of any substantial improvements on the earlier estimates for aboriginal gray whaling (IWC, 1993) and ship-based gray whaling north of Mexico (Henderson, 1984). The only significant improvement on estimates of 20th century landings is the previously overlooked 20th century removals by *California* (see above). Therefore, judging by the sensitivity analyses of Butterworth et al. (2002) and Wade (2002), there is no reason to expect that uncertainties about population status associated with previous population modeling approaches would be resolved by incorporating our new estimates of removals.

It is relevant to consider the possibility that lagoon whaling had a more severe effect than would be evident solely from the record of removals. As indicated above, our logbook data confirm that lagoon whaling in Mexico focused on adult females with calves. Further, although calves apparently were seldom tried out (i.e. secured and processed), many were wounded if not killed outright as the whalers attempted to secure their mothers, and many more were orphaned when their mothers were killed. Given that logbooks do not consistently record the presence and fate of calves, it is unlikely that data needed for rigorous quantitative estimates of calf "removal" levels can be obtained.

Although we currently have no way of apportioning the aggregate catch data by area, i.e. inner lagoons vs. lagoon entrances vs. outer coasts (alongshore whaling), it is possible that, with closer scrutiny of logbooks and other sources, this could be done. For example, in the early years of exploitation of a given

lagoon, the hardest hit group may have been the cows with calves in the inner reaches. Only after a few years, as that component became depleted, would the whalers have spent substantial time pursuing the more difficult-to-catch and individually lower-yield quarry (bulls, juveniles, and resting females) that congregated in the outer parts of the lagoons and along the outer coasts (Norris et al., 1983; Swartz, 1986). Thus, the composition of catches (specifically the proportion of calving/nursing cows and, in turn, the numbers of killed, mortally wounded, or orphaned calves) could be estimated, based on the pattern of discovery and exploitation of each lagoon.

In any event, the lagoon fishery for gray whales must have had a greater effect on the population than either an unbiased removal regime or a regime biased toward an age or sex class other than adult females (Cooke, 1986). Friday and Smith (2003) showed that the harvest pattern associated with lagoon whaling would have the highest per capita impacts of any pattern considered. A complete assessment of the status of the population will require accounting in some way not only for the sex ratio of the adults removed, but also for the calves that were killed or orphaned, and presumably died, as a consequence of whaling operations.

Further Research

As noted above, our new estimates of the commercial catch history do not come anywhere near to the 60% increase needed to fit existing population models of the eastern gray whale population (Butterworth et al., 2002; Wade, 2002). Also, our numbers, when combined with the relatively well-documented catch levels of the 20th century and the best available estimates of aboriginal catches, do not appear consistent with the genetically derived estimate of average long-term abundance of about 96,000 by Alter et al. (2007), which refers to the entire North Pacific basin and thus encompasses both eastern and western populations.

Thus, two major problems remain. One is the difficulty of obtaining reasonable estimates of historical carrying capacity from catch-based population models. The other is that estimates of historical abundance derived from analyses of genetic variability seem far too high, given what is known about total removals by whaling and recent or current estimated population size.

At least four avenues of investigation to address these problems come to mind: 1) further reconstruction of the catch history, 2) reassessment of the demographic and social effects of lagoon whaling, especially in regard to calving, nursing, and breeding, 3) searching for a better understanding of environmental or ecological factors that determine carrying capacity for gray whales, and 4) reevaluation of the underlying assumptions and methods of genetic variability-based estimates of abundance.

With regard to the first of these, catch history, we suggest that future effort should focus on the poorly documented but long history of whaling for gray whales by aboriginal people throughout the North Pacific, including the Bering and Chukchi Sea coasts (Mitchell, 1979; O'Leary, 1984; Krupnik, 1984; Mitchell and Reeves, 1990) and on the better documented but incomplete history of gray whaling in the western North Pacific. Although there are reasonably good records from Japan (Omura, 1984; Kato and Kasuya, 2002), this is not the case for Korea and China (e.g. Reeves et al., 2008).

In addition, improvements could be made in our present estimates for the eastern North Pacific by sampling additional logbooks to determine landings per vessel-season. Linking the vessel-season data in the Appendix to information in the American Offshore Whaling Voyage database (Lund et al., 2008) reveals that we have sampled about 25% of the extant relevant logbooks. Sampling more logbooks would address uncertainties in our estimation procedures in two ways: 1) by reducing the numbers of Maybe and Unknown vessel-seasons (Table 3) and 2) by reducing the standard errors of the average numbers of whales taken in vessel-seasons that we know involved gray whaling (Table 1).

The resources available for this study were not sufficient to allow additional logbook sampling, but with the information provided here concerning the uncertainties, together with the information in the Appendix and the AOWV database on logbook availability, it should be possible to design an efficient sampling scheme to improve our estimates in a number of ways. Such a scheme would allow greater statistical precision and, with more emphasis on catch locations (e.g. deep inside the lagoons, in the lagoon entrances, or along the outer coast) than was possible in this study, allow us to partition removals by area and hence age/sex class, at least to some extent. It is also worth noting that the estimate of ship-based landings north of Mexico (Henderson, 1984) is not well documented, and further examination of the data on which it is based could be useful.

With regard to the second avenue of investigation, the effects of lagoon whaling, it may be useful to explore population models that would better account for the effects of whaling on a population's breeding grounds. This issue was raised previously by Cooke (1986) and subsumed by Butterworth et al. (2002:66) under the rubric of depensation, which they defined as "the phenomenon of a decrease in the per capita growth rate of a resource when population size is reduced below a certain level." However, the issue deserves further exploration and should explicitly include consideration of the differential sex ratio of the catches, the deaths of calves, and the disruptive effects of whaling at the point in the life cycle when females give birth, nurse their young, and conceive (Friday and Smith, 2003).

