HUBBS MARINE RESEARCH INSTITUTE

MARINE SCIENCES
ENVIRONMENTAL CONSULTING
AQUACULTURE
BIOACOUSTICS

A Study of Past and Current Uses by Endangered Whales of Waters in and near the St. George Basin, Alaska

Contract NA-82-RAC-00039
Technical Report No.85-186

Final Report

1700 SOUTH SHORES ROAD, SAN DIEGO, CALIFORNIA 92109

A Study of Past and Current Uses By Endangered Whales of Waters in and near the St. George Basin, Alaska

Final Report to

National Oceanic and Atmospheric Administration
National Ocean Service
Office of Oceanography and Marine Assessment
Ocean Assessments Division
Alaska Office
701 C. Street
P.O.Box 56
Anchorage, Alaska 99513

on

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Submitted By
Hubbs Marine Research Institute
1700 South Shores Road
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Edited by

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From Contributions by

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I. INTRODUCTION

There is significant public concern that activities associated with the exploration, development and transport of oil and gas resources will work to the detriment of the environments in which they occur. That concern has precipitated a major commitment by the responsible government agencies to support research programs designed to: a) assess the status of biological communities in selected study areas; b) predict effects on those communities, and on the environment as a whole, of planned resource development, and; c) suggest mitigating measures to permit resource development and fragile or threatened portions of the marine environment to co-exist peacefully. Inherent in this last objective is the understanding that some animal populations are at present depleted, so that consideration of the effects of development must take into account the ability of the population(s) to recover to former levels of abundance. Obviously, this requirement also dictates that some work be directed towards determining those former levels, whenever possible, and towards elucidating what factors other than the resource development might affect the ability of the species to recover, especially given the present condition of its habitat (e.g. depletion of food stocks, expansion of competing species, human uses of the environment, pollution).

In February 1982, anticipating the leasing of tracts in the eastern Bering Sea and Shelikof Strait, Alaska, The National Oceanic and Atmospheric Administration (NOAA), Office of Marine pollution Assessment (OMPA), Outer Continental Shelf Environmental. Assessment Program (OCSEAP)[1], issued a contract to this institute to conduct a series of eight semi-seasonal surveys for marine mammals in the southeastern Bering Sea (south of latitude 62N and east of longitude 174W) and in Shelikof Strait. The results of those surveys, conducted between March 1982 and April 1983, and of a review of other information available on cetaceans occurring in the area, are reported by Leatherwood, Bowles and Reeves (1983). Basically, that study indicated that there were few great whales in the study areas during the periods of the surveys, even in regions where great whales of several species were formerly present in numbers sufficient to support major and protracted whaling efforts. In particular, the authors found surprising the small number of sightings within the hunting radii of whaling stations which operated at Akutan, a small island in the eastern Aleutians, from 1912 through 1939, and at Port Hobron, on Sitkalidak Island off the southeast coast of Kodiak Island, from 1926 through 1937 (these stations took at least 6,188 and 2,35'7 whales, respectively, during their years of operation). Because of some important known limitations to the 1982-83 surveys there was concern that the low density of sightings might have been an artifact of inadequate survey coverage (the study areas contained over

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[1] Responsibility for this original contract and its continuation were subsequently transferred to NOAA, National Ocean Service (NOS), Office of Oceanography and Marine Assessment, Ocean Assessment Division, Alaska Office, 701 C Street, Anchorage, AK.

20,000 square nautical miles of ocean surface) under inhospitable survey conditions (many of the surveys were flown under conditions of Beaufort 5 and above, when the probabilities of seeing animals were much reduced)? a sign of highly localized whale distribution, or evidence of severe population depletion. Therefore, before it was concluded that these areas of western and southwestern Alaska scheduled for development were of little importance to endangered whales it was considered prudent to examine selected portions of each area in greater detail. In selecting such areas the criteria were a) that historical data were available to indicate past relative abundance and seasonality of species of interest and b) that logistics and other limiting factors would permit adequate coverage on new surveys.

In the review of data available on cetaceans of the southeast Bering Sea and Shelikof Strait, Leatherwood et al. (1983) reported results of a preliminary review of data on the effort and catches of the Akutan and Port Hobron whaling stations. The data were contained in the William S. Lagen collection at the University of Washington Libraries and were heretofore unanalyzed. It was felt that a thorough analysis of those data could provide insight on former abundance of endangered whales in and near the St George Basin, help determine whether by the late 1930's the whales in those regions had been depleted by whaling (as evidenced by changes in catch-per-unit-of-effort) , and guide us in planning an intensive, stratified field survey of the former whaling grounds in summer 1984, at the peak season of former whaling activity. Accordingly, on 29 September 1983, the institute was awarded a continuation of the original contract, effective through 1984. The goals of the extension were to:

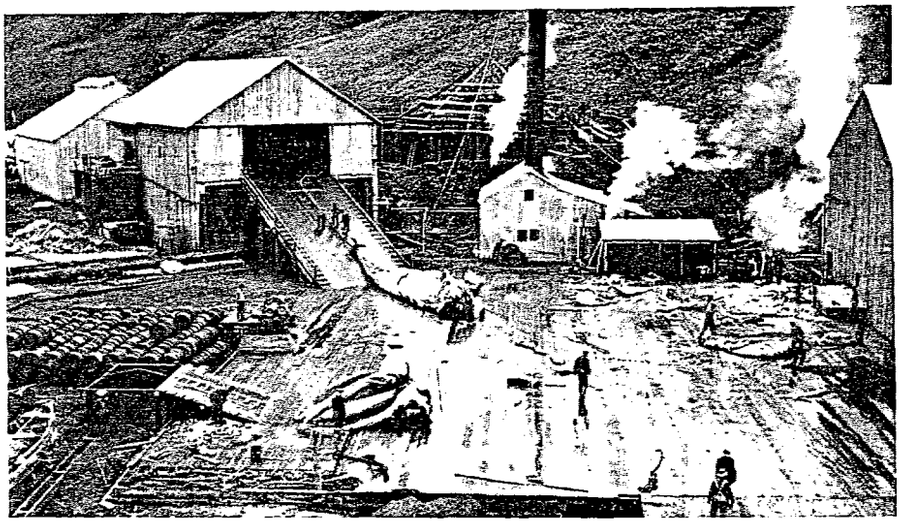
a) conduct aerial surveys to determine distribution and abundance of endangered whales in and near the St. George Basin, late summer and early fall;
b) correlate the above defined distribution and abundance with environmental and oceanographic conditions;
c) compare the above data with those from 1982-83 surveys with available data on historical distribution and abundance in and adjacent to the study area; and
d) report observed distribution and abundance of other marine mammals in the study area.

The review and analysis of the historical data were conducted in 1983 and 1984. The aerial survey was conducted in July and August 1984. Because the subtasks on this project fall into three more-or-less discrete topics, they are presented here as three separate manuscripts, each prepared for and submitted to referreed journals for publication. By presenting the results of this work in this manner we have hoped to make them available for use and citation by colleagues much sooner than would have been possible if they had been presented solely as a 'gray literature report. Each manuscript has been peer reviewed and incorporates reviewer suggestions. The" status of each is described in introductory remarks preceding it.

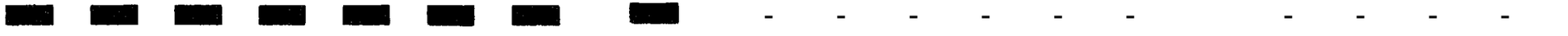
Complete sets of the data used in the research reported in these papers have been filed with the MMS Anchorage Office, National Ocean Data Center, (NODC), the National Marine Mammal Laboratory, in Seattle, Washington, and the International Whaling Commission (IWC). The original sources, including journals, notes, photographs, etc. have been deposited at the Alaska Historical Library, Juneau, Alaska.

11. HISTORY OF SHORE WHALING AT AKUTAN AND PORT HOBRON, ALASKA (1912-1939)

The report on this portion of subject contract was submitted to the sponsor in May 1984 and was subsequently presented as Documenmt SC/36/O 7 at the 35th annual meeting of the International Whaling Commission's (IWC) Scientific Advisory Committee, held in Eastbourne, U. K. from 24 May through 14 June 1984. A revised version, incorporating review comments from the sponsor, from anonymous reviewers for W, and from anonymous reviewers for IWC, was published in March 1985. A reprint is included here.



The flensing deck at the Akutan, Alaska whaling station, date unknown. The stripped carcass of a partially processed rorqual is on the ramp to the boilers; its skull and jaws are at the lower left. (Photo from Univ. Wash., Suzzalo Library Historical Photography Collection: Whales and Whaling-Ab-21 [Akutan, AK], courtesy Dr. Victor B. Scheffer).



SC/36/O 7

Whaling Results at Akutan (1912-39) and Port Hobron (1926-37), Alaska

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ABSTRACT

Modern whaling stations operated at Akutan, Alaska. from 1912 to 1939 and at Port Hobron, Alaska. from 1926 to 1937. Unpublished records of the American Pacific Whaling Company. deposited in the Manuscripts and University Archives Division of tbe University of Washington libraries (Seattle. Washington, USA). together with a variety of other sources. were used to compile information on the catch at these two stations. It consisted mainly of blue (*Balaenoptera musculus*), fin (B. *physalus*). humpback (*Megaptera novaeangliae*). and sperm (*Physeter macrocephalus*) whales. The whaling season lasted from May to October. Akutan whaling was carried out on both the Bering Sea and Pacific Ocean sides of the Aleutian chain. as well as iUnimak Pass. Port Hobron whaling took place mainly- off the southeastern shores of Kodiak and Afognak islands. Both sexes were well represented in the catch of mysticetes. but the sperm whale catch consisted almost entirely of males. Tbe sperm whales taken at Akutan were significantly larger rhan those taken at Port Hobron.

Although a high proportion of the eastern Pacific stock of gray whales (*Eschrichtius robustus*) uses Unimak Pass as a spring and autumn migration corridor. only four were caught. all at Port Hobron. Right whales (*Eubalaena glacialis*) were rarely encountered on the whaling grounds but were chased at every opportunity before 1935, when international protection of the species came into force. Twenty-one right whales were landed at Pnrt Hobron and Akutan from 1916 to 1935.

A small percentage of whales struck with an explosive harpoon escaped when gear broke or the harpoon drew nut of the body. In addition. some killed whales were never delivered [o [be station. An attempt was made to estimate the magnitude of this struck-but-lost component, using detailed entries in catcher-boat logs. A loss rate factor of 1.02 was calculated.

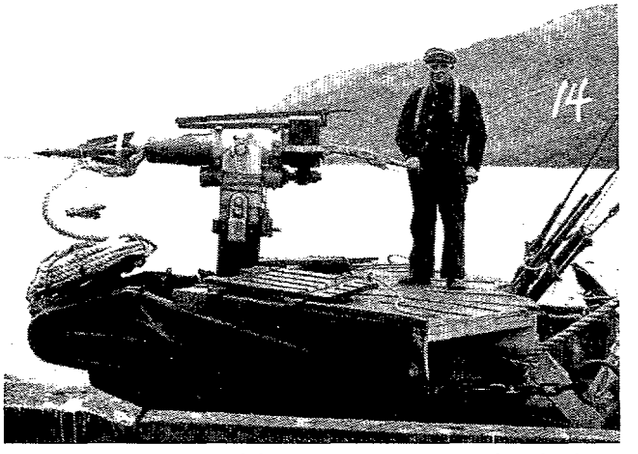
An evident declining trend in the catch of blue whales at Akutan indicates a decrease in stock size during the course of this fishery. However. this stock and others fished at Akutan and Port Hobron were also being exploited elsewhere in their range. Thus, any interpretation of the causes of trends in availability of whales at these two stations must take into account a much broader catch history than is recounted here. A full analysis of catch-per-unit-of-effort at Akutan (1926–39) is reported elsewhere.

INTRODUCTION

With the development of modern whaling techniques in Norway during the late nineteenth century (Fig. 1). a global initiative was begun. Shore whaling stations were established to exploit whale stocks in all the world's oceans during the 1890's and the first third of the twentieth century (Tønnessen, 1967-70; Tønnessen and Johnsen, 1982). The stations at Akutan, a small island in the eastern Aleutians. and Port Hobron. on Sitkalidak Island off the southeast coast of Kodiak Island (Fig. 2). were two of less than a dozen modern whaling stations that operated in Alaska and British Columbia (Bower and Fassett, 1914: Kellogg. 1931; Kirchhoff. 1984).

Basic data on the number of whales caught at the Alaska whaling stations, by year and for some years by species, have been presented in various publications. Among the most notable of these are *Pacific Fisherman* and *Pacific Fisherman Yearbook* [which were often in turn summarized in *Norsk Hvalfangst- Tidende):* annual reports called *Alaska Fisheries* and *Fur Industries* (later called *Alaska Fishery and Fur-Seal Industries)* published by the Bureau of Fisheries. U.S. Department of Commerce: and *International Whaling Statistics* published in Oslo, Norway. by the Committee for Whaling Statistics. A good description of the techniques. products and markets of shore whaling in Alaska was given in *Pacific Fisherman (1914, 12[6]:* 15-16). Partial summaries of the catches have been given by Kellogg (1931). Tønnessen (1967-70. pp. 553-4, footnote 35). and Tønnessen and Johnsen (1982, Table 45). Thompson (1940) reported the stomach contents of whales taken at Akutan in 1937–38 and at Port Hobron in 1937. However. no complete and detailed summary or analysis of the biological characteristics, seasonal availability. and trends over time of the whales caught at Akutan and Port Hobron has been published.

Our own interest in these data stemmed from a field census conducted in 1982 and 1983 to document the current status of large cetaceans in the southeast Bering Sea and Shelikof Strait (Leatherwood, Bowles and Reeves, 1983). The small number of sightings made during the eight semi-seasonal aerial surveys was considered surprising in view of the fact that the hunting radii of the Akutan and Port Hobron stations fell partially inside or very near the two study areas. Was this an artifact caused by inadequate survey coverage, a sign of highly localized whale distribution, or evidence of severe population depletion?



Fig, 1, Gunner posing with harpoon cannon on bow of catcher boat, American Pacific Whaling Co, dock at Akutan, Alaska, (US Coast Guard Photograph #14: Alaska Historical Library. Album #26-G-150D-10A).

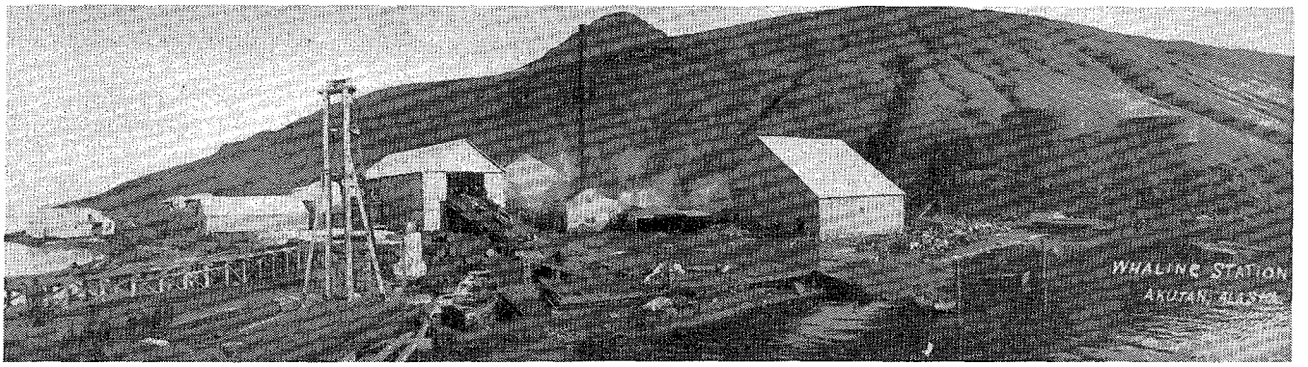


Fig. 2a. The whaling station at Akutan. (Alaska Historical Library).

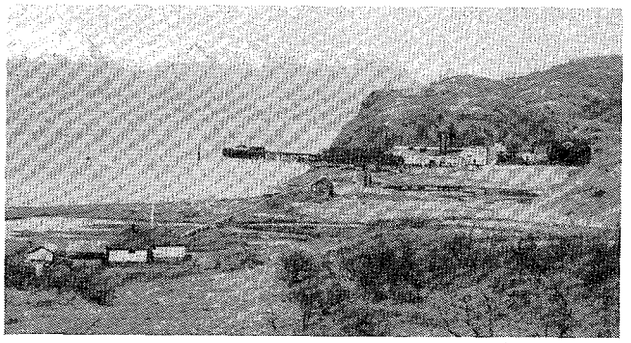


Fig. 2b. The whaling station at Port Hobron. (Alaska Historical Library).

The sponsoring agency, National Ocean Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, was interested in knowing the geographic and seasonal distribution and relative abundance of whales in the study areas so that the potential could be assessed for interaction between whales (especially 'endangered' species) and activities related to oil and gas development on the outer continental shelf. Explicit support for an analysis of the Akutan whaling data was provided for three main purposes: (1) to guide us in planning an intensive, stratified field survey of the former whaling grounds in summer 1984 (Stewart, Yochem, Karl and Leatherwood, 1985Ms), (2) to provide insight on where and when concentrations of whales formerly occurred, and (3) to help determine whether, by the late 1930's the populations of large whales in the region had been depleted by whaling, as evidenced by changes in catch-per-unit-of-effort at the Akutan station.

DATA SOURCES

William S. Lagen, heir to the American Pacific Whaling Company, donated the records of the Lagen family's whaling businesses, including American Pacific Whaling Co. and Consolidated Whaling Corp., to the University of Washington Libraries, Seattle, in 1974. They are cataloged and retained in the manuscripts and University Archives Division (MUAD) at Suzzallo Library, and known there as the William S. Lagen Collection (Accession No. 2292). In this paper we cite the collection as 'WSL Coil.' and, where appropriate, refer specific materials to the labeling and numbering system used in the guide and inventory prepared by staff of the MUAD.

Lagen assured us during phone conversations in May 1984 and during an interview in Bellevue, Washington, 11 July 1984, that no additional materials, other than photographs, are in his personal collection which are pertinent to the present study. Searches were made for additional material in the Alaska and Polar Regions Department, Elms E. Rasmuson Library, University of Alaska (Fairbanks), U.S. Department of Interior Alaska Resources Library (Anchorage), Alaska State Archives and Museum (Juneau), Alaska Historical Library (Juneau), and U.S. National Museum (Washington, D.C.). The historical photograph collections of the Alaska Historical Library and University of Washington Libraries were especially rich sources of photographs.

The important unpublished material available for this study consisted of the following:

1. Catcher-Boat Logs

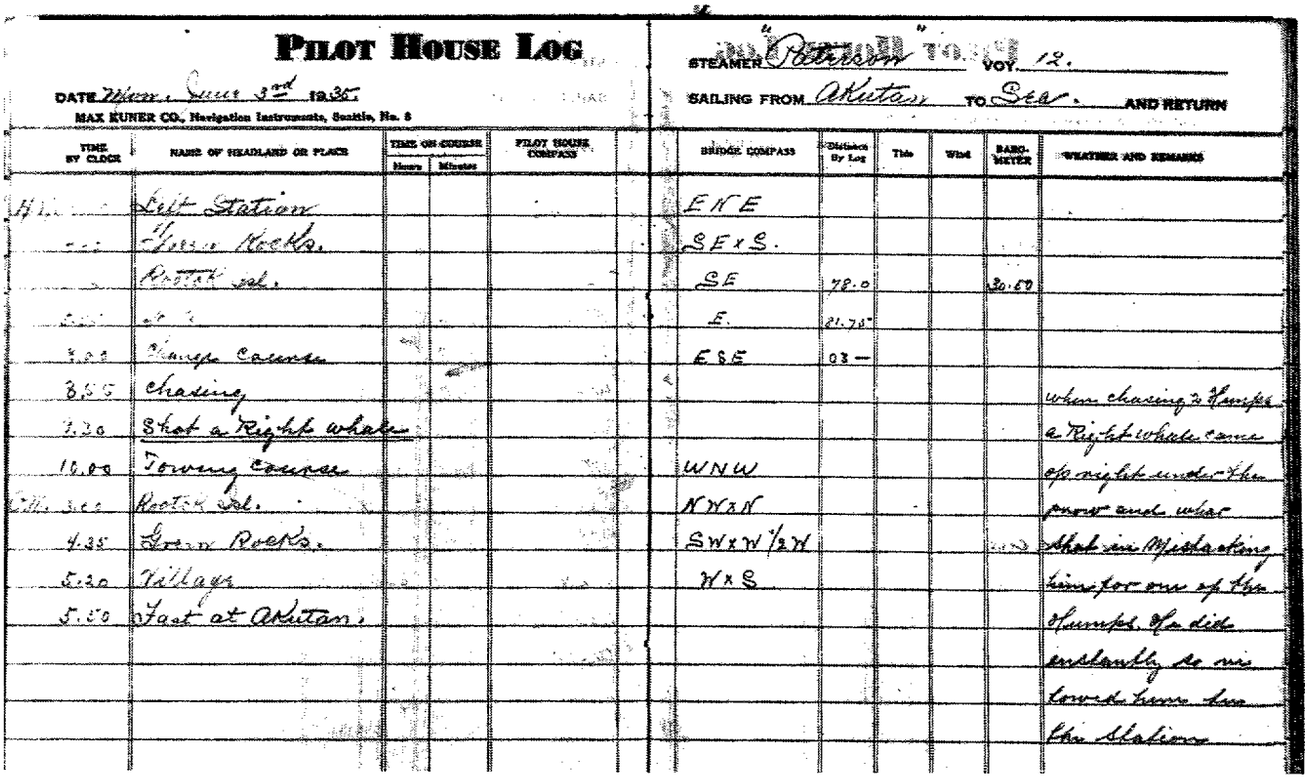
Pilot-house logbooks kept aboard catcher boats are available for Akutan (1917, 1920, 1923–24, 1926-30, 1934-39) and Port Hobron (1926-29, 1932–37) (boxes 7–11, WSL Coil.). These logbooks cover approximately two-thirds of the total whaling effort at Akutan after 1923 and at Port Hobron from 1926 to 1937. Logbooks were apparently maintained by the vessel's captain or another senior officer. They generally include notations, by time, of vessel activity (e.g. search, chase, tow, drift), shots at whales, kills, and retrievals (Fig. 3). Weather conditions, relative speed of vessel (e.g. slow, half speed, full speed), and headings are also noted. A few of the more detailed logbooks contain additional information on sightings and on difficulties experienced in securing struck whales and delivering them to the station.

2. *Station Tallies*

Handwritten tables, presumably compiled by the station manager for company use, contain information on each whale taken, as follows: date received at station, date killed, vessel, species, sex, total length, sex and length of fetus if present, location of kill (usually expressed as bearing and distance from a landmark), and for 1937 and 1938 only, stomach contents (see Thompson, 1940) (Fig. 4). These station tallies are available for the years 1924-30 and 1934–39 at Akutan and 1926-30 and 1932–37 at Port Hobron (Oversize, Catch Records, 1924-39, WSL Coil.).

3. *Weekly Manufacturing Reports*

A bound set of company forms contains weekly reports on whales taken, by vessel and date; production from caught whales; amount of whale products on-hand and shipped



PILOT HOUSE LOG

DATE Wed. June 3rd 1936.

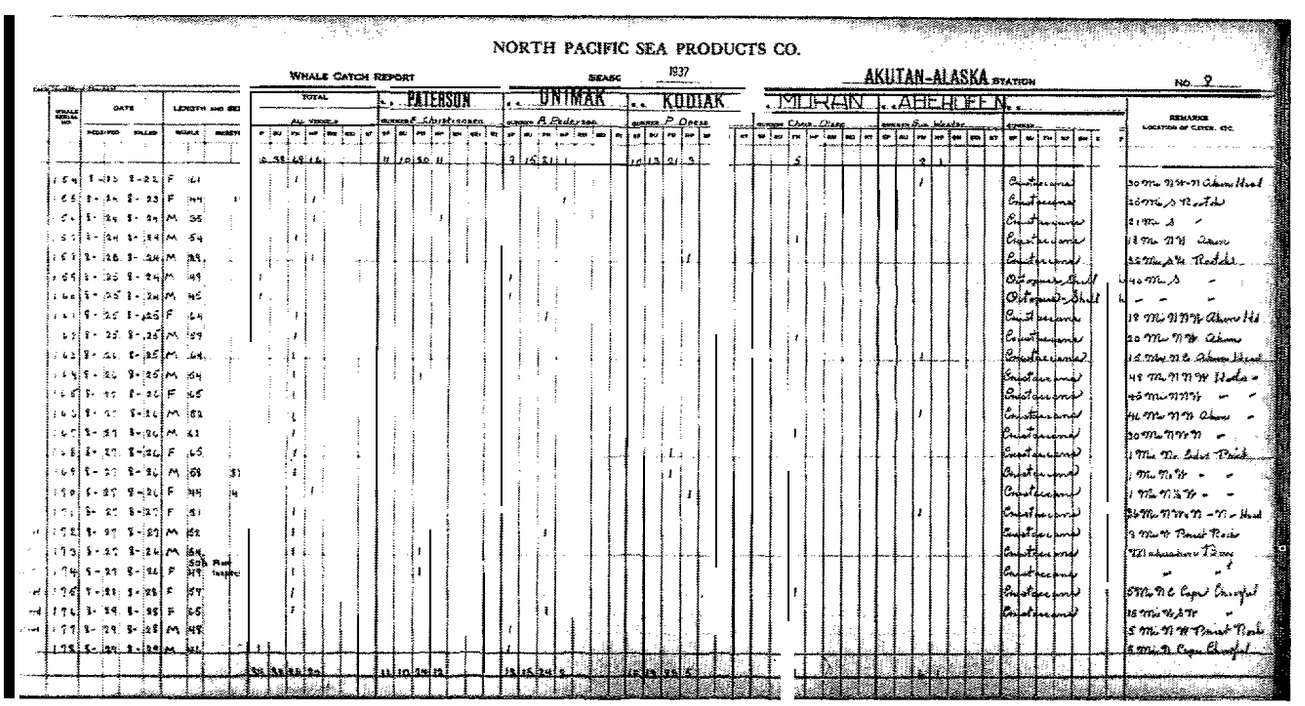
MAX KUNER CO., Navigation Instruments, Seattle, No. 8

STEAMER "Paterson" No. [illegible] VOY. 12.

SAILING FROM Akutan TO Sea. AND RETURN

TIME BY CLOCK	NAME OF HEADLAND OR PLACE	TIME ON COURSE Hours	TIME ON COURSE Minutes	PILOT HOUSE COMPASS	BRIDGE COMPASS	Distance By Log	Tide	Wind	BAROMETER	WEATHER AND REMARKS
H[illegible]	Left Station				ENE					
[illegible]	Sea Rocks.				SE x S.					
[illegible]	Protar Isl.				SE	78.0			30.69	
[illegible]	[illegible]				E.	21.75				
[illegible]	Pumps Common				ESE	03 —				
3.55	Chasing									when chasing 3 Pumps
7.30	Shot a Right whale									a Right Whale came
10.00	Towing compass				WNW					off right under the
[illegible]	Protar Isl.				NW x N					prow and what
4.35	Sea Rocks.				SW x W 1/2 W					Shot in Mistaking
5.20	Village				W x S					him for one of the
5.50	Fast at Akutan.									Humps. He did
										evidently see us
										towards Sunset Cove
										the Station

Fig. 3. Page from an Akutan catcher-boat log. (Courtesy of Manuscripts and University Archives Division. University of Washington Libraries).



NORTH PACIFIC SEA PRODUCTS CO.

WHALE CATCH REPORT SEASON 1937 AKUTAN-ALASKA STATION NO. 9

PATERSON (Master E. Sjostrand) UNIMAK (Master A. Peterson) KODIAK (Master P. Olsen) MURRAY (Master Chas. Olsen) AHEHUEEN (Master Sam Wesley)

Fig. 4. Page from an Akutan station tally. (Courtesy of Manuscripts and University Archives Division, University of Washington Libraries)

south: vessel activity expressed as time and date of arrival and departure from the station; weekly weather reports: and remarks by the station manager (Oversize. Catch Records, 191%39. WSL Coll.). These reports cover the years 191%20. 1922–30 and 1934–39 for Akutan and 1935–37 for Port Hobron.

4. *Production and Catch Summaries*

A set of tables. partly typed and partly handwritten. contains data for Akutan on total oil production (1917–23), total whale catch (1917–23). and catch by vessel. by day. and by species (1917–19) (Box 11, WSL Coil.),

5. *General Correspondence*

In general correspondence of the American Pacific Whaling Company we found documents containing details on the catch at both stations in 1937 and at Akutan in 1938 (Boxes 1-3. WSL Coll.). In addition. we found typed tables showing the total whales caught. by year and by month. at Akutan (1914-36) and Port Hobron (1926-36).

Table 1

Catch of whales at Akutan whaling station, Alaska, 1912-1939. n = number of catchers, Hump = humpback whales, Ri = right whales and Sp = sperm whales

Year	Operation period[1]	n	Blue	Fin	Hump	Ri	Sp	Other	Total
1912	3 June-21 Oct.	2		162	148				310[2]
1913	Not operating								
1914	? -early Oct.	2							307[2,3]
1915	early May-30 Sep.	2							307[4,5]
1916		3							237[5,6]
1917	16 May-3 Oct.	3[7]	131	115	23	1	15		285[7]
1918	19 May-16 Oct.	4[7]	79	150	58		23		310
1919	22 May-4 Oct.	4	54	211	125		29		419
1920	4 May-14 Oct.	4	62	138	67		23	1[9]	291
1921	Not operating[10]								
1922	29 April–25 Oct.	3	53	178	87		7		325
1923	1 May-16 Oct.	4	29	151	155	2	16	2[11]	355
1924	17 May-8 Oct.	4	48	148	71	1	17		284
1925	24 May-8 Oct.	6	36	235	191	1	33		496
1926	24 May-2 Oct.	7	16	175	146	1	1		339
1927	27 May-3 Oct.	4	21	85	98	1	3		208
1928	26 May-28 Sep.	4	36	51	42		16	1[12]	146
1929	28 May-19 Ott.	4	26	79	45	1	9		160
1930	27 May-21 Sep.	7	53	29	13		32		127
1931	Not operating[13]								
1932	Not operating[13]								
1933	Not operating[13]								
1934	25 May-2 Oct.	5	29	154	27		18		228
1935	15 May-3 Oct.	4	53	61	104	1	38		257
1936	22 Nay-1 Oct.	4	29	107	11		50		197
1937	12 May-1 Oct.	5	42	113	61		40		2%
1938	2 June-6 Oct.	5	33	65	12		63		173
1939	8 June-10 Oct.	3	5	91	26		49		171
Totals			835	2498	1510	9	482	4	6188

[1] From some years, based on span of catch dates in station tallies and other sources; may under-represent actual period of operation, as boats were often whaling for several days before catching the first whale and for several days after catching the last whale.