With regard to the third avenue, carrying capacity, there has been considerable speculation in the literature on how and to what extent the environmental carrying capacity for gray whales has changed over time. For this species, with its long-distance migration and the sharp geographical separation between its feeding and breeding habitat, population size could be limited either by the size and condition of Mexican lagoons or

by the extent and productivity of boreal and Arctic shelf waters. Half a century ago, there was lively debate concerning how much gray whale breeding habitat had been lost in southern California and Mexico, whether due to inshore vessel traffic (Gilmore and Ewing, 1954), cooling sea temperatures (Hubbs, 1959), or sea level fluctuations and other geophysical processes (Gilmore, 1976).

More recently, the emphasis has been on food limitation. A large-scale die-off along the west coast of North America in 1999 fueled speculation that foraging conditions for gray whales in the Bering and Chukchi Seas had deteriorated, leading to poor survival and low calf production (Le Boeuf et al., 2000). The die-off continued in 2000, with a relatively high proportion of the mortality consisting of subadult and adult whales and with some but not all of the dead animals exhibiting signs of nutritional stress (Gulland et al., 2005). Annual strandings returned to background levels from 2001 through 2006 (Brownell et al., 2007), and Moore et al. (2001) concluded, "The causes of the recent spate of gray whale deaths may never be discovered." The factors determining carrying capacity for gray whales are not clearly known, and alternative model formulations may be useful for exploring this issue further.

Finally, with regard to the fourth avenue, the reliability of genetic variability-based estimates of average long-term abundance, concerns have been raised about such things as the mutation rate attributed to gray whales, the relationship of effective and census population size, the demographic and social characteristics assumed, and the applicability of genetic variability-based estimates of abundance to contemporary (or recent historic) populations (Palsbøll et al., 2007; Alter and Palumbi, 2007; Palsbøll, 2009). Although such concerns were addressed to some degree by Alter et al. (2007) and Alter and Palumbi (2007), further testing is needed of both the methodology and the assumptions leading to those authors' seemingly very high estimate of average long-term abundance compared to estimates of pre-whaling abundance derived from other methods.

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Appendix

Identity of vessels whaling in Mexico during the gray whaling winter season from 1846 to 1874 showing the vessel name (Vessel), the nationality of registry (Nat), the vessel number (Ves), and the voyage number (Voy). Also shown are the source of information on each vessel-season (VS) and the likelihood that each vessel-season involved gray whaling (GW). For vessel-seasons where we had information on landings, the estimated number of gray whales taken during that season (EGW) and the nature of the source of those landings (LS) is indicated. Voyage and vessel numbers for American vessels are from the American Offshore Whaling Voyage database (Lund et al., 2008) and the voyage numbers for the French vessels are from Annex 7 of du Pasquier (1982:242–9, as 30,000 plus the numerical sequence). Details of the American vessels and voyages can be obtained by tracing the Ves and Voy values given here into the National Maritime Data Library (www.nmdl.org).

Coded Fields:

VS (Vessel Source): H = Henderson (1972, 1984, and unpublished notes and files), O = Other, primarily Hawaii port records

GW (Gray Whaling): Y = Yes, M = Maybe, N = No, U = Unknown

LS (Landings Source): L = logbook we read, T = logbook read by Townsend (1935), N=newspaper.

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
A. M. Simpson	1860	American	809	35	H	N		
Addison	1859	American	3	229	H	Y		
Adeline	1854	American	2	257	O	U		
Adeline	1863	American	2	259	H	Y	16	L
Adeline	1864	American	2	259	H	Y	21	L
Agate	1857	American	795	341	O	U		
Agate	1858	American	795	341	H	Y		
Agate	1859	American	795	341	H	Y		
Alexander	1854	American	5	465	H	M		
Alexander Coffin	1854	American	13	517	O	U		
Alice	1859	Hawaiian			H	Y	9	N
Alice	1861	American	842	550	H	Y		
Almira	1861	American	806	672	O	U		
Almira	1866	American	806	763	O	Y	4	T
Almira	1867	American	806	673	H	Y		
Aloha	1860	Hawaiian			O	Y		
Alpha	1865	American	36	693	H	M		
Alpha	1866	American	36	694	H	Y	14	N
Alpha	1867	American	36	694	O	M		
America	1847	American	6	818	H	M		
America	1853	American	6	825	H	U		
America	1854	American	6	825	H	U		
Antilla	1859	Hawaiian			H	Y		
Antilla	1860	Hawaiian			O	Y		
Aquetnet	1852	American	898	1146	O	U		
Aquetnet	1853	American	898	1146	H	Y	5	L
Arab	1856	American	899	1166	H	N		
Arab	1864	American	39	1173	O	U		
Architect	1857	American	902		O	U		
Arnolda	1854	American	18	1254	O	M		
Arnolda	1865	American	18	1257	H	Y		
Arnolda	1866	American	18	1257	H	Y		
Aurora	1868	American	37	1438	H	N		
Baltic	1854	American	73	1526	O	N		
Barnstable	1858	American	718	1592	H	Y		
Barnstable	1863	American	718	1593	H	Y	2	L
Bartholomew Gosnold	1858	American	72	1600	O	U		
Bartholomew Gosnold	1861	American	72	1602	O	N		
Bartholomew Gosnold	1864	American	72	1603	H	Y		
Bartholomew Gosnold	1865	American	72	1603	H	Y		
Bay State	1854	Undetermined			H	N		
Belle	1855	American	963	1645	O	N		
Belle	1855	American	964	1647	O	N		
Bengal	1854	American	968	1735	H	N		
Bengal	1855	American	968	1735	H	N		
Benjamin Morgan	1858	American	970	1765	O	Y		
Benjamin Morgan	1859	American	970	1765	H	Y		
Benjamin Rush	1858	American	971	1776	O	Y		
Benjamin Rush	1859	American	971	1776	H	M		
Benjamin Rush	1865	Undetermined			O	U		
Benjamin Tucker	1858	American	63	1786	H	Y		
Bingham	1848	American	986	1871	H	Y		
Black Eagle	1853	American	78	1880	O	N	0	T
Black Eagle	1858	American	78	1881	O	Y		
Black Prince	1863	Undetermined			H	U		
Black Warrior	1857	Hawaiian			O	M		
Black Warrior	1858	Hawaiian			O	Y		
Black Warrior	1859	Hawaiian			H	N		
Boston	1857	American	1000	1945	H	Y		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Boston	1858	American	1000	1946	H	Y		
Bowditch	1848	American	1001	1976	H	N		
Braganza	1858	American	69	2004	H	Y		
Brookline	1847	American	1011	2060	H	Y	29	N
Brunswick	1863	American	71	2107	H	Y	12	T
Brunswick	1864	American	71	2107	H	Y		
Brunswick	1865	American	71	2107	H	U		
Cabinet	1847	American	1016	2132	H	M		
California	1854	American	93	2193	O	U		
California	1861	American	93	2195	H	Y		
California	1863	American	93	2196	H	Y		
California	1864	American	93	2196	H	Y	4	L
California	1865	American	93	2196	H	Y	9	T
California	1868	American	93	2197	O	M		
Callao	1857	American	80	2227	H	N		
Callao	1861	American	80	2228	H	U		
Cambria	1861	American	82	2243	H	Y	11	T
Camilla	1864	American	132	2255	H	N		
Camilla	1865	American	132	2255	H	N		
Camilla	1866	American	132	2255	H	Y		
Camilla	1867	American	132	2255	H	N		
Candace	1855	American	1029	2284	H	Y		
Canton Packet	1865	American	88	2334	H	Y		
Carib	1858	American	1034	2364	H	Y		
Carib	1859	American	1034	2365	H	Y		
Carib	1860	American	1034	2365	H	Y		
Carib	1862	American	1034	16805	H	Y		
Carlotta	1871	American	1035	2373	H	Y		
Caroline E. Foote	1864	American	1038	2401	H	Y		
Caroline E. Foote	1865	American	1038	16783	H	Y		
Caroline E. Foote	1866	American	1038	2402	H	Y		
Caroline E. Foote	1871	American	1038	2403	H	Y		
Catharine	1847	American	1055	2470	H	M		
Catharine	1863	American	1054	2468	H	Y		
Catharine	1864	American	1054	2468	H	Y		
Catharine	1865	American	1054	2468	H	M		
Cavalier	1853	American	125	2497	H	M		
Champion	1858	American	1064	2526	H	U		
Champion	1867	American	1064	2528	O	N		
Chandler Price	1861	American	116	2556	H	Y		
Chariot	1854	American	1068	16947	O	U		
Charles Carroll	1856	American			H	N		
Charles Frederick	1853	American	90	2676	H	N		
Charles Phelps	1846	American	1085	2696	H	N	0	L
Charles Phelps	1852	American	1085	2698	O	N	0	T
Charles W. Morgan	1858	American	89	2716	O	N		
Charles W. Morgan	1859	American	89	2716	O	U		
Charles W. Morgan	1861	American	89	2717	H	Y		
Charles W. Morgan	1862	American	89	2717	H	Y	13	N
Cherokee	1853	American	101	2811	H	N		
Cherokee	1854	American	101	2811	O	N		
Citizen	1848	American	115	2902	H	N		
Citizen	1853	American	1104	2898	O	N		
Citizen	1854	American	1104	2898	O	Y		
Clematis	1855	American	1112	2967	H	N		
Clement	1853	American	1113	2974	H	Y		
Clementine	1848	German			O	Y		
Cleone	1861	American	121	2977	H	Y	14	T
Cleopatra	1859	Columbia			H	Y		
Columbia	1852	American	1121	3021	H	N		
Columbia	1853	American	1121	3021	H	M		
Columbus	1858	American	110	3092	H	Y		
Comet	1861	German			H	Y	11.5	N
Comet	1862	German			H	Y		
Comet	1863	German			H	Y		
Comet	1864	German			H	Y		
Congress	1865	American	112	3254	O	Y		
Congress	1866	American	112	3254	H	N	0	L
Congress	1867	American	112	3254	H	Y	3	L