[2] All catches in 1912 and 1914 were in the Bering Sea. In 1912 the *Admiralen,* a floating factory, also operated at Akutan, 3 June-21 October (Chamberlain and Bower, 1913, pp. 67–71; Tønnessen and Johnsen, 1982, p. 121; *Pacific Fisherman 1913,* 11 [1]: 79).

[3] Catches not differentiated to species. Combined total for Akutan and Port Armstrong on SE Baranof Island, was 482 whales, consisting of 43 sperm, 35 blue, 259 fin, 131 humpback and 14 'other' (Bower and Aller, 1915). Of these, 151, including all 43 sperms, were taken at Port Armstrong (*Pacific Fisherman Yearbook,* Jan. 1915: 108). At Akutan, 307 whales had been taken by the end of September (General Correspondence file, Boxes 1–3, WSL Coil,). Total catches are given as 462 (155 + 307) and 505 on the same page (p. 108) of the *Pacific Fisherman Yearbook.* We suspect this inconsistency may be, at least partially, due to inclusion of some belugas, *Delphinapterus leucas*, in the summary table, *Pacific Fisherman (1914, 12[12]: 24)* indicates the season's catches at Akutan were 172 bv the *Unimak* and 135 bv the *Kodiak.*

[4] Catches not differentiated to species. Combined total for Akutan and Port Armstrong was reported as 470 (Bower and Aller, 1917a, p. 64) and 530 (*Pacific Fisher'man Yearbook,* Jan. 1916: 109), including 25 sperm, 53 blue, 239 fin and 153 humpback. The higher total probably includes some behrgas, Prior to September, almost the entire catch at Akutan was of fin and humpback whales (Birkeland, 1926, pp. 131-6).

[5] Totals only through end of September; may have been additional catches in October.

[6] Total catch for Alaska shore whaling given as 389, including 1 bowhead (*Balaena mysticetus*), *20* sperm, 64 blue, 161 fin, 121 humpback, 1 right and 21 sei (Bower and Aller, 1917b, p. 74). Only the Akutan and Port Armstrong stations were operating, but the bowhead was presumably taken somewhere farther north. At least 12 sperm whales taken at Akutan, the first ever taken there; also 'quite a few' blue whales were taken at Akutan, only 2 having been taken there in previous years *(Pacific Fisherman 1916, 14[9]: 34).*

[7] The *Halcyon,* a small (61 ton) power schooner used by North Pacific Sea Products in 1917 and 1918 'in whaling and exploring in the vicinity of Akutan' was lost in a storm in late Nov. 1918 *(Pacific Fisherman 1981, 16[12];* also see Bower and Aller, 1918, p. 51; Bower, 1919, p. 52).

[8] Total catch for Alaska shore whaling said to have included 2 bowheads and 26 whales not identified to species (Bower and Aller, 1918, p. 52).

notes continued on right

6. Reports of Whales Caught and Production

Tables showing the whales caught, by species and by week, as well as some information on oil, fertilizer, and bonemeal production and weather or operating conditions, are available for Akutan (1918-20) (Oversize, Catch Records, 1918-24, WSL Coil.); for Akutan (1920, 1922–27) and Port Hobron (1926--27) (Oversize, Catch Records, 1920-27, WSL Coil.); and for Akutan (1934-39) and Port Hobron (1934-37) (Oversize, Catch Records, June 1934-October 1939, WSL Coil.). These tables were not used as a source of any of the information presented in this paper.

7. Bureau of Fisheries Reports

The Bureau of Fisheries, U.S. Department of Commerce, solicited whaling reports from Akutan in at least 1937. Forms, completed by hand and signed individually by a U.S. Coast Guard inspector, requested the following: whale serial number, date killed and date received at the station, sex, length, sex and length of fetus, vessel, name of gunner, species, stomach contents, location of catch and remarks. Completed forms must exist for other years, but we have obtained copies of only the 1937 Akutan forms (International Marine Archives, microfilm item No. 596B, Whaling Museum Library, Old Dartmouth Historical Society, New Bedford, Massachusetts).

8. International Whaling Statistics Forms

For at least the years 1937–39, forms were completed for submission to the Association of Whaling Companies, Sandefjord, Norway. The long forms requested the following information: date, species, length, sex, stomach contents, reproductive status of females (pregnant or not), length and sex of fetuses and positions of kills. In addition to the long forms, summary forms requested information on monthly catches, by species and by vessel, as well as information on weekly production of oil and meal. We had available the completed forms for Akutan, 1937–39, and Port Hobron, 1937.

9. Coast Guard Inspector Report

A report on the 1938 whaling season at Akutan was prepared by the U.S. Coast Guard inspector, A. VanDeVenter (1938). In addition to a crude CPUE analysis of Akutan baleen whale data 1924-38 showing a decline in catch per boat-day from 0.45 in 1924 and 0.68 in 1925 to an 'all time low' of 0.16 in 1930, VanDeVenter made some comparisons of the 1938 Akutan catch with those from Port Hobron in 1937 and the S. S. *Frango's* Antarctic expedition in 1937. An attempt was made to determine lengths of fin whales (*Balaenoptera physalus*) at physical maturity by examination of the vertebral epiphyses. VanDeVenter also measured the girths of a small sample of blue whales *(B. musculus*) and commented on pregnancy rates of blue whales, fin whales and humpbacks (*Megaptera novaeangliae*). Procedures for specimen collection and preservation, as well as a list of photographs taken by VanDeVenter, are presented.

[9] Killer whale taken on 23 September by *Tanginak*; yielded 4 bbls oil (Weekly Manufacturing Reports, WSL CoIl.).

[10] Station closed 'owing to the unsatisfactory market for whale products' (Bower, 1922, p. 46).

[11] Reported as 2 bowheads by Bower (1925, p. 108), but reported initially in Weekly Manufacturing Reports as sei whales and later identified in the same sources as minke whales. Bower also listed one of the two right whales as a sei whale.

[12] One sei whale.

[13] 'Complete suspension of whaling operations' which was 'attributed to the low prices on whale oil' (Bower, 1932, p. 70).

METHODS OF DATA COMPILATION AND ANALYSIS

From all available sources. we compiled tables showing the catches at Akutan (Table 1) and Port Hobron (Table 2), by year and by species. Species other than those routinely reported in catch records were taken occasionally-e .g. minke whales (*Balaenoptera acutorostrata*) (Morgan, 1978, p. 37). killer whales (*Orcinus orca*) (Morgan. 1978. p. 36: Birkeland, 1926). and harbor porpoises (*Phocoena phocoena*) (Fig. 5). Killer whales, although common, were 'for the most part ignored' by the Akutan whalers (Birkeland. 1926, p. 24). We found no evidence that beaked whales (Ziphiidae) were seen on the whaling grounds. although sightings of 'Bottlenose' whales (probably Baird's beaked whales, *Berardius bairdii*) were reported at Naden Harbour (20 August 1938) and Rose Harbour (8-11 September 1935). British Columbia (oversize, Catch Records. 1935-43. WSL Coil.): a few Baird's beaked whales were taken at British Columbia shore stations (Pike and MacAskie, 1969).

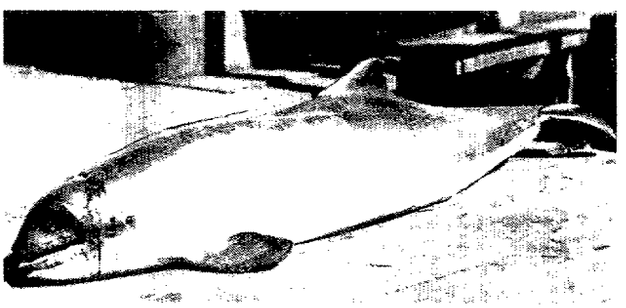


Fig. 5. This photograph of a harbor porpoise is labeled "'Dead whale (small) on pier [Akutan AK. fetus]". (Historical Photography Collection. University of Washington Libraries: Whales and J% 'haling-Whales #15).

Table 2

Catch of whales at Port Hobron whaling station. Alaska, 1926-1937. n = number of catchers, Hump = humpback w-hales. Ri = right whales and Sp = sperm whales

Year	Operation period'	n	Blue	Fin	Sei Hump	Ri	Grav	SD	Total
1926	17 July-31 Oct.	6		5	2%	1			242[2]
1927	24 May-9 Oct.	3	5	23	244				272[3]
1928	9 May-lo Oct.	3	15	47	178	6	2	8	256
1929	23 May-13 Oct.	3	27	26	169			3	225
1930	8 May-15 Aug.	3	25	21	178			4	228
1931	Not operating								
1932	17 May-23 Sep .	4	78	60	12?3	2		2	270
1933	26 June-n Sep.	3	1	61	114	1	2	3	182
1934	15 May-13 Sep.	3	15	78	2 139			3	.237
1935	7 May-26 Sep .	3	34	33	37	1		32	137
1936	25 Apr.-15 Sep.	3	12	53	107			16	188[4]
1937	6 May-13 Aug.	3	3	57	1 43			16	120
Totals		215	464	3	1573	11	4	87	2357

[1] For some years, based on the span of catch dates in station tallies: may under-represent actual period of operation, as boats were often whaling for several days before catching the firstwhale and for several days after catching the last whale.

[2] Note that in 1925. Captain Louis L. Lane took 1 fin whale and 15 humpbacks from the vessel *Gummar* in Prince William Sound and Cook Inlet and around Kodiak Island 'for sale as fox food to ranches along the coast' (Bower. 1926: 139).

[3] Note that floating factory Lansing was also operating this year near Kodiak Island with 3 catcher boats (Bower. 1928: 140).

[4] According to Bower (1938, p. 121) the Port Hobron statistics for 1936 mistakenly included 2 fin and 11 humpback fetuses.

The data from all available station tallies (Akutan, 1924-30. 1934-39; Port Hobron. 1926-30, 1932–37) were filed in a WICAT-150 computer at Hubbs Research Institute. Reported positions of catches were plotted on a chart and converted to latitude and longitude. In order to display the geographic distribution of catches graphically, the computer files were transferred to facilities at the Inter-American Tropical Tuna Commission in La Jolla, California, where the AMPS mapping package was used to plot catch locations. The resultant figures were examined for trends that might be tested statistically. Additional preliminary analyses consisted of (1) calculation of ranges, means. and standard deviations of lengths of whales caught, by species, sex and year, at each whaling station (Tables 3 and 4); and (2) examination of scatterplots of fetal lengths. by date, for blue, fin and humpback whales (Fig. 6).

Table 3

Body lengths by year, species and sex of blue, fin, humpback and sperm whales taken at Akutan 1924–1930 and 1934–1939. with range. mean and standard deviation (all measurements are in feet). Only animals for which length and sex were recorded are included. Source: Station tallies

Year		Blue M	Blue F	Fin M	Fin F	Humpback M	Humpback F	sperm' M
1924	n	2	5	2 2	79	69	28	43	17
	Range	43–81	66–86	42–64	40-66	27-46	28–48	50–60
	Mean	73.16	76.67	55.21	56.86	35.86	37.65	54.65
	SD	7.?8	5.67	5.60	7.47	5.62	6.20	3.20
1925	n	23	13	116	119	84	107	33
	Range	66–80	40–83	42–75	44-69	27-66	24–54	42–60
	Mean	73.%	73.38	55.86	59.00	37.48	37. 50	51.49
	so	3.99	11.39	5.57	5.87	5.83	5.64	5.12
1926	n	10	6	77	98	61	84	1
	Range	66–74	40–80	36–69	35-70	23–41	23-77	-
	Mean	71.03	63.67	53.90	56.14	32.70	34.02	-
	so	5.33	14.45	6.01	7.85	4.19	7.06	-
1927	n	12	9	38	46	4a	49	3
	Range	65-76	72-83	44-65	28-S7	26-42	21-543	41-50
	Mean	71.16	76.00	55.72	57.78	34.75	34.25	46.01
	SD	3.93	3.20	4.80	6.60	4.52	6.11	4.58
1928	n	21	15	20	31	19	23	16
	Range	66-85	65–82	3S-63	40-70	26-48	24-46	45-58
	Mean	73.10	75.13	52.60	54.42	36.63	37.03	51. %
	SD	4.56	4.60	6.46	8.01	7.33	6.79	4.35
1929	n	12	13	35	42	23	22	9
	Range	68–85	70-S4	40–65	48–73	20–51	26-48	50–61
	Mean	75.67	77.54	54.14	59.17	34.83	36.19	55.44
	SD	4.6s	4.08	5.90	6.50	5.s9	6.63	3.94
1930	n	35	17	10	18	6	7	32
	Range	68–85	72-84	42-69	44-72	30-46	28-44	42-W
	Mean	76.51	78.29	56. 80	58.06	39.67	37.86	50.22
	SD	3.44	3.46	7.12	6.70	5.85	6.64	5.39
1934	n	13	16	72	81	13	14	18
	Range	72-W	58–82	45–67	40–72	28–40	30–48	44-61
	Mean	76.69	76.13	57.18	57.96	33.09	38.43	53.22
	SD	2.32	7.29	5.04	6.38	2.90	5.98	5.57
1935	n	34	19	28	33	55	49	38
	Range	56-82	6%82	43–65	42–70	27–44	25–47	40–60
	Mean	74.62	77.68	52.39	58.39	36.04	38.04	50.32
	SD	4.61	3.25	5.75	6.58	4.50	5.20	4.86
1936	n	19	10	51	56	6	5	49
	Range	70-82	74–84	50–68	48-70	%-44	36-46	42–60
	Mean	75.58	79. 60	57.35	60.16	39.50	41.63	50.20
	SD	3.45	3.31	4.61	6.15	3.27	4.04	5.24
1937	n	23	19	65	48	31	30	39
	Range	64-78	67-83	45–66	47-67	31-51	30–46	40–60
	Mean	73.00	74.47	%.33	58.86	37.82	39.77	49.69
	SD	3.71	4.34	4.24	5.42	4.10	3.67	4.87
1939	n	19	14	35	30	5	7	63
	Range	69-79	W-83	50–65	50-69	35--42	35-48	39-58
	Mean	74.57	76.25	58.87	60.95	37.30	38.86	49.04
	SD	2.43	4.55	4.05	5.07	2.78	4.53	4.80
1939	n	3	2	37	53	14	12	49
	Range	71–78	73-78	53-65	49-67	35-41	35-47	40–54
	Mean	74.33	75.50	58.62	58.97	37.54	38.33	47.65
	SD	3.51	3.54	2.93	3.88	2.04	4.44	3.36

[1] Only one female was taken, m 1937.

Rice and Wolman (1971, p. 3; and see Mackintosh and Wheeler, 1929, p. 273) cautioned against using measurements from whaling data indiscriminantly to assess fetal growth and size at sexual maturity. Unpublished notes of the Akutan station manager suggest that, once minimum length limits were imposed by the whaling convention in 1935, procedures for measuring whales became a source of controversy. For example:

> Inspector measures whales from upper jaw or snout–Plant measurement taken from lower jaw—or from the *furthest* or *anterior prolongation—as* per dictionary definition of 'Snout'. Which is correct? Inspector refuses to commit himself on Paterson short Humps—but will report same *and* wants a note made of product received (Oversize, Catch Records, 1919–39, WSL Coil.).

There continued to be some ambiguity in the procedure used to measure whales at Akutan and Port Hobron. In 1937, for example, the Coast Guard inspector at Akutan measured at least 16 whales for which lengths were also measured by station personnel, Discrepancies were noted on the station tallies, which were signed by the inspector. His measurements were longer ($\bar{x}$ = +0.88 ft) than the station measurements in 14 of 16 instances. The difference between the two sets of measurements ($\bar{x}$ = 39.38, s.d. = 7.396 for the inspector; $\bar{x}$ = 38.47, s.d. = 7.127 for the station personnel) is significant (two-tailed t-test, $p < 0.007$),

Table 4

Body lengths by year, species and sex of blue, fin, humpback and sperm whales taken at Port Hobron, 1926-1930 and 1932–1937, with range, mean and standard deviation (all measurements are in feet). Only animals for which length and sex were recorded are included. Source: Station tallies

Year		Blue M	Blue F	Fin M	Fin F	Humpback M	Humpback F	Sperm M
1926	n	0	0	3	1	142	94	0
	Range			58-62	-	30-60	28-53	-
	Mean	.	.	60.03	-	43.49	45.30	-
	SD	–	–	2.00	-	3.90	4.03	-
1927	n	4	3	7	14	116	128	0
	Range	67-78	77–80	54–62	40–64	24–46	20–50	-
	Mean	71.50	78.33	57.71	56.14	36.61	36.70	-
	SD	4.80	1.53	3.15	6.54	4.44	6.11	-
1928	n	6	9	23	24	94	84	8
	Range	60-75	49-82	36–60	36-67	26-43	22-46	42–60
	Mean	69.50	70.11	52.17	52.58	34.32	36.82	52.13
	SD	5.01	11.21	5.98	8.24	4.55	5.84	6.15
1929	n	20	7	13	13	91	78	3
	Range	67-78	68–80	45–72	50–73	24–48	22–46	53–55
	Mean	70.75	74.57	55.00	59.69	35.31	36.18	54.33
	SD	3.13	4.08	7.30	6.59	4.45	4.81	1.16
1930	n	14	11	13	7	86	92	4
	Range	65-75	50–81	4846	28–60	22-43	22–48	48-50
	Mean	71.21	69.91	57.08	47.14	34.36	35.59	49.50
	SD	3.26	8.35	5.80	11.55	4.42	6.14	1.00
1932	n	39	39	26	34	72	56	2
	Range	56–85	55-88	43-67	50-69	29-48	24-55	51–54
	Mean	74.77	76.51	56.62	59.18	37.76	40.48	52.50
	SD	6.61	7.59	7.16	6.23	4.54	7.80	2.12
1933	n	1	0	28	33	53	61	3
	Range	-	-	34-69	44–69	28-50	26-55	44-55
	Mean	–	–	57.21	58.09	37.51	39.95	51.33
	SD	–	–	7.26	5.68	4.70	7.45	6.35
1934	n	10	5	35	43	63	76	3
	Range	51-74	61-82	36-59	31-66	23-47	24–46	37-48
	Mean	66.60	73.03	48.26	52.93	33.87	34.33	44.33
	SD	6.50	8.16	5.82	8.36	4.48	5.14	6.35
1935	n	17	16	21	12	16	20	32
	Range	57-79	45-81	40-60	46-69	30–43	30–46	3543
	Mean	69.82	73.00	52.05	57.83	36.13	36.90	43.66
	SD	5.34	8.41	5.50	8.28	5.08	5.38	5.77
1936	n	6	6	28	23	45	51	16
	Range	67-87	61–82	50–72	50–72	35-49	35–54	38-59
	Mean	81.50	75.50	58.82	60.61	39.64	41.67	48.19
	SD	7.37	7.37	5.86	5.81	3.39	5.04	5.29
1937	n	2	1	31	26	19	24	16
	Range	78-81	-	50-71	50-68	35-46	35-51	42-55
	Mean	79.50	-	59.24	58.21	40.16	42.78	46.56
	SD	2.12	-	4.73	5.76	4.(XI	4.69	3.72

RESULTS AND DISCUSSION

Gunner Selectivity

The whale hunt at Akutan and Port Hobron centered on four target species: blue, fin, humpback and sperm (*Physeter macrocephalus*) whales (Fig. 7). During the early years of the Akutan fishery (1912 to, say, the early 1920's) sperm whales were considered 'much more valuable in proportion' than the balaenopterids (Chamberlain and Bower, 1913, p. 70). 'Special efforts are always put forth to capture sperm whales, as this species is much more valuable than the others found off the Pacific shores of Alaska' (Bower and Aller, 1915, p. 59). Blue whales, because of their relatively high individual yield of oil, were also a preferred species (Kellogg, 1931) (Fig. 8). In 1912,

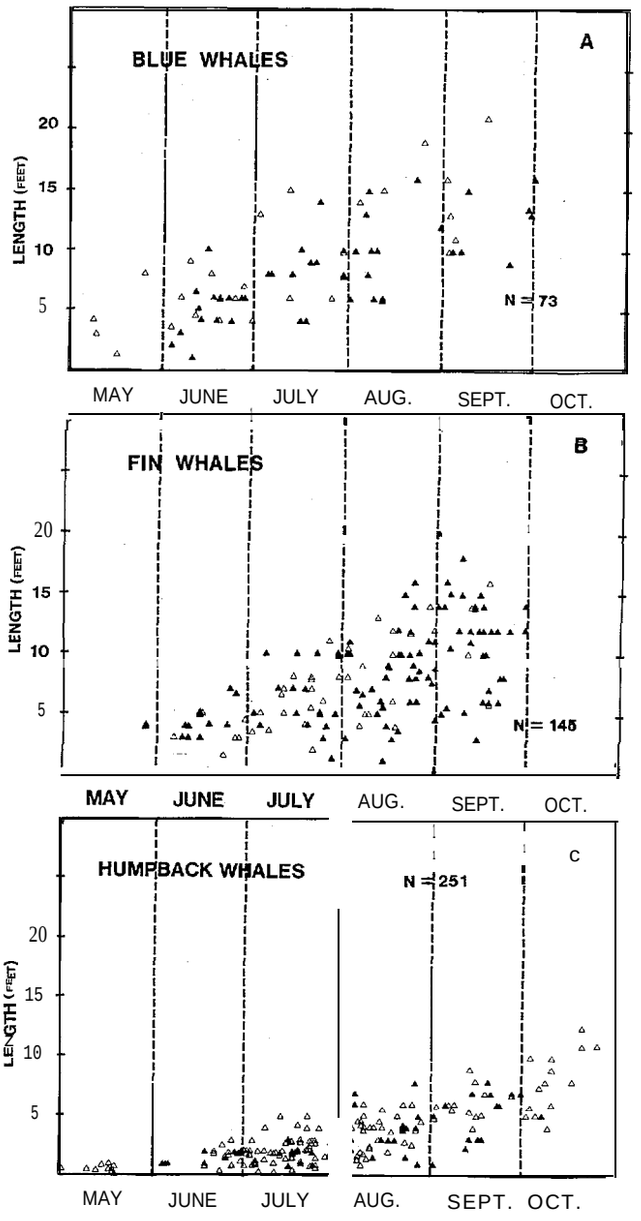


Fig. 6. Scatterplots of lengths of fetuses from Akutan (closed triangles) and Port Hobron (open triangles). Source: Station tallies.

the 'average' oil yield of whales taken at the three Alaskan shore stations (Tyee, Port Armstrong. Akutan) was sperm 80 bbls, blue 78. fm 30 and humpback 25 (Chamberlain and Bower. 1913, p. 70). The 'average' value of the various species in 1913 was estimated by a spokesman for the Tyee Whaling Co. as $1.000 for sperm. $2.000 for right (*Eubalaena glacialis*), *$600* for blue. $500 for fin, and S400 for humpback whales *(Pacific Fisherman* 11[6]: 33).

We assume that the schedule of bonuses paid to gunners and certain other crew members provides an accurate index of whaling preferences. In 1913 the United States Whaling Co. operating at Port Armstrong. Alaska. paid gunners $5 .50 for each humpback delivered to the station, $10.50 for each fin whale, $13 for each blue whale, $30 for each sperm whale and $50 for each right whale (*Pacific Fisherman 11[4]:* 23). From payroll records (Payrolls. Oversize, 1926-42) and general correspondence (Boxes 1–3) in the Lagen Collection. we compiled data on bonuses paid to gunners at Akutan and Port Hobron (Table 5), These indicate that right whales. before they became protected in 1935. were consistently more valuable than any other species (except. perhaps," in 1932). Because of their scarcity, right whales probably did not influence decisions about where the Akutan and Port Hobron vessels searched; rather, these whales were a prize to be chased at every opportunity during the course of operations aimed at finding and catching the more common species (Fig. 9). It is clear that by 1927, the first year for which we found full details of the bonus schedule for the stations considered in this paper, the blue whale had surpassed the sperm whale in value. The station manager at Port Hobron stated in 1935 that 'the boats are out anywhere from 55 to 90 miles looking for Blues and naturally if they can't find a Blue will pick a Sperm if there are any there' (General Correspondence, Box 2. WSL Coil.).

Although all vessels engaged in the fishery were evidently capable of killing, securing. and towing any species of whale they encountered. factors other than bonuses may have helped determine whaler preferences. Certainly in later years when sperm whales were no more valuable (judging by the bonus schedule) than fin whales and humpbacks (Table 5), the considerably greater difficulty of flensing and processing sperm whales at the plant discouraged their capture (Fig. 10) (W. S. Lagen,

Fig. 7. A shot at a balaenopterine whale, probably a fine whale. near the Akutan station. (Alaska Historical Library).

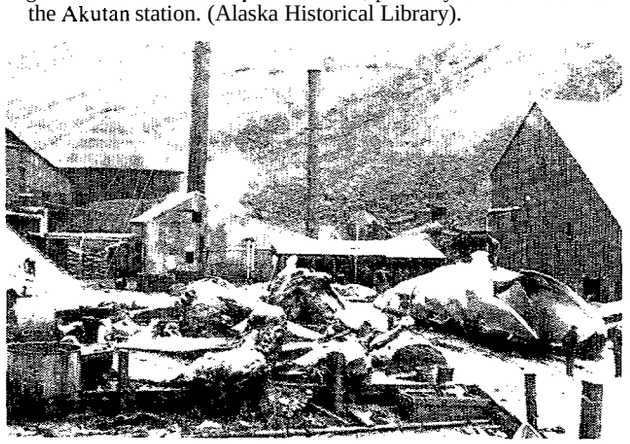


Fig. 8. A [probable] blue whale on the flensing deck at Akutan; date unknown. (Alaska Historical LibraV).

Table 5

Bonus schedule for Akutan and Port Hobron whaling stations. 1925–1939. Figures (in US dollars) are for amounts paid to gunners for each whale of a given species delivered to the station. Source: WSL Coll.

Year	Sperm	Blue	Fin	Humpback	Right
1925		30.00	10.00		
1926	-	30.00	10.00		45.00
1927	10.00	30.00	10.00	10.03	45.03
1928	10. W	30.00	10.00	10.03	45.00
1929	20.00	30.00	15.00	15.00	
19X3	15-20.00	30.00	15.00	15.00	45/Co
1931					
1932	22.53 [?]	15.00	7.50	7.50	22. n
1933	10.00	15.00	7.50	7.50	
1934	10-15.00	22.50	11.25	11.25	30.00
1935	15.00	30.00	15.00	10.00	
1936	15.00	30.00	15.00	12.50	
1937	10.CO	32.00	15.00	15.00	
1938	10.03	32.03	15.02	15.03	
1939	10.CO	32.09	15.00	10.00	

Fig. 9. A right whale landed at Akutan; year unknown (Alaska Historical Library).

Fig. 10. 'Snout view of sperm whale being butchered at American Pacific Whaling Co.. Akutan. Alaska', (U.S. Coast Guard Photo #68, Alaska Historical Library. Album #26-G-150 D-8A).

pers. comm., 11 July 1984; also see General Correspondence, Box 2, WSL Coil.). This factor may have been offset in some degree by the company's ability to 'get the money out of the sperm oil immediately' (General Correspondence, Box 1, WSL Coil.).

The catcher-boat log of the *Tanginak's 1937* season at Port Hobron reveals another type of selectivity. The vessel began to chase, then stopped chasing cows accompanied by calves on at least six occasions, 'undersize' humpbacks on four occasions, and sei whales (*Balaenoptera borealis)* twice. Small humpbacks and sei whales may have been passed up partly because of the anticipated low yield of oil and other products from them, whereas mothers and calves likely were spared mainly because of adherence to an international protective agreement. To our knowledge, only four sei whales were landed at Akutan and Port Hobron over the entire life of the fisheries (Tables 1 and 2; Fig. 11).

Distribution of Catches: Blue, Fin, Humpback and Sperm Whales

Until September 1915, Akutan catcher boats cruised only in the Bering Sea; the prospect of finding blue whales and sperm whales 'outside the Davidson Banks' led them to work 30-50 miles south of Akutan after this date (Birkeland, 1926, pp. 30-31). If it is assumed that the distribution of catches reflects the distribution of effort, then except for May and June, when most catching was done on the Pacific side of the Aleutian Chain, effort at Akutan after 1924 was fairly well balanced between the Bering Sea and the Pacific (Fig. 12). At Port Hobron, virtually all catching was done on the Pacific side of Kodiak and Afognak islands, with no evidence of any appreciable effort in Shelikof Strait (Fig. 13). The geographic spread of catches was somewhat broader, and catches certainly higher, during summer (June–August) than early and late in the season.

Blue whales were taken at Akutan principally on the Pacific side (Fig. 14). Because they were a preferred species (see 'Gunner Selectivity y' above) and considerable whaling effort was expended in the Bering Sea, we consider the relatively low catch of blue whales in the Bering Sea to reflect a low level of abundance there (also see Birkeland, 1926, pp. 131–36 and Omura, 1955). There is no obvious seasonal trend in the Akutan blue whale catches, although the relatively low catches in May and October may prove meaningful when corrected for effort.

Fin whales, by contrast, were taken in greatest numbers in the Bering Sea (Fig. 15). They were very widely distributed on the whaling grounds, and some movement through Unimak Pass (as well as Akutan Pass) is suggested by the monthly catch plots. Some variability in the distribution of concentrations of fin whales is indicated by a comment of the station manager at Akutan in June 1934:

> With the exception of a few all finbacks are from ten to thirty miles off Akun Head. In 1930 there were no finbacks in this locality (General Correspondence, Box 1, WSL Coil.).

Humpbacks (Fig. 16) were caught mainly in the Pacific, Unimak Pass and the Bering Sea just north of the pass (Fig. 17). Many humpbacks were reported on Davidson Bank in August 1934 (General Correspondence, Box 1, WSL Coil,). Sperm whales were taken mostly in the Pacific (Fig. 18).