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Congress II	1861	American	113	3258	H	Y		
Congress II	1862	American	113	3258	O	Y		
Coral	1861	American	109	3323	H	Y	17.5	N
Corinthian	1859	American	97	3357	O	U		
Corinthian	1861	American	97	3357	O	Y		
Corinthian	1867	American	97	3359	O	N		
Corinthian	1868	American	97	3359	H	N		
Cornelius Howland	1865	American	103	3405	H	Y	5	L
Cornelius Howland	1866	American	103	3405	H	Y	19	L
Cornelius Howland	1867	American	103	3405	H	Y		
Cornelius Howland	1870	American	103	3407	O	Y	2	L
Cosmopolite	1848	French		30511	H	M		
Cowper	1854	American	117	3476	O	N		
Cynthia	1859	Hawaiian			H	Y		
Cynthia	1860	Hawaiian			O	Y		
Cynthia	1861	Hawaiian			H	Y		
Dartmouth	1857	American	145	3599	H	Y	27	L
Delaware	1855	American	1198	3659	H	Y	6	L
Delaware	1860	American	1198	3663	H	Y		
Delaware	1861	American	1198	16809	H	Y		
Delaware	1862	American	1198	16809	H	N		
Draper	1857	American	147	3858	H	Y		
Draper	1858	American	147	3858	O	Y		
Dromo	1846	American	1232	3864	H	N		
Dromo	1852	American	1232	3866	H	Y		
Dromo	1859	American	1232	3869	H	Y		
Eagle	1857	American	1244	3988	H	U		
Eagle	1858	American	177	3982	H	Y		
Eagle	1867	American	177	3984	O	M		
Eagle	1868	American	177	3984	H	Y	9	T
Eagle	1868	American	2811	16952	H	Y		
Eagle	1869	American	2811	16953	H	Y	14	N
Eagle	1869	American	177	3984	H	Y	9	T
Edward	1848	American	180	4020	H	M		
Edward L. Frost	1852	American	2813	17047	H	U		
Edward L. Frost	1855	American	2813	16957	O	Y		
Edward L. Frost	1857	American	2813	16957	H	Y		
Edward L. Frost	1858	American	2813	16958	H	Y		
Electra	1861	American	1261	4119	H	Y		
Eliza	1858	American	193	4141	H	Y		
Eliza Adams	1853	American	199	4171	H	N	0	L
Eliza Adams	1854	American	199	4171	O	N		
Eliza Adams	1860	American	199	4173	H	Y		
Eliza Adams	1865	American	199	4174	H	N		
Eliza Adams	1866	American	199	4174	H	N		
Elizabeth Swift	1865	American	190	4268	H	N		
Ellen	1859	American	1283	4271	H	U		
Emeline	1855	American	1288	4349	H	U		
Emerald	1858	American	178	4371	O	M		
Emerald	1859	American	178	4371	H	Y		
Emerald	1860	American	178	4371	H	Y		
Emerald	1861	American	178	4371	H	Y		
Emily Morgan	1868	American	170	4407	H	N		
Emily Morgan	1871	American	170	4409	H	N		
Emma Rooke	1862	Hawaiian			O	Y		
Emperor	1852	American	1299		H	N		
Emperor	1853	American	1299		H	N		
Endeavor	1866	American	173	4492	H	M		
Endeavor	1867	American	173	4492	H	M		
Erie	1851	American	2753	4583	H	U		
Erie	1860	American	2753	4585	H	Y		
Espadon	1854	French		30554	O	N		
Eugenia	1867	American	198	4656	H	U		
Euphrates	1859	American	175	4688	H	N	0	T
Euphrates	1860	American	175	4688	O	Y	1	T
Euphrates	1864	American	175	4689	H	Y		
Euphrates	1865	American	175	4689	H	M		
Europa	1861	American	1328	4692	H	Y		
Europa	1864	American	1328	4693	H	Y		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Europa	1865	American	1328	4693	H	U		
Europa	1868	American	1328	4694	H	Y	2	L
Fabius	1860	American	222	4784	H	Y	20	L
Fabius	1861	American	222	4784	H	Y	13	L
Fabius	1863	American	222	4785	H	Y		
Fabius	1864	American	222	4785	H	Y	3	L
Fabius	1865	American	222	4785	H	Y	3	T
Faith	1859	British			H	Y		
Fame	1852	Undetermined			H	N		
Fanny	1858	American	1361	4887	O	U		
Fanny	1860	American	1361	4887	O	U		
Fanny	1866	American	1361	4889	H	Y	1	T
Fanny	1867	American	1361	4889	H	N	0	T
Fanny	1868	American	1361	4889	H	N		
Fanny	1871	American	1361	4890	H	N		
Favorite	1856	American	2817	16992	H	Y		
Florence	1864	Hawaiian			H	Y		
Florida	1861	American	213	5004	H	Y	3	L
Florida	1862	American	213	5004	H	U		
Florida	1866	American	213	5005	H	Y		
Florida	1867	American	213	5005	H	M		
Florida II	1861	American	1376	5009	H	U		
Fortune	1858	American	224	5041	O	M		
Fortune	1859	American	224	5041	H	Y		
Fortune	1860	American	224	5041	H	Y		
Frances Henrietta	1854	American	217	5133	H	Y		
Frances Palmer	1858	American	1392	16996	H	Y		
Francis	1856	American	1399	5163	H	Y		
Francis	1857	American	1399	5165	O	Y		
Francis	1858	American	1399	5165	H	N		
Franklin	1858	American	1411	5300	H	N		
Franklin	1860	American	1411	5300	O	N		
Gay Head	1867	American	253	5405	H	Y		
Gay Head	1868	American	253	5405	H	M		
General Pike	1860	American	235	5499	O	N		
General Scott	1858	American			O	N		
General Scott	1861	American	263	5511	H	Y		
General Scott	1867	American	1441	5513	O	M		
General Scott	1868	American	1441	5513	H	Y		
General Teste	1852	French		30529	O	U		
General Teste	1854	French		30555	O	N		
General Williams	1860	American	1445	5534	H	Y		
General Williams	1861	American	1445	5534	H	Y		
George	1853	American	1464	5594	H	U		
George	1856	American	2820	16999	O	U		
George	1867	American	234	5578	H	M		
George	1871	American	234	5579	O	M		
George Howland	1855	American	236	5694	O	N		
George Howland	1860	American	236	5695	H	Y	16	T
George Howland	1861	American	236	5695	H	Y	8	T