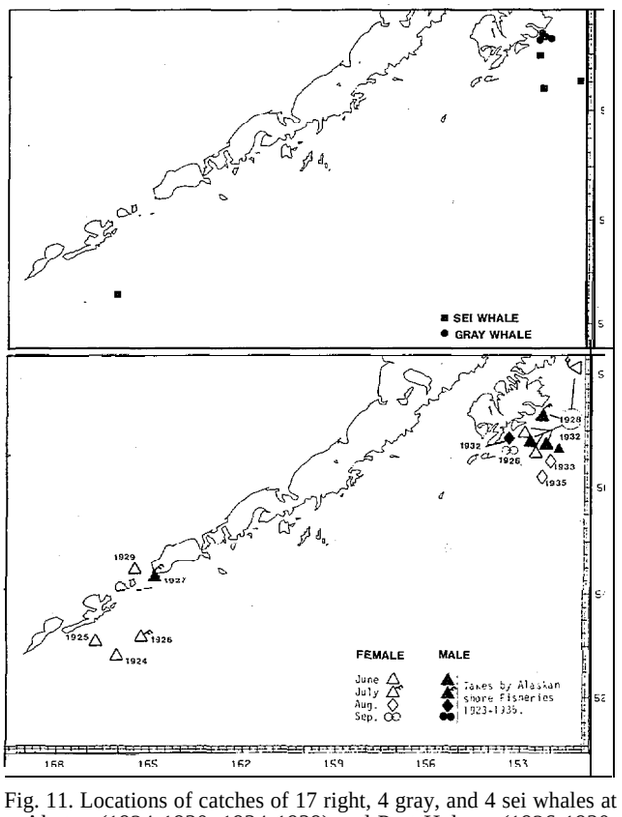


Fig. 11. Locations of catches of 17 right, 4 gray, and 4 sei whales at Akutan (1924-1930, 1934-1939) and Port Hobron (1926-1930, 1932-1937).

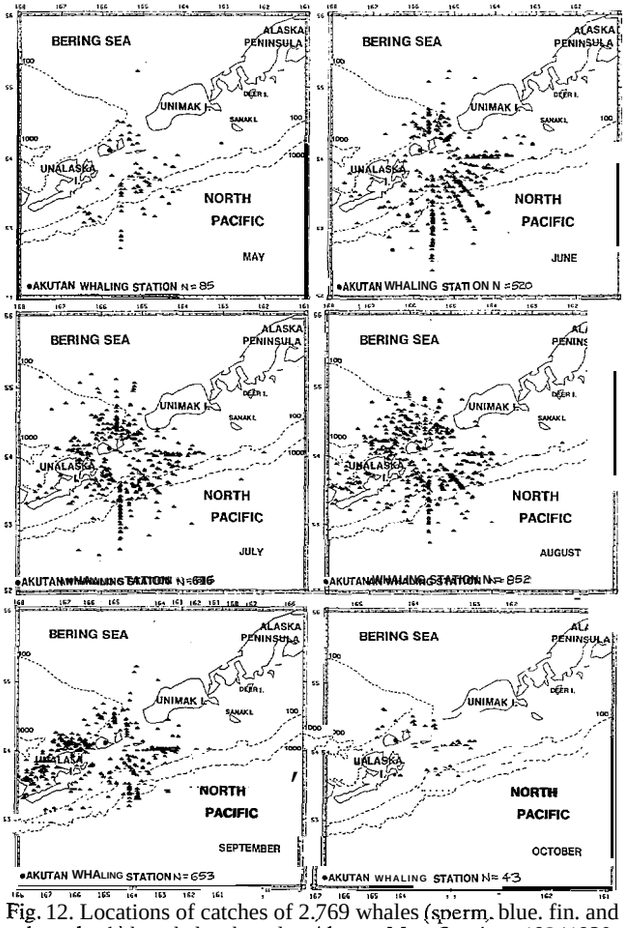


Fig. 12. Locations of catches of 2,769 whales (sperm, blue. fin. and humpback) by whalers based at Akutan, May–October, 19241930, 1934-1939, Only animals for which location was recorded are included.

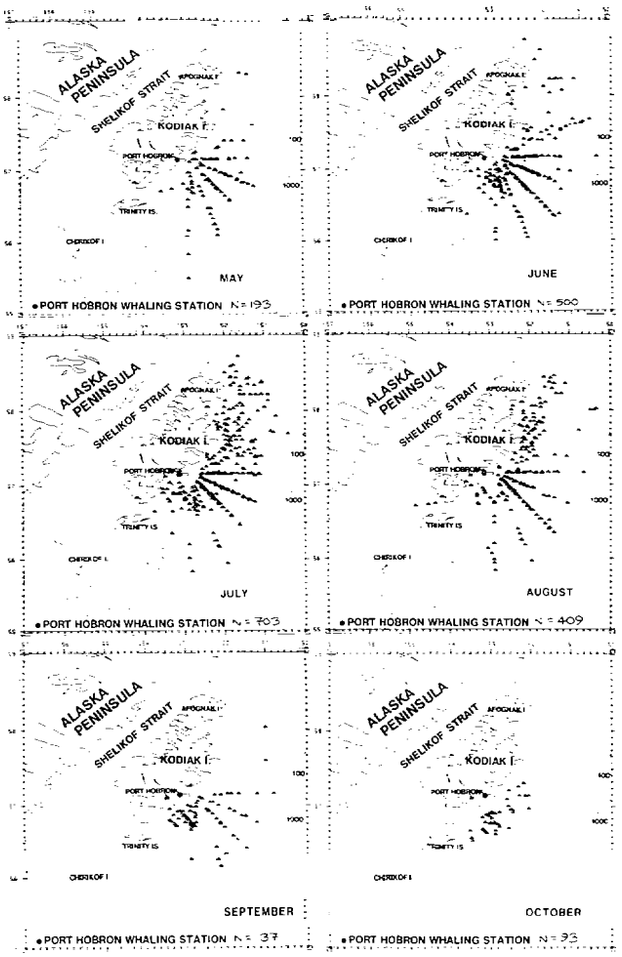


Fig. 13. Locations of catches of 2,035 whales (sperm. blue. fin, and humpback) by whalers based at Port Hobron, May–October. 1926–1930. 1932–1937. Only animals for which location was recorded are included.

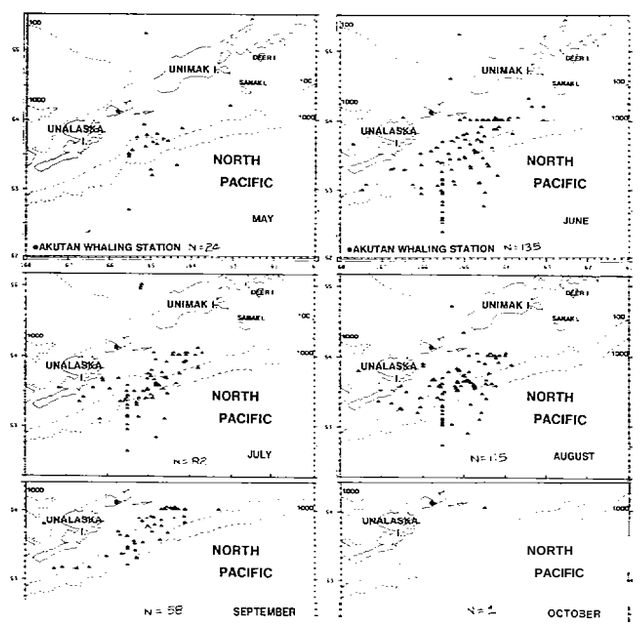


Fig. 14. Locations of catches of 415 blue whales at Akutan, 1924-1930, 1934-1939. Only animals for which location was recorded are included.

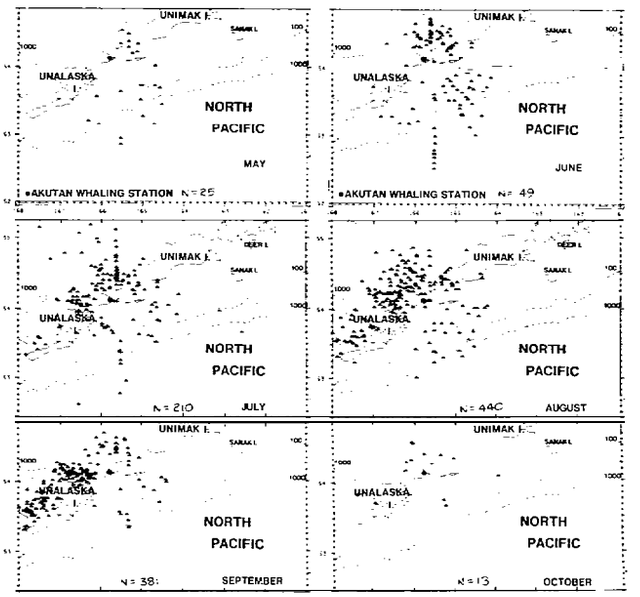


Fig. 15. Locations of catches of 1.218 fin w-hales at Akutan. 19241930, 1934-1939, Only animals for which location was recorded are included.

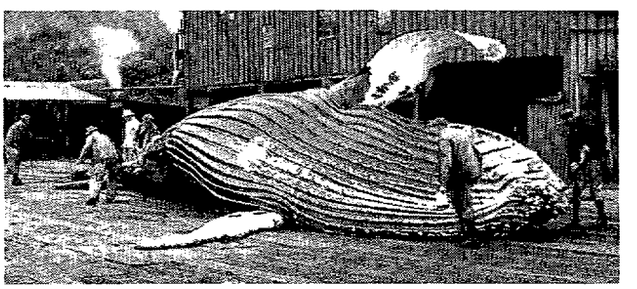


Fig. 16. Butchering a 37ft female humpback whale at Akutan, Alaska, 6 August 1938. (Photo by V. B. Scheffer, VBS Photo Number 164 = FWS B-63624 = FWS 315).

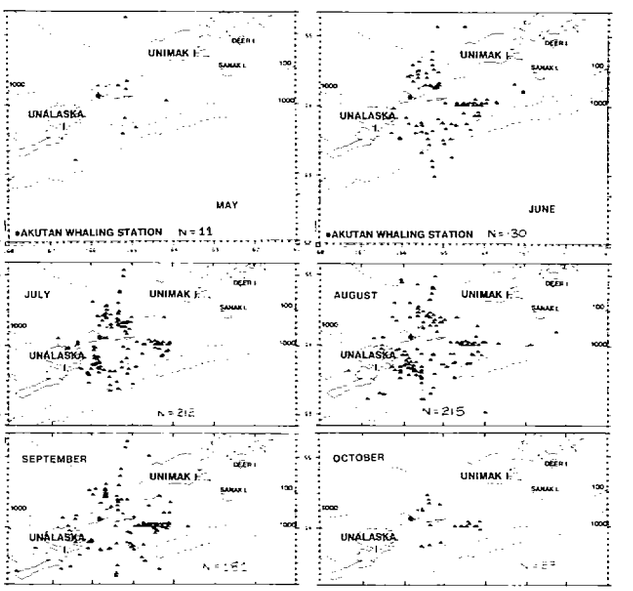


Fig. 17. Locations of catches of 776 humpback whales at Akutan. 1924–1930, 1934–1939. Only animals for which location was recorded are included,

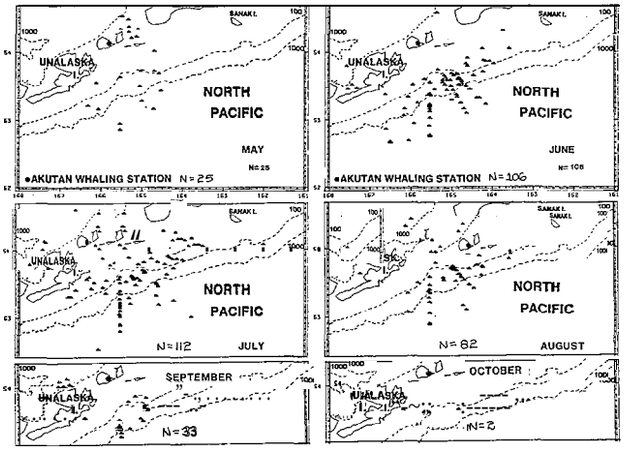


Fig. 18. Locations of catches of 360 sperm whales at Akutan, 1924–1930, 1934-1937, Only animals for which location was recorded are included,

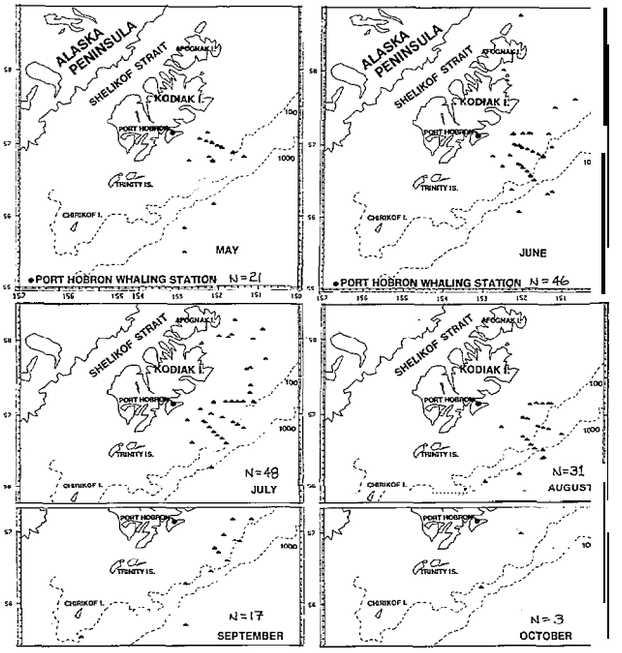


Fig. 19. Locations of catches of 166 blue whales at Port Hobron, 1926–1930, 1932–1937. Only animals for which location was recorded are included.

Blue whale catches at Port Hobron tended to be well away from the coast (Fig. 19); whereas fin whales and humpbacks were taken regularly inshore as well as across the entire continental shelf (Fig. 20 and 21). Of these latter two species, the humpback appears to be the more coastal, having been taken frequently inside bays (see Elliott, 1886, p. 150). Except for one catch in Marmot Bay just northwest of Spruce Island in June, sperm whale catches were concentrated along the shelf edge and on the continental slope (Fig. 22).

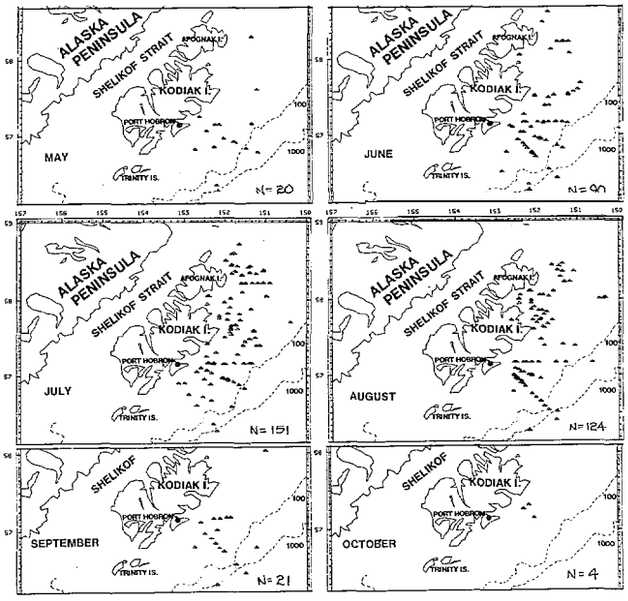


Fig. 20. Locations of catches of 410 fin whales at Port Hobron, 1926-1930, 1932–1937. Only animals for which location was recorded are included.

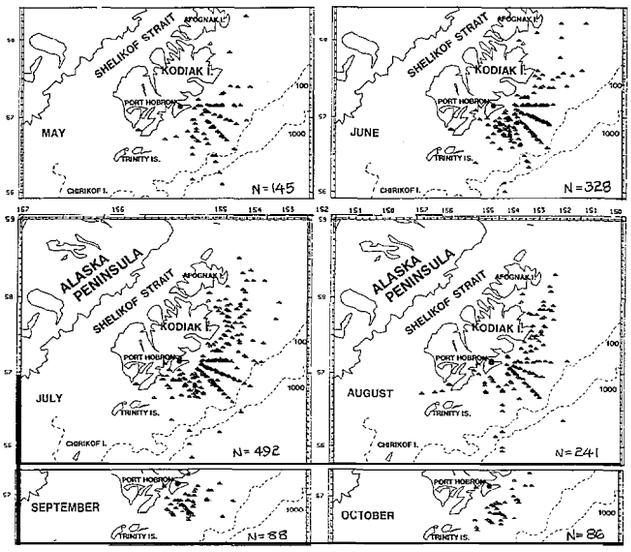


Fig. 21. Locations of catches of 1,380 humpback whales at Port Hobron, 1926-1930, 1932–1937. Only animals for which location was recorded are included.

The monthly summary charts do not seem to reveal significant seasonal variations for any species. It is possible that by combining years we have obscured yearly changes in phenology and distribution. However it would be difficult to interpret such apparent changes as anything other than artifacts of effort.

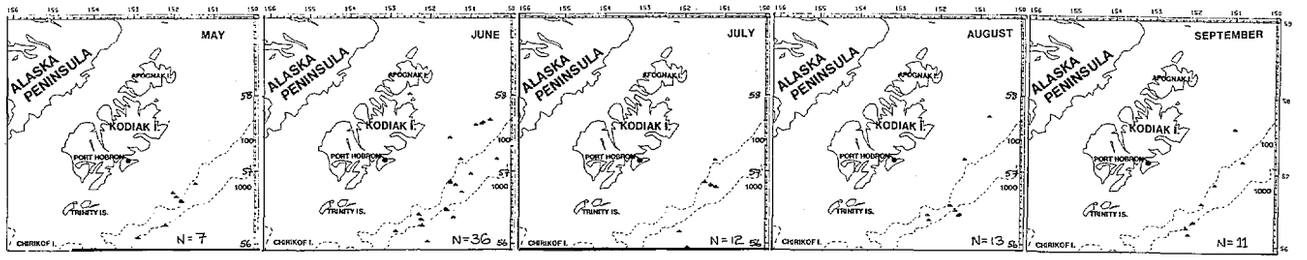


Fig. 22. Locations of catches of 79 sperm whales at Port Hobron, 1926-1930, 1932–1937. Only animals for which location was recorded are included.

Data on Pregnancy and Lengths of Fetuses and Calves

The forms used by the American Pacific Whaling Company to report its whale catch data, at least after 1923, included column headings concerning the reproductive status of females (pregnant or not) and the length and sex of fetuses. Judging by the presence of such headings. we assume appropriate station personnel were expected to examine females for evidence of a fetus. Birkeland's (1926, p. 26) statement that. 'In the majority of the female whales . . . we did not find any evidence of embryos", can be taken to imply that some effort was made as early as 1914 and 1915, when he was present at Akutan. However. we cannot be certain that an adequate examination was made in every case. In particular. we consider it likely that small fetuses would have been overlooked at least occasionally. VanDeVenter (1938) noted that 'a small number of gravid females may be overlooked during the processing operations'. Even large fetuses may have been lost sometimes due to putrefaction of carcasses prior to flensing. Pregnancy rates derived from these data would. therefore, presumably have a downward bias. and fetal lengths would most likely have an upward bias.

With these reservations in mind. we compiled the existing data on fetal lengths. by species (Fig. 6). and considered their implications. Taken at face value, the data indicate the following:

1. There is little evidence in the unpublished sources that lactating whales or milk-fed calves were taken. A blue whale taken by the *Tanginak* at Port Hobron in late August or early September 1935 was 'sucking' (Oversize. Catch Records, 1919-39, WSL Coil.). Birkeland (1926, p. 149) mentioned that at Akutan lactating female fin whales and 'almost full-grown" calves were sometimes caught, the latter with only milk in their stomachs. Also, aboriginal whalers in the eastern Aleutians traditionally hunted 'yearlings' and 'calves" in preference to adults (Elliott. 1886, pp. 15 1–52). In June 1935 the Port Hobron station manager complained:

   > The Sperm Whales have been exceptionally small and the Humps and Fins are miserable, many of them yielding less than 10 barrels although all of them are over the required 30 feet (General Correspondence. Box 2, WSL Coil.).

2. Pregnant blue whales were caught from mid-May through late October. containing fetuses ranging in length from 1 ft to 21 ft. The spread in fetal lengths within a given month is wide. 2.5 to 8 ft in May. 3.5 to 10 ft in June, 4 to 15 ft in July, 6 to 19 ft in August. and 10 to 21 ft in September. Since the length at birth of (Antarctic) blue whales is about 25 ft (Slijper. 1979. p. 363), many of the larger August and September blue whale fetuses can be considered near term. with birth expected perhaps some time in October.
3. A similar picture is shown for fin whales. Pregnant females were taken from late May through late September, and fetuses from less than 4 in to 20 ft long were reported. Again. the spread in fetal lengths within a given month is wide, less than 4 in to 7 ft in June. somewhat less than 2 ft to 11 ft in July, somewhat more than 1 ft to 16 ft in August, and 2 to 20 ft in September. The larger August and September fetuses would probably reach term by some time in September or October. as the length at birth of (Antarctic) fin whales is about 20 ft (Slijper, 1979, p. 363).
4. The large number of humpback fetuses, taken from early May through mid to late October. tend to have a more clustered monthly size distribution. In May, they fell within the range of several inches to 3 ft (except for one anomalous 10 ft specimen): in June, several inches to 3 ft: in July. several inches to 5 ft; in August. 9 inches to 7 ft; in September, 2.5 ft to 9 ft and in October. 6 ft to 12.5 ft.
5. Linear regression lines were fitted to the data and to natural log transforms of the data shown in Fig. 6. The results were: blue whales (n = 73). $y = 0.885x - 9.0966$, $R^2 = 0.5402$ and $\ln y = 0.118x - 0.0366$. $R^2 = 0.5118$; fin whales (n = 145). $y = 0.0783x - 9.3085$. $R^2 = 0.3711$ and $\ln y = 0.0115x - 0,6142$, $R^2 = 0.3454$: and humpback whales (n = 251), $y = 0.0434x - 5.8317$. $R^2 = 0.5834$ and $\ln y = 0.0173x - 2.7765$. $R^2 = 0.5618$.
6. Comments on gray whale (*Eschrichtius robustus*) and right whale fetuses appear below in the relevant species accounts.

Gray Whales

We can account for only four gray whales taken. all at Port Hobron (Table 6. Fig. 11). Judging from available data on size at sexual maturity (Rice and Wolman, 1971). all were adults. One. a 42 ft female taken 9 July 193325 nm ENE of Cape Barnabus, was carrying a 36 inch female fetus. At this length. the fetus probably was conceived in December and would have been born the following February. It was well within the size range and 1 standard error of the mean (range 2.07-4 .3 ft. $\bar{x} = 3.379$. s.d. = 0.53) of five fetuses taken in July 1980 off Chukotka reported by Blokhin (1982) and used by Rice (1983, Fig. 1) to support his curve representing hypothetical mean fetal growth.

Considering the present abundance and seasonal occurrence of gray whales in the whaling areas of both stations, it is surprising that they were taken so infrequently. According to the most plausible model of gray whale population growth (Reilly. 1981. Fig. 23), following a low in the 1870s the recovering population increased during the 23 years of the Akutan and Port Hobron fisheries from about 15% (in 1912) to about 40% (in 1939) of its maximum equilibrium population size (24.000). With the exception of a few animals which do not complete the annual migration to the Bering and Chukchi Sea feeding grounds (Braham, 1984). gray whales are present in the Akutan and Port Hobron areas only during migration. In spring. most have entered the eastern Bering Sea by early May. but that first component of the population is followed in mid-May through mid-June by mothers and calves-of-the-year. Since whaling usually began some time from early May to early June (Tables 1 and 2). it is the tail of the northward migration that would have been available to the whalers. In fall. gray whales do not begin moving south through Unimak Pass in appreciable numbers (i.e. still less than five per day at the end of October) until mid to late November (Rugh, 1984),

Table 6

Gray whales caught by vessels operating from Port Hobron. Alaska. Source: station tallies

Date	Location	Vessel	Sex	L	Fetus
10.5.28	15nm NE of Dangerous Cape	Aberdeen	F	40ft	so
15.5.23	15nm NE of Dangerous Cape	Aberdeen	M	38ft	--
6.7.33	Inside Nyak	Moran	F	32ft	No
9.7.33	25nm ENE of Barnabas Is.	Aberdeen	F	42ft 36"	female

well after the whaling season had ended (Tables 1 and 2). It is possible that, in addition to being relatively scarce on the whaling grounds during the peak whaling season, gray whales were a less preferred target because of their low oil yield, especially while on their northward migration (cf. Rice and Wolman, 1971, p. 36).

Right Whales

We can account for 21 right whales killed by the Akutan and Port Hobron whalers between 1916 and 1935 (Table 7, Fig. 11). There may have been a few additional right whales taken during the early years of the Akutan fishery when the entire catch was not differentiated to species (Table 1; see Birkeland, 1926, p. 26), Also, some right whales were taken by modern shore stations in Alaska before 1912 (e.g. 1 at Tyee in 1910-Marsh and Cobb, 1911, p. 53). There is every reason to believe they were regarded as a preferred species and thus would have been chased whenever encountered prior to 1935. Protection afforded by the Convention for the International Regulation of Whaling, which took effect in 1935 (or earlier), may in part explain the lack of catches after 1935. In this regard, it is interesting that in the daily log of the catcher boat *Paterson,* working out of Akutan on 3 June 1935, an unusually long explanation is given of the circumstances surrounding the capture of a right whale (see Fig. 3):

> When chasing 2 humps a right whale came up right under the prow and was shot in mistaking him for one of the humps. He died instantly so we towed him to the station.

An inquiry from a company (Van Nouhuys and Co., San Francisco) wishing to purchase 'whalebone' in summer 1934 elicited the following reply from the American Pacific Whaling Company: '. . . we are not taking any more right whales, owing to the international prohibition on same' (General Correspondence, Box 1, WSL Coil.). There is evidence of a continuing market through at least 1937 (General Correspondence, Boxes 1-3, WSL Coil.). The infrequency of catches before 1935 testifies to the low availability of this species at both stations throughout their periods of operation. Sightings made from 1935 to 1939 indicate a continuing presence of right whales on the grounds of both stations after protection was introduced (Table 8).

Right whales were taken and sighted in all months from May through September. The catch of six right whales at Port Hobron between 4 June and 5 July 1928 is especially noteworthy. More right whales were reported at Akutan in

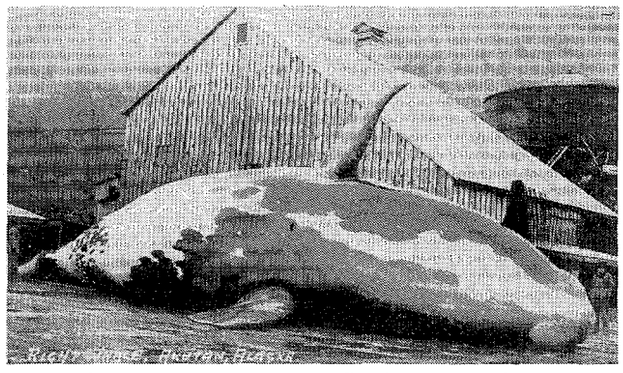


Fig. 23. A large right whale on the flensing deck at Akutan; year unknown. (Alaska Historical Library).

Table 7

Right whales caught by vessels operating from shore stations in Alaska and British Columbia (BC), 19141951. A = Akutan, P = Port Hobron, N = Naden Harbour, BC, R = Rose Harbour, BC, C = Coal Harbour, EC. Data sources: 1 Production and catch summaries (Rose Harbour and Naden Harbour); 2 Bower and Aller, 1917b. 3 Production and catch summaries (Akutan); 4 Oversize, catch records, WSL Coll.; 5 Pike and MacAskie, 1969; 6 Station tallies (Akutan and Port Hobron); 7 Weekly manufacturing reports; 8 Catcher-boat logs

Date	Station, Location of kill	Vessel	Sex L, ft.	Remarks
16.6.14[1,2]	N, not reported	White	-	
?.?.16[2]	A, not reported			
14.7.173	A, not reported	Unimak	-	
14.6.18[1]	R, not reported	Orion		
13.8.234'7	A, not reported	Tanginak	-	1880 lbs baleen
9.6.234'7	A, not reported	Kodiak	-	1400 lbs baleen
15.6.24[4,5]	N, 54°33'N, 133°55'W	Blue	♂57	
24.6 .24[4,5]	N, 54°05'N, 133°40'W	W. Grant	'262	
30.6.2467	A, 30nm S Biorka Is.	Tanginak	$'57	'Good ' condition; 1512 lbs baleen
28.6. 25[6,7]	A, 10nm SSE C. Prominence	Paterson	955[a]	'Fair ' condition; 918 lbs baleen
10.6.26[1,4,5]	N, 53°40'N, 133°45'W	W.Grant	♀45	-
2.7.26[6,7]	A, 25nm SE Rootok Is.	Aberdeen	$'41	Described as 'very small ' 526 lbs baleen
18.9.26[6]	P, 18nm S Barnabas Is.	Aberdeen	♀62[b]	-
6.7.27[6,7]	A, Unimak Pasa	Westport	♂36	Logged as 'calf'; described as 'very small ' ; 47bbls oil, 1751bs baleen
4.6.28[6]	P, 45nm ESE C. Barnabas	Moran	1336	
6.6.28[6]	P, 18nm SE C. Barnabas	Aberdeen	♀33	
8.6.28[6]	P, 20nm SE C. Barnabas	Aberdeen	1343	
8.6.28[6]	P, 25nm SE C. Barnabas	Tanginak	♀46	-
3.7.28[6]	P, 25nm E Marmot Is.	Moran	'?50	-
5.7.28[6]	P, 20nm ESE C. Barnabas	Moran	♂50	-
4.6.296'78	A, 07nm N Tanginak	Unimak	♀ 59	'Poor' condition 1300 lbs baleen
25.6.29'	R, not reported			
14.6.32[6]	P, 30nm SE C. Barnabas	Aberdeen	♂52	
2.8.32[6]	P, 18nm NE Sitkinak Is.	Westport	♂44	
1.8 .33*	P, 45nm SE C. Barnabas	Aberdeen	♀45	
3.6.35[6,7,8]	A, 30nm E Rootok Is.	Paterson	♀ 47	378 lbs baleen
20.8.3567	P, 60nm S3E Barnabas Is.	Aberdeen	♀39	150 lbs baleen
?.5.51[1]	C, off NW Vancouver Is.		♂41	

[a] One 5.5 ft fetus, sex unknown
[b] One 18 ft male fetus.