George Howland	1864	American	236	5696	H	Y	14	T
George Howland	1868	American	236	5697	H	Y	10	L
George Howland	1869	American	236	5697	H	N	0	L
George Washington	1860	American	2735	5747	O	U		
George and Mary	1860	American	1450	5633	H	Y		
George and Mary	1860	American	259	5645	H	U		
Good Return II	1854	American	218	5903	O	N	0	L
Good Return II	1860	American	218	5905	O	M		
Governor Troup	1860	American	247	5952	O	N	0	L
Governor Troup	1864	American	247	5955	H	Y	5	T
Governor Troup	1865	American	247	5955	H	Y	2	L
Governor Troup	1866	American	247	5955	H	Y	12	L
Gratitude	1864	American	248	6011	O	Y		
Gustave	1861	French		30582	O	Y		
Hae Hawaii	1868	Hawaiian			O	Y		
Hansa	1848	German			O	Y		
Harmony	1860	Hawaiian			H	Y		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Harmony	1861	Hawaiian			H	Y	18.5	N
Harmony	1862	Hawaiian			O	Y		
Harrison	1867	American	279	17049	O	M		
Harvest	1862	American	282	6256	H	Y		
Helen Mar	1867	American	290	6337	H	N		
Helen Mar	1868	American	290	6337	H	N		
Helen Snow	1874	American	284		O	U		
Henry	1855	American	1581	6394	O	Y		
Henry	1857	American	1584	6414	H	Y	19	N
Henry Kneeland	1860	American	280	6438	H	Y		
Henry Kneeland	1861	American	280	6438	H	Y		
Hercules	1856	American	271	6542	O	N		
Hercules	1859	American	271	6543	H	Y		
Hercules	1865	American	271	6544	H	Y		
Hercules	1869	American	271	6545	O	M		
Hercules	1870	American	271	6545	H	Y	13	N
Heroine	1854	American			O	M		
Hibernia	1855	American	273	6667	H	Y	5	L
Hibernia	1856	American	273	6667	H	N	0	L
Hibernia	1857	American	273	6667	O	N	0	L
Hibernia	1859	American	273	6668	H	Y		
Hibernia II	1846	American	285	6678	H	Y	22	N
Hibernia II	1847	American	285	6678	H	Y		
Hibernia II	1870	American	285	6676	O	M		
Hillman	1859	American	287	6704	H	Y		
Hillman	1864	American	287	6705	O	Y		
Hillman	1865	American	287	6705	H	Y		
Hope	1848	American	210	6771	H	N		
Hopewell	1856	American	1622	6792	H	Y		
Huntsville	1853	American	1633	6901	O	N		
Iris	1867	American			O	U		
Isabella	1861	American	311	7167	H	Y	2	L
Isabella	1862	American	311	7167	H	Y		
Isabella	1864	American	311	7168	H	N		
Isabella	1865	American	311	7168	H	Y	2	N
Islander	1858	American	312	7184	O	N		
J. D. Thompson	1860	American	345	7208	O	Y		
J. D. Thompson	1865	American	345	7211	H	N		
J. D. Thompson	1866	American	345	7211	H	Y		
J. D. Thompson	1867	American	345	7211	H	Y		
J. E. Donnell	1847	American	331	7216	H	M		
James Allen	1867	American	329	7260	H	Y		
James Allen	1868	American	329	7260	O	M		
James Andrews	1856	American	335	7278	H	Y		
James Andrews	1857	American	335	7278	H	Y		
James Loper	1853	American	1675	7303	O	N		
James Loper	1854	American	1675	7303	O	N		
James Maury	1853	American	330	7308	H	Y	9	L
James Maury	1854	American	330	7308	H	Y	7	L
James Maury	1855	American	330	7308	H	Y	15	L
James Maury	1858	American	330	7309	O	N		
James Trosser	1857	Undetermined			H	Y		
Jane	1859	Undetermined			O	Y	22	N
Janus II	1857	American	324	7379	O	U		
Janus II	1861	American	324	7380	H	M		
Janus II	1867	American	324	7382	O	M		
Janus II	1868	American	324	7382	O	M		
Jeannette	1860	American	328	7497	H	Y		
Jeannette	1861	American	328	7497	H	Y		
Jesse D. Carr	1858	American	2873	17012	O	Y		
Jireh Perry	1867	American	337	7530	H	Y		
John Howland	1860	American	321	7745	H	Y		
John Howland	1861	American	321	7745	H	Y		
John Howland	1862	American	321	7745	H	Y	20	L
John Howland	1863	American	321	7745	H	Y	14	L
John Howland	1866	American	321	7747	H	Y		
John Howland	1867	American	321	7747	H	M		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
John Howland	1868	American	321	7747	O	Y		
John Howland	1869	American	321	7747	H	Y		
John P. West	1861	American	350	7772	H	Y		
John P. West	1864	American	350	7774	H	M		
John P. West	1865	American	350	7774	H	Y		
John P. West	1866	American	350	7774	H	Y		
John P. West	1867	American	350	7774	H	Y		
John and Edward	1853	American	325	7639	H	N		
John and Edward	1854	American	325	7639	H	Y		
John and Elizabeth	1846	American	1707	7654	H	N		
John and Elizabeth	1853	American	1707	7656	O	N		
John and Elizabeth	1858	American	1707	7659	O	Y		
Joseph Haydn	1854	German			H	Y		
Josephine	1861	American	346	7886	H	Y		
Josephine	1865	American	346	7887	O	Y	6	L
Josephine	1866	American	346	7887	O	Y	1	L
Judson	1852	Undetermined			H	N		
Julian	1858	American	323	7936	O	N		
Jupiter	1852	American	1744		H	N		
Jupiter	1853	American	1744	8011	H	N		
Kalama	1862	Hawaiian			H	Y		
Kamchatka	1865	Undetermined			H	M		
Kamehameha V	1864	Hawaiian			O	Y		
Kamehameha V	1865	Hawaiian			O	M		
Kate	1860	American	1749	8030	H	N		
Kate	1862	American	1749		H	N		
Kate Darling	1857	Undetermined			H	Y		
Kathleen	1863	American	357	8042	H	M		
Kauai	1860	German			O	Y		
Kohola	1862	Hawaiian			H	Y		
Kutusoff	1854	American	356	8094	O	M		
L. C. Richmond	1856	American	377	8103	H	Y	17	L