Table 8

Sightings of right whales. Information taken from the log of the vessel from which the sightings were made, except for the second record, which was from Oversize Material, catch records, Akutan, Port Hobron, 1919-1939, WSL Coil

Date	Position	Vessel (Station)	Remarks
27.6.28	20nm SE of Rootok Island	Paterson (Akutan)	2 right whales seen aad chased for 1 hr.
29.7–3.8.28	Not indicated	Unimak (Akutan)	'Unimak shot Right Whale - Harpoon pulled out.'
3.9.29	40nm E1/2N of Rooktok Island	Unimak (Akutan)	1 right whale chased for 6hr 20mins; nr 2 blue and 20 humpback whales.
11.5.37	ca.20nm SE of Twohead Island	Moran (Port Hobron)	At 1600hrs 'Chasing 2 Right whales.' Apparently did not shoot.
14.5.37	ca.1nm SE of Twoheaded Island	Tanginak (Port Hobron)	0700hrs noted 'chasing ' ; 0800hrs 'quit chasing (Right whale).'
20.6.37	SE of Unalaska Island	Paterson (Akutan)	while towing fin whale, stoppad & flagged it to 'chase' a right whale; apparently did not shoot.
24.8.37	28nm SE of Roo tok	Kodiak (Akutan)	'Sean 1 Right Whale'; humpback shot 4nm distant.
17.8.39	Bering Sea, general vicinity of Akutan Pass	Kodiak (Akutan)	'Seen 1 Right whale'.

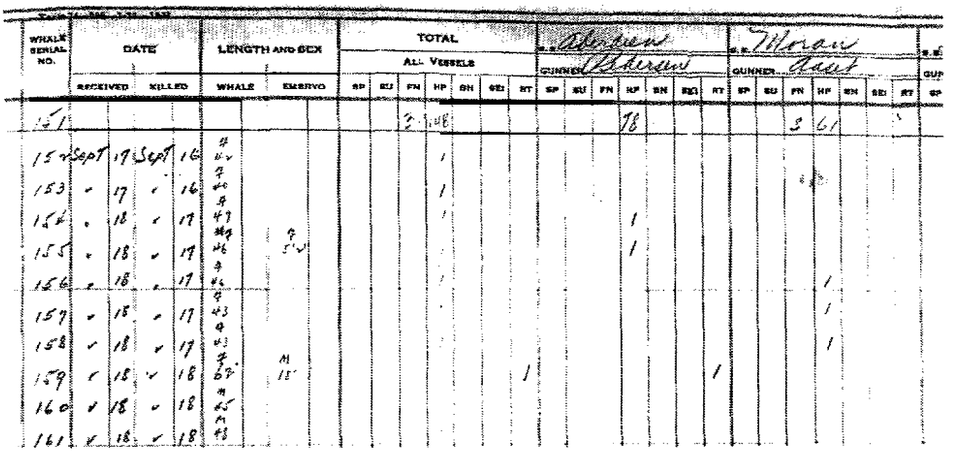


Fig. 24. Detail of page from the Akutan station tally indicating that a 62 ft right whale killed. 18 September 1926 (whale No. 159), contained an 18 ft male fetus. (Courtesy of Manuscripts and University Archives Division, University- of Washington Libraries).

June than in any other month. More females than males were taken (11 vs. 6 for animals that were sexed). and the catch tended to consist of large individuals (seven of them 50 ft or longer, six in the 40-49 ft range, and four in the 30-39 ft range) (Fig. 23). Two females were noted as being pregnant, one taken at Akutan in late June with a 5.5 ft fetus: the other at Port Hobron in mid-September with an '18 ft' fetus. The latter fetus is of particular interest as it would have been near term. assuming its length was measured and reported accurately.

The length of the September fetus was given in the station tally as '18". and this figure was handwritten (Fig. 24). We tried to corroborate the measurement by examining other sources of data. A photograph in the Alaska Historical Library, Juneau, Alaska, shows a right whale fetus on a flensing platform which. judging by structures in the background, is almost certainly at Port Hobron (Fig. 25). The '18 ft' specimen is the only right whale fetus reported in the Port Hobron records. so we assume it is the subject of this photograph. Using as a reference the men standing near the fetus. we estimate the fetus's length as approximately 12 ft.

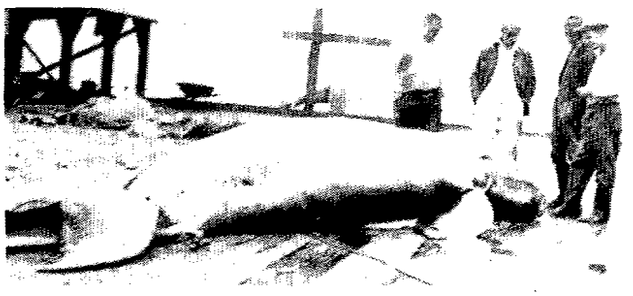


Fig. 25. A right whale fetus at Port Hobron – probably the '18 ft' specimen found in a 62 ft female taken 18 September 1926 (Table 7). (Alaska Historical Library).

Sperm Whales

The first sperm whales were evidently taken at Akutan in September 1915 (Birkeland.1926.p. 131-36) or 1916 *(Pacific Fisherman, 1916, 14[9]: 34).* Of 456 sperm whales taken from 1924 to 1939 at Akutan and Port Hobron. only one, from Akutan. was a female.

VanDeVenter (1938) observed that the mean oil yield of sperm whales was greater at Akutan in 1938 (53.96 barrels) than at Port Hobron in 1937 (49.56 barrels). He also observed that 'the heavy and worn teeth and the battlescarred bodies of the Akutan Sperms showed them to be definitely more mature than those at Port Hobron' (Fig. 26). Although apparently based only on this one between-year comparison. VanDeVenter's conclusion is borne out by our body-length data. There is a significant difference between the mean body length of sperm whales taken at Akutan (50.32 ft. s.d. = 4.37. n = 368) and at Port Hobron (46.93 ft. s.d. = 5.92, n = 87) (F-test. df = [1.453]. $p < .001$).

The exceptional catch of sperm whales at Port Hobron in 1935 (Table 2) was considered by the station manager there to be due to 'the fact we are operating outside the 100 fathom bank'. He also noted:

> Although the Sperms we get are not to be compared with the Sperms caught at Akutan they seem to be much younger and we have not as yet gotten any teeth except the hollow ones which I understand are only in the young Sperm (General Correspondence, Box 2. WSL Coil.).

Schools of females and calves were occasionally observed on the whaling grounds off the Queen Charlotte Islands, British Columbia (General Correspondence. Box 1, WSL Coil.).

Struck-but-Lost Component

There is no published estimate of the proportion of whales struck but not secured in the Akutan and Port Hobron fisheries. We do know that during the early years of the Akutan fishery there was a period when the whalers had

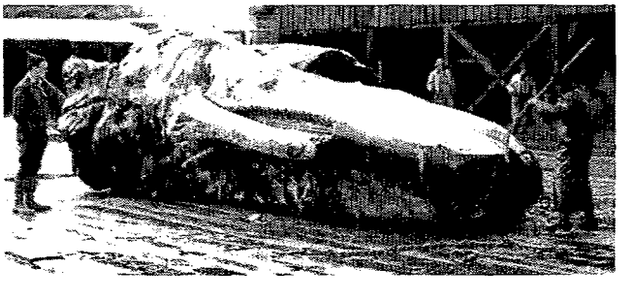


Fig. 26. Flensing a sperm whale at Akutan, Alaska, 26 May 1937: V.B.

great difficulty with their equipment and complained of losing whales because of it. For example, on 13 June 1915 a large fin whale 'broke the line' and 'ran away' with the foregoer after being struck by the *Kodiak* (Birkeland, 1926, p. 111). On another occasion, a large fin whale ran out 600 fathoms of line and escaped; it was found dead and floating several hours later (Birkeland, 1926, p. 142). A large humpback was recognized by the whalers because of the scar it bore, indicating that the whale 'probably had been harpooned a year or so before' (Birkeland, 1926, p. 143). An emaciated bull sperm whale with a 3-ft long, festering wound on its head was taken at Akutan in 1938. It was believed, 'due to the character of the scar, that this wound could have been caused by a harpoon . , .' (VanDeVenter, 1938, p. '1O).

If it is assumed that catcher-boat logs contain a record of all shots fired at whales which struck their target and of all whales killed but, for whatever reason, not finally delivered to the station, then it is possible to derive from the Akutan and Port Hobron logbook data a realistic estimate of the hunting loss rate. In some years the station manager reported in Weekly Manufacturing Reports incidents involving struck-but-lost whales (Oversize, Catch Records, 1919–39, WSL Coil.). We checked these comments against information in logbooks whenever the latter were available for the appropriate period. This check revealed no major inconsistencies. In July 1938 a telegram was sent by the Akutan station manager to all whaling captains advising that 'whaling treaty regulations' required them to furnish in their trip reports information on 'when a whale is fired at—and hit—but not recovered' (General Correspondence, Box 3, WSL Coil.),

The most serious problem in estimating the loss rate is judging, for whales not killed outright and so noted in the logbook or other source, what proportion would have died from harpoon wounds. Struck-but-lost whales were assigned by us to the following categories (Table 9):

1. *Definitely killed* (Category 1)–In some cases, the logbook states explicitly that a whale was killed before being lost, usually due to a broken harpoon, foregoer, or line, or simply because the harpoon drew from the carcass. In other cases, it is noted that a whale sank, was lost during 'heaving-in' or towing, or was flagged but could not be relocated. The Akutan logbook sample contained 13 records of whales definitely killed but lost; the Port Hobron sample, two. Four more killed-but-lost whales are mentioned only in the Weekly Manufacturing Reports.

2. *Drawn harpoon* (Category 2)—A common reason for losing a whale was that the harpoon drew out of the animal's body. In such instances, we assume the whale escaped wounded but free of all whaling gear. There are 10 such records in the Akutan logbook sample that fit this category; two in the Port Hobron sample. In addition, seven Category 2 records were found in the Weekly Manufacturing Reports that were not also mentioned in available logbooks.

3. *Broken line, foregoer, shackle, or harpoon* (Category 3)—In many cases, whales were lost when the harpoon line or foregoer 'parted', 'snapt', 'broke', or became fouled in the boat propeller. Presumably, these whales usually escaped with the harpoon still imbedded; some trailed a length of line as well. In one instance, the foregoer 'parted before Harpoon entered Whale'; we scored the whale as having been struck and placed it in this category. Since a broken shackle or broken harpoon probably resulted in at least pieces of whaling gear remaining imbedded in an animal's flesh, such occurrences were assigned to Category 3. In one instance, a second shot on a fin whale 'broke 1st harpoon in 2', and the animal was lost. The Akutan logbook sample contained 27 records in Category 3; the Port Hobron sample, four. In addition, 26 records assigned to this category were found in the Weekly Manufacturing Reports (Akutan and Port Hobron combined).

4. *Unspecified* (Category 4)—Some descriptions in the logbooks, while adequate to determine that a whale was struck and lost, are not adequate for placing the strike in one of the above categories. Among these are statements indicating the whale 'broke away' or 'broke loose' after being shot, In one instance, a fin whale was 'lost' 2 hr 40 min after being shot and before being brought alongside the boat. In another, the harpoon 'glanced off' a humpback. We placed four strikes from the Akutan logbook sample in this category; none from the Port Hobron sample. Seven unspecified records appear only in the Weekly Manufacturing Reports.

5. *Missed* shots—Missed shots at whales are noted consistently in only a few logbooks. Since they evidently did not strike the target at all, we ignored these missed shots in our calculations of loss rate.

There is no record in either the Akutan or the Port Hobron logbook sample of a harpoon shell's failure to explode upon entering the whale, but this undoubtedly happened occasionally. We assumed that, for most records assigned to Categories 2, 3 and 4, a bomb did explode in the struck whale. As a consequence, mortality of struck whales was probably high. We estimate that 50% of the whales in Categories 2 and 4 and 75% of those in Category 3 were dead or moribund when lost.

VanDeVenter's (1938, p. 4) report allows us to check the validity of such percentages. He described five instances of hunting loss in the 1938 Akutan whaling season. By our criteria stated above, and using only the information in catcher-boat logs and Weekly Manufacturing Reports, three of these were classified in Category 4 and two in Category 3. Thus, in the absence of further information, we would have estimated that three of the five struck whales were dead or moribund when lost. The VanDeVenter report reveals that one of the Category 3 whales was lost during towing; thus it definitely was dead. Two of the three Category 4 whales actually belonged in Category 3, and VanDeVenter noted that both were 'wounded and would probably die'. The other Category 4 whale was 'only slightly wounded when harpoon glanced off its back, slightly scratching blubber. Whale should recover'. VanDeVenter did not comment on the condition of the fifth whale, a blue whale which escaped after the foregoer was cut by the vessel's propeller blade. The consistency between our estimate (three of five struck whales died) and VanDeVenter's assessment (three, or possibly four of five struck whales died) leads us to conclude that our criteria and procedures used to estimate dead or moribund loss are sound.

The opportunistic discovery of floating whale carcasses is an aspect of the two fisheries that may have offset hunting loss to a small degree. Seven occasions are noted in the Akutan logbooks of whale carcasses being found by the whalers and towed to the plant for processing. One of these carcasses had a flag in it and therefore definitely represented a hunting kill. There is no way of knowing whether the other six whales had been killed by whalers. To account for the one flagged carcass, we reduced the Category 1 total for Akutan from 13 to 12. Four salvaged

Table 9

Reported struck-but-lost whales in the Akutan and Port Hobron fisheries. Key: F_r = flagged. not relocated; L_h = lost during heaving in: L_t = lost during towing: H_d = harpoon drew: B = line or shackle parted. harpoon broke; L' = unspecified: S = carcase salvaged. See text for further explanation of column headings. Sources: 1. Catcher-boat logs: 2. Weekly Manufacturing Reports; 3. VanDeVenter (1938): 4. Station tallies; 5. General Correspondence, WSL Collection