L. C. Richmond	1859	American	377	8104	H	Y		
L. C. Richmond	1860	American	377	8104	H	Y		
L. C. Richmond	1861	American	377	8104	H	Y		
L. P. Foster	1866	American	1758	17050	H	Y		
L. P. Foster	1867	American	1758	17051	H	Y		
Lagoda	1848	American	381	8156	O	N		
Lagoda	1858	American	381	8161	O	Y		
Lark	1856	American	1770	8236	H	Y		
Lark	1859	American	1770	8238	H	Y		
Lark	1860	American	1770	8238	H	Y		
Leonore	1852	American	1790		H	Y		
Leonore	1856	American	1790	8369	H	Y		
Leverett	1857	American	1795	16834	O	M		
Levi Starbuck	1852	American	385	8385	O	M		
Levi Starbuck	1859	American	385	8387	H	Y		
Levi Starbuck	1861	American	385	8387	H	Y		
Lewis	1860	American	380	8400	O	Y		
Liverpool	1856	American	373	8497	H	Y		
Liverpool	1865	Undetermined			O	U		
Louisa	1854	American	388	8578	O	N		
Louisa	1873	American	388	8583	H	Y	2	N
Louisa	1874	American	388	8583	H	U		
Lydia	1867	American	397	8715	H	Y	2	L
Lydia	1868	American	397	8715	H	M		
Magnolia	1847	American	419	8768	H	M		
Magnolia	1848	American	419	8768	H	M		
Majestic	1859	American	453	8795	H	Y	5	L
Majestic	1860	American	453	8795	H	Y	1	L
Manuella	1866	American	1837	8826	H	N		
Manuella	1867	American	1837	8827	H	Y		
Marengo	1853	American	461	8916	H	N	0	L
Marengo	1858	American	461	8917	H	Y		
Maria	1861	Hawaiian			H	Y	20	N
Maria	1862	Chilean			O	Y		
Martha	1859	American	1869	9096	O	U		
Martha	1861	American	1869	9096	H	Y		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Martha	1861	American	401	9141	H	Y		
Martha	1865	American	401	9143	H	Y		
Martha	1867	American	401	9143	H	M		
Martha II	1861	American	2852	9163	O	U		
Mary and Martha	1854	American	469	9232	O	N	0	L
Mary and Susan	1853	American	1875	9261	O	M		
Mary and Susan	1871	American	481	9241	H	Y		
Massachusetts	1853	American	444	9420	H	M		
Massachusetts	1858	American	444	9422	H	N		
Massachusetts	1859	American	1906	9413	H	Y		
Massachusetts	1859	American	444	9422	H	Y		
Massachusetts	1867	American	444	9424	H	Y		
Massachusetts	1868	American	444	9424	O	N		
Massachusetts	1870	American	444	9427	H	N		
Massachusetts	1871	American	444	9426	H	Y		
Massasoit	1859	American	1907	9433	O	Y		
Massasoit	1860	American	1907	9433	O	Y		
Massasoit	1861	American	1907	9433	H	Y	16	N
Maunaloa	1871	Hawaiian			O	U		
Mechanic	1853	American	1915	9506	H	U		
Mechanic	1854	American	1915	9506	H	Y		
Menschikoff	1871	American	1922	9533	H	U		
Mercator	1855	American	408	9569	O	N		
Meteor	1853	American	1937	9689	H	U		
Metropolis	1859	American	2821	17002	H	Y		
Milo	1861	American	400	9774	H	Y		
Milo	1863	American	400	9774	H	U		
Milo	1865	American	400	9775	H	Y		
Milo	1866	American	400	9775	H	Y		
Milo	1867	American	400	9775	H	Y		
Milton	1860	American	420	9784	O	U		
Milton	1864	American	420	9785	H	Y		
Minerva	1853	American	407	9871	O	N		
Minerva II	1850	American	424	9896	H	N		
Mogul	1854	American	1958	9946	H	Y		
Mogul	1855	American	1958	9946	H	Y		
Mogul	1856	American	1958	9946	H	Y		
Monmouth	1861	American	1962	9966	H	Y		
Montauk	1858	American	1966	9976	H	Y		
Montezuma	1860	American	1970	10002	H	Y		
Montezuma	1861	American	1970	10002	H	Y		
Montezuma	1862	American			H	Y		
Montgomery	1850	American	472		O	U		
Monticello	1867	American	1978	10047	O	Y		
Montreal	1859	American	467	10062	H	Y	14	L
Montreal	1861	American	467	10062	O	U		
Morea	1846	American	458	10063	H	N		
Mount Wollaston	1865	American	465	10131	H	M		
Nassau	1865	American	492	10284	H	M		
Nathaniel S. Perkins	1866	American	2021	17052	H	Y		
Nathaniel S. Perkins	1867	American	2021	17052	O	M		
Navigator	1857	American	2023	10325	H	Y		
Neptune	1856	American	2032	10376	H	M		
Nevada	1860	American	2038	10410	H	Y		
New England	1860	American	488	10422	H	Y		
New England	1861	American	488	10422	H	Y		
Nile	1854	American	2046	10485	O	M		
Nile	1859	American	491	10491	O	U		
Nile	1861	American	491	10491	H	Y		
Nile	1863	American	491	10491	H	Y		
Nile	1864	American	491	10491	H	Y		
Nile	1865	American	491	10491	H	Y		
Nile	1866	American	491	10491	H	Y		
Nile	1867	American	491	10491	H	Y		
Nimrod	1855	American			O	Y		
Nimrod	1865	American	494	10513	H	M		
Norman	1868	American	505	10576	O	M		
Norman	1871	American	505	10576	O	N		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
North Star	1853	American	2059	10615	H	Y		
North Star	1854	American	2059	10615	H	Y		
Northern Light	1860	American	503	10622	H	U		
Nye	1863	American	477	10666	H	U		
Oahu	1858	Hawaiian			H	Y		
Oahu	1859	Hawaiian			H	Y		
Oahu	1860	Hawaiian			O	Y		
Ocean	1860	American	2073	10698	H	Y		
Ocean	1861	American	2073	10698	H	Y		
Ocean	1862	American	2073	10698	O	Y		
Ocean	1863	American	2073	10698	H	Y		
Ocean	1867	American	515	10692	H	Y		
Ocean Bird	1859	American	2065	10718	H	Y	46	L
Ocean Bird	1860	American	2065	10718	H	Y		
Ocean Bird	1861	American	2065	17053	H	Y		
Ocmulgee	1859	American	2076	10730	O	U		
Ocmulgee	1860	American	2076	10730	H	Y		
Ohio	1859	American	516	10781	H	Y		
Ohio	1860	American	516	10781	H	Y		
Olive	1860	American	2091	10825	H	Y		
Oliver Crocker	1859	American	519	10844	O	U		
Oliver Crocker	1860	American	519	10844	O	Y	35	L
Oliver Crocker	1861	American	519	10844	H	Y	5	L
Oliver Crocker	1864	American	519	10845	O	U		
Oliver Crocker	1867	American	519	10847	H	Y		
Olivia	1861	American	2093	10852	H	Y		
Omega	1853	American	2095	10863	H	N		
Ontario	1861	American	2104	10914	H	Y		
Onward	1860	American	730	10920	H	Y		
Onward	1861	American	730	10920	H	Y		
Onward	1864	American	730	10921	H	Y		
Onward	1865	American	730	10921	H	Y		
Onward	1866	American	730	10921	H	Y		
Onward	1867	American	730	10921	H	U		
Onward	1870	American	730	10923	H	N		
Oriole	1865	American	735	10971	H	Y		
Oriole	1868	American	735	10972	H	M		
Orion	1853	French		30552	H	Y		
Oscar	1853	American	2118	11025	H	Y		
Oscar	1854	American	2118	11025	H	N		
Pacific	1860	American	530	11147	O	U		
Pacific	1861	American	530	11147	H	Y		
Page	1865	American	2134	17056	H	M		
Page	1866	American	2134	17057	H	Y		
Paulina	1859	American	543	11321	H	Y	11	L
Paulina	1860	American	543	11321	H	Y	8	L
Paulina	1861	American	543		O	U		
Pearl	1864	American	2158	11341	H	Y		
Pfeil	1857	Hawaiian			O	N		
Phenix	1853	American	526	11538	O	N		
Phenix	1858	American	526	11539	O	N		
Philip	1861	American	2183	11567	H	Y		
Phoenix	1853	American			H	N		
Phoenix	1860	American	2188	11631	H	Y		
Phoenix	1861	American	2188	11631	H	Y		
President	1867	American	548	11927	H	Y		
Prince de Joinville	1856	American	2241	11986	H	Y		
Progress	1868	American	554	11989	O	M		
Progress	1873	American	554	11990	O	N		
Rajah	1853	American	576	12111	H	N	0	L
Rajah	1854	American	576	12111	H	N	0	L
Rambler	1857	American	588	12125	H	U		
Rambler	1859	American	588	12125	H	Y		
Rebecca Sims	1858	American	574	12204	H	N		
Rebecca Sims	1859	American	574	12204	O	N		
Reindeer	1858	American	574	12219	O	Y		
Reindeer	1859	American	589	12219	H	Y		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Reindeer	1862	American	589	12220	H	Y		
Reindeer	1863	American	589	12220	H	Y		
Reindeer	1866	American	589	12221	H	Y		
Reindeer	1867	American	589	12221	H	Y		
Reindeer	1868	American	589	12221	H	Y		
Revello	1854	Chilean			O	N		
Richard Mitchell	1854	American	2288	12296	H	N		
Richmond	1864	American	573	16962	H	Y		
Richmond	1866	American	573	16966	H	Y		
Ripple	1860	American	2295	12348	H	Y		
Robert Edwards	1856	American	575	12424	O	M		
Robert Edwards	1861	American	575	12425	H	Y		
Robert Morrison	1853	American	586	12430	H	Y		
Robin Hood	1861	American	2305	12445	H	Y		
Roman	1853	American	579	12469	H	N		
Roman	1857	American	579	12470	H	M		
Roman	1858	American	579	12470	H	Y	10	L
Roman II	1853	American	580	12482	H	Y		
Roscoe	1867	American	564	12571	O	M		
Rousseau	1855	American	578	12623	H	N		
Rousseau	1858	American	578	12624	O	U		
Rousseau	1867	American	578	12626	O	U		
S. F. Constantin	1860	Russian			O	Y		
S. H. Waterman	1853	American	2327	12689	H	Y		
Sarah	1846	American	2358	12867	H	N		
Sarah	1861	American	2359	12858	H	M		
Sarah McFarland	1856	American	2351	17043	H	Y		
Sarah McFarland	1861	American	2351	17043	H	M		
Sarah Sheafe	1858	American	617	12947	O	Y		
Sarah Warren	1858	American	2354	12957	H	Y		
Sarah Warren	1859	American	2354	12958	H	Y		
Sarah Warren	1860	American	2354	12958	H	Y		
Sarah Warren	1861	American	2354	12959	H	Y		
Sarah Warren	1862	American	2354	12960	H	Y		
Sarah Warren	1863	American	2354	12961	H	Y		
Sarah Warren	1864	American	2354	12961	H	M		
Saratoga	1854	American	614	12964	H	N		
Saratoga	1855	American	614	12964	H	N		
Saratoga	1858	American	614	12965	O	Y	14	L
Scotland	1859	American	618	12979	H	Y	6	L
Scotland	1861	American	618		O	U		
Sea Breeze	1867	American	628	12991	H	Y	11	L
Sea Breeze	1868	American	628	12991	H	Y	14	L
Sea Breeze	1869	American	628	12991	H	N		
Sea Breeze	1870	American	628	12991	O	M		
Sea Breeze	1871	American	628	12991	H	U		
Seine	1860	American	610	13102	O	U		
Seine	1868	American	610	13105	O	N		
Sharon	1860	American	2382	13146	H	Y		
Sharon	1861	American	2382	13146	H	Y		
Sheffield	1850	American	2384	13152	O	U		
Sheffield	1856	American	2384	13153	H	Y		
Sheffield	1858	American	2384	13153	H	U		
Sophie	1860	Undetermined			H	M		
South America	1858	American	620	13265	O	Y	2	L
Speedwell	1858	American	2414	13328	O	N		
Speedwell	1861	American	2414	13328	H	Y		
Splendid	1857	American	2420	13348	H	Y	14	L
Splendid	1858	American	2420	13350	O	Y		
Splendid	1867	American	2420	13350	O	U		
St. George	1854	American	591	13366	O	N		
St. George	1866	American	591	13368	H	Y		
St. George	1867	American	591	13368	H	Y		
Superior	1855	American	616	13550	H	N		
Susan Abigail	1864	American	13601		H	Y		
Susan Abigail	1865	American	2451		H	Y		
Tamerlane	1861	American	656	13695	O	N		
Tamerlane	1864	American	656	13696	H	Y		

continued

Appendix (continued)

Vessel	Season	Nationality	Ves	Voy	VS	GW	EGW	LS
Tempest	1860	American	2480	13747	H	Y		
Tenedos	1854	American	2481	13755	H	Y		
Tenedos	1855	American	2481	13755	H	Y		
Thomas Dickason	1858	American	657	13797	H	Y		
Thomas Dickason	1863	American	657	13798	H	Y	13	L
Thomas Dickason	1864	American	657	13798	H	Y		
Thomas Dickason	1865	American	657	13798	H	N		
Thomas Dickason	1866	American	657	13799	H	N		
Thomas Dickason	1870	American	657	13801	H	Y		
Three Brothers	1867	American	662	13948	H	Y		
Tiger	1847	American	2501	13970	H	Y	16	L
Trader	1869	Undetermined			H	M		
Trescott	1847	American	2505	14013	H	Y		
Trescott	1848	American	2505	14013	H	Y		
Trident	1869	American	651	14044	O	M		
Trident	1870	American	651	14044	O	U		
Two Brothers	1853	American	648	14200	H	N	0	L
Tybee	1858	American	2521	14213	O	N		
Uncas	1853	American	665	14237	H	Y		
Union	1854	Undetermined			O	N		
United States	1846	American			H	Y	10	N
United States	1847	American			H	Y		
Valparaiso	1854	American	671	15089	O	N		
Venezuela	1853	American	2552	17038	H	Y		
Vesper	1854	American	2557	15129	H	Y		
Vesper	1861	American	2557	15133	H	Y		
Victoria	1858	Hawaiian			H	Y		
Victoria	1859	Hawaiian			H	Y		
Victoria	1860	Hawaiian			H	Y		
Victoria	1862	Hawaiian			H	Y		
Victoria	1863	Hawaiian			H	Y		
Victoria	1864	Hawaiian			O	Y		
Vigilant	1858	American	672	15162	H	Y		
Vineyard	1868	American	2564	15180	O	N		
Walter Clayton	1853	American			H	N		
Warren	1858	American	691	15326	O	Y		
Warsaw	1846	American	2583	15346	H	N		
Waverly	1865	American	688	15471	H	M		
Whampoa	1859	Undetermined			H	Y		
William C. Nye	1853	American	684	15626	H	N	0	L
William C. Nye	1863	American	684	15633	H	Y		
William C. Nye	1865	American	684	15633	H	Y		
William Gifford	1866	American	693	15636	H	Y		
William Gifford	1867	American	693	15636	H	Y		
William T. Wheaton	1852	American	2621	15717	O	M		
William T. Wheaton	1853	American	2621	15717	H	N		
William T. Wheaton	1855	American	2621	15717	H	M		
William Tell	1856	American	2622	15725	H	N		
Winslow	1854	French		30557	H	M		
Winslow	1865	French		30597	O	M		
Winslow	1866	French		30594	H	M		
Winslow	1867	French		30594	H	N		
Zone	1865	American			H	M		
Zoroaster	1853	American	700	15934	O	N		
Zuid Pool	1848	Dutch			O	Y		