Date	Vessel	Category: Species	1 F_r	L_h	L_t	2 H_d	3 B	U	4 S	Source
Akutan										
17.8.17	Unimak	Blue	-	-	-	-	x	-	-	1
18.8.17	Unimak	Blue		x	-	-	-	-	-	1
24.8.17	Unimak	Blue		x	-	-	-	-	-	1
25.8 .17	Unimak	Sperm							x	1
16.9.17	Unimak	Fin						x	-	1
17.9.17	Unimak	sperm					x	-	-	1
23.7.24	Paterson	Blue					x	-	-	2
25.7.24	Unimak	Blue					x	-	-	2
19.8.25	Kodiak	Blue						x	-	2
3.10.25	Aberdeen	Humpback		-	-	-		-	-	2
7.7.26	Unimak	Fin				x	-	-	-	1
10.7.26	Paterson	?							x	1
20.6.27	Unimak	Fin		-	-	-	x	-	-	2
21.6.27	Paterson	sperm		-	-	-	x	-	-	1,2
7.7.27	Unimak	Fin				x	-	-	-	1
8.7.27	Unimak	Fin			-	-	x	-	-	2
15.7.27	Paterson	?							x	1
24-30.7.27	Paterson	Humpback					x	-	-	2
2439.7.27	West port	Humpback			-	-	-	x	-	2
29.7.27	Unimak	Blue					x	-	-	2
29.7.27	Westport	Blue		-	-	-	x	-	-	2
4.8.27	Paterson	Blue			-	-	x	-	-	2
4.8.27	WestPort	2 Blues	-	-	-	-	xx	.	.	2
10.8.27	West port	Blue		x	-	-	-	-	-	2
19.8.27	Unimak	Fin					x	-	-	2
26.8.27	Kodiak	Fin					x	-	-	2
26.6.28	Westport	Blue						x	-	1
22.7.28	Unimak	Fin	x	-	-	-	-	-	-	2
4.8.28	Unimak	Right				x	-	-	-	2
16.9.28	Westport	Humpback	x	-	-	-	-	-	-	1
27.5.29	Unimak	Humpback							x	1
7.6.29	Westport	Humpback						x	-	1
8.6.29	Unimak	Blue	-	-	-		-	x	-	- 1,2
4.7.29	West port	Fin					x	-	-	- 1
21.7.29	Westport	Humpback		x		-	-	-	-	- 1
27.7.29	Unimak	Humpback							x	1
25.8.29	Pat erson	Blue						x	-	- 1,2
3.9.29	Unimak	Humpback		x		-	-	-	-	- 1
19.9.29	Unimak	Fin				-	-	x	-	- 1
22.9.29	Unimak	Fin						x	-	- 1
23.9.29	Paterson	Fin						x	-	- 1,2
27.5.X3	Paterson	Fin							x	- 1
21.6.33	Paterson	Fin				x	-	-	-	- 1
10.7.3I	Unimak	Blue							x	- 2
17.7.33	Aberdeen	Sperm	x	-	-	-	-	-	-	- 1,2
20.7.30	Aberdeen	Blue					x	-	-	- 1,2
24.7.30	Aberdeen	Blue				-	-	x	-	- 1[1],2
25.7. 30	Aberdeen	Blue						x	-	- 2
2C-22.7.	30 Paterson	Fin				x	-	-	-	- 2
2.8.3.43	Aberdeen	Blue						x	-	- 1
13.8.30	Kodiak	Sperm							x	- 2
13.8.20	Kodiak	Blue						x	-	- 2
18.8.33	Kodiak	Blue	-	-	-	x	-	-	-	2
19.8.33	Paterson	Blue						x	-	- 2
19.8.3)	Tanginak	Fin					-	-	x	- 2
19.8.33	Unimak	Blue							x	- 2
19.8.30	Westport	Blue							x	- 2
21.8.33	Paterson	Blue							x	- 2
11.9.33	Tanginak	Blue					x	-	-	- 2
11.9.33	Tanginak	Blue			-	-	-	x	-	- 2
17.9.3	Kodiak	Fin					x	-	-	- 2
17.9.33	Aberdeen	Humpback			-	-	-	x	-	- 1,2
18.9.33	Aberdeen	Fin		x	-	-	-	-	-	- 1,2
20.9.30	Paterson	Fin	-	-	-		-	-	-	- 2

Date	Vessel	Category: Species	1 F_r	L_h	L_t	2 H_d	3 B	U	4 S	Source
5.6.34	Paterson	Fin					x			1
9.6.34	Paterson	Fin					x			1
13.7.34	Westport	Fin				x				1
5.8.34	Paterson	Blue		x						1
26.8.34	Westport	Blue					x			1,2
14.9.34	Paterson	Fin	x							1,2
9.34	Moran	Fin				x				2
33.7.35	Kod iak	Humpback					x			1
17.8.35	Aberdeen	Blue					x			2
2.7.36	Unimak	Fin				x				1
5.7.36	Westport	Blue					x			2
29.8.36	Paterson	Fin					x			1,2
10.9.36	Westport	Fin						x		2
12.9.36	Paterson	Humpback	x							1,2
12.9.36	Unimak	Fin					x			1
17.9.36	Unimak	Blue					x			1
30.5.37	Unimak	Blue				x				1,2
6.6.37	Unimak	Fin				x				1,2
20.6.37	Paterson	Blue					x			1,2
23.6.37	Unimak	Blue					x			1,2
6.7.37	Paterson	Blue					x			1,2
7.7.37	Paterson	Blue					x			1,2
7.7.37	Unimak	Blue				x				1
14.7.37	Unimak	Humpback					x			1,2
14.7.37	Kodiak	Humpback	-	-	-	-	x	-	-	1,2
16 or 17.7.37	Paterson	Blue							x	1,2
24.7.37	Paterson	Blue					x			1,2
26.7.37	Kodiak	Fin				x				1,2
8.8.37	Unimak	Blue					x			1
26.8.37	Paterson	Fin					x			1
30.8.37	Unimak	Fin					x			1
18.9.37	Kodiak	Humpback		x						1
27.9.37	Kodiak	Fin							x	1,2
14.8.38	Paterson	Blue					x			2,3
28.8.38	Kodiak	Fin					x			1,3
30.8.38	Unimak	Fin				x				1,2,3
9.9.3a	Paterson	Blue					x			2,3
13.9.38	Moran	Blue						x		2
13.9.28	Paterson	Blue						x		2
9.8.39	Paterson	Fin				x				2
11.9.39	Aberdeen	Humpback				x				2
Port Hobron										
31.8.26	Aberdeen	Humpback							x	1,4
10.8.27	Tang inak	Humpback					x	-	-	1
22.6.32	West port	Blue					.	.	.	1
29,6.32	Moran	Blue	-	-	-	-	-	-	x	4
7.7.32	Westport	Humpback	-	-	-	-	-	-	x	1
16.8.32	Paterson	2 Humpbacks	-	-	-	-	-	-	xx	1
19.5.34	Aberdeen	Blue	-	x	-	-	-	-	-	1
28.5.34	Tanginak	Humpback	-	-	-	-	x	-	-	1
5.6.34	Aberdeen	Humpback	-	-	-	x	-	-	-	1
17.7.34	Aberdeen	Fin	x	-	-	-	-	-	-	1
24.7.34	Tanginak	Humpback	-	-	-	x	-	-	-	1
17.6.35	Aberdeen	Blue	-	-	-	-	x	-	-	1[2]
6.35	Tanginak	2 Blues	-	-	-	-	-	-	-	5[3]
X).8.36	Moran	Blue	-	-	-	-	x	-	-	2
12.6.36	Aberdeen	Humpback	-	-	-	-	-	-	x	2

[1] Catcher-boat log does not mention loss of this whale: 'Shot a blue whale alongside Full Speed'.

[2] Catcher-boat log does not specify, but letter from Port Hobron station manager. dated 24 June 1935. states tbe whale 'went right out and snapped the foregoer' (General Correspondence. Box 2. WSL Co]],).

[3] In letter from station manager to American Pacific Whaling Co,. dated 18 June 1935, due to 'Spring cable parting'.

carcasses—all of humpbacks—were reported in the available Port Hobron logbooks. No flags or other whaling gear were mentioned as having been found in association with these carcasses. Although we recognize that some of the salvaged carcasses (in addition to the one at Akutan) may well have represented hunting kills, we chose not to correct further our struck-but-lost totals. Because so few salvaged carcasses are involved. the possible error caused by not correcting for them should be slight.

All struck-but-lost whales reported in the two logbook samples were identified to species. For Akutan, there were 6 humpbacks, 4 blues, 6 fins. and 1 sperm in Category 1:10 fins, 5 blues. and 1 right in Category 2; 16 fins. 30 blues, 5 humpbacks, and 2 sperms in Category 3; and 3 fins, 5 blues,

2 humpbacks, and 1 sperm in Category 4. For Port Hobron, Category 1 contained 1 blue whale and 1 fin whale; Category 2, 2 humpbacks; Category 3,2 blues and 2 humpbacks; and Category 4, 1 blue.

Since we can be relatively certain that *all* struck-but-lost-whales are noted only for vessel-seasons or portions of vessel-seasons covered by an available catcher-boat log, we used only these data to calculate a hunting loss rate for the fishery. The estimated total of whales killed but lost in the combined Akutan-Port Hobron logbook sample is 45. The secured catch covered by available logbooks is 2,426 whales. Thus, the reported total catches of the two fisheries should be multiplied by 1.02 to estimate total whales killed. The killed-but-lost component was approximately 1. 80/0 of the landed catch.

Interpretation of Trends in Catch

There are only three Akutan logbooks available for years before 1926. All three are for the *Unimak*—1917, *1923* and 1924. This meager coverage for the early period of the Akutan fishery is unfortunate. It means that the availability y of preferred species, particularly the blue whale, may already have been reduced before 1926, the year for which a large enough sample of logbooks is available to begin detailed CPUE analysis. Since the blue whale was always a preferred species, the fact that 491 were taken at Akutan in the eight years (32–34 vessel-seasons) 1917–25, and only 343 in the 11 years (53 vessel-seasons) 1926-39 suggests a greater availability before 1926 than after.

The 1917 *Unimak* logbook is especially impressive. From 1 August to 20 September (including 45 days in which some searching or chasing occurred), the *Unimak* took 10 blue whales, 37 fin whales, eight humpbacks, and one sperm whale. In addition, five whales were struck but lost, and one sperm whale killed by another vessel was found and towed to the station. Thus, the *Unimak* averaged well over one whale secured per day during the latter half of the whaling season.

It is also important to bear in mind that other shore stations as well as some pelagic floating factories were operating in the North Pacific contemporaneously with the Akutan and Port Hobron stations (Tønnessen, 1967-70; Tønnessen and Johnsen, 1982). There is no reason to believe the whales hunted near these two stations belonged to separate stocks, or that these stocks were different from those being exploited elsewhere in the North Pacific. With respect to blue whales for example, Rice (1974) postulated that some of the animals occurring on the whaling grounds off Vancouver Island in June proceed as far north and west as the eastern Aleutians later in the summer. At least 367 blue whales were taken at British Columbia shore stations from 1911 to 1942 (Pike and MacAskie, 1969, Appendix I). Movement by a blue whale from the eastern Sea of Okhotsk to waters east of Kodiak Island, documented by tagging data (Ivashin and Rovnin, 1967; also see Omura and Kawakami, 1956; Omura and Ohsumi, 1964; Ohsumi and Masaki, 1975), demonstrates that even catches from the west side of the North Pacific could involve whales that, in other years or at other times of year, might be encountered off Akutan or Port Hobron. Thus, the 1,439 blue whales taken off Japan and Korea from 1910/11 to 1940/41 (Tomilin, 1957 [1967, p. 109]) may have included whales that otherwise would have been available to the Akutan or Port Hobron whalers,

Previously, we discussed the published evidence concerning stock relationships for fin, humpback and sperm whales in the North Pacific (Leatherwood *et al.* 1983). None of the stocks hunted near Akutan or Port Hobron can be considered as a closed population; thus, any analysis of trends in the catches at these stations must take into account the potential impact of whaling operations along the west coast of North America south of Alaska, pelagic whaling in the North Pacific, and in some cases even coastal whaling in east Asia.

A detailed analysis of catch-per-unit-of-effort, covering years for which adequate logbook data are available (1926-39), has been completed (Leatherwood, Reeves and Karl, 1985 Ms).

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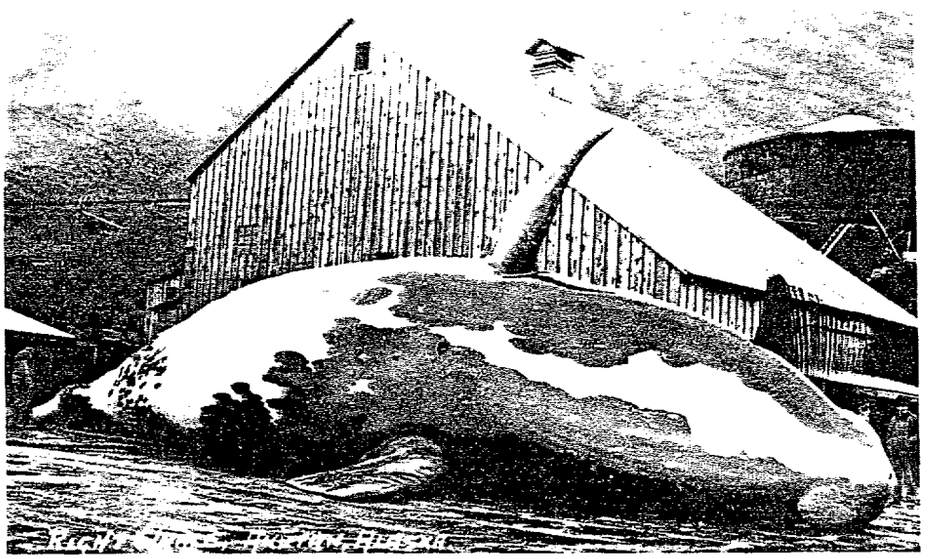
III. TRENDS IN CATCHES AT THE AKUTAN AND PORT HOBRON, ALASKA SHORE STATIONS (1912-1939)

The report on this portion of subject contract was submitted to the sponsor in May 1985 and was subsequently presented at the 36th annual meeting of the IWC Scientific Committee, held in Bournemouth, U.K. between 24 June and 13 July 1985. It was also submitted to the Scientific Reports Whales Research Institute, Tokyo, for consideration for publication. The revised draft, incorporating all reviewers comments, is presented here in its entirety.



A right whale on the flensing deck at the Akutan, Alaska whaling station, date unknown. Though prized, right whales were rarely taken at either Akutan or Port Hobron (Alaska postcard, Alaska Historical Library, courtesy Ms. Verda Carey).

TRENDS IN CATCHES AT THE AKUTAN AND PORT HOBRON (ALASKA) WHALING STATIONS, 1912-39

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ABSTRACT

Catch and effort data from the shore whaling stations at Akutan . (1912-39) and Port Hobron (1926-37), Alaska, were examined for quantitative evidence of trends in whale availability over time. Both fisheries were principally for humpback (Megaptera novaeangliae), fin (Balaenoptera physalus), blue (B. musculus), sperm (Physeter macrocephalus), and right (Eubalaena glacialis) whales. Fin whales predominated in the catch at Akutan and humpbacks in the catch at Port Hobron.

Three approaches, each employing a progressively more refined measure of effort, were used to calculate catch-per-unit-of-effort (CPUE). CPUE-I, Catch Per Gross Catcher Day, was defined as the total number of whales taken (no attempt was made to separate the five principal species) in a given year divided by the total catcher days in that year. CPUE-I was calculated for both Akutan and Port Hobron. Other CPUE calculations were possible (or meaningful) only for Akutan. CPUE-II, Catch Per Gross Daylight Hour at Sea, was defined as the total number of whales taken in a given year, divided by the total number of daylight hours spent at sea in that year by all vessels. CPUE-III, Catch per Hour of Searching and Chasing, was defined as the total number of whales taken during vessel-seasons covered by available Catcher-boat Logs divided by the total number of hours spent Searching and Chasing. Three CPUE-III estimates were calculated, one with no correction for weather conditions (A), one corrected only by eliminating effort (Searching and Chasing) in 'unacceptable" weather conditions (B), and one corrected by eliminating all effort except that in "good to excellent weather conditions (C).

At Akutan, a steep decline in CPUE occurred after the 1915 whaling season. From 1916 to 1927, it remained fairly stable (CPUE-I: 0.41-0.80; CPUE-II, 1924-27 only: 0.034-0.062). With CPUE at relatively low levels from 1928 to 1930 (CPUE-I: 0.24-0.30; CPUE-II:0.022-0.023; CPUE-III: A, 0.026-0.033, B, 09032 0.040, C, 0.035-0.061), the whaling operations at Akutan were suspended for three years. Some improvement in CPUE was experienced after whaling resumed in 1934 (from 1934 to 1939, CPUE-I: 0.28-0.51; CPUE-II: 0.022-0.041; CPUE-III: A, 0.027-0.055, B, 0.036-0.061, C, 0.040-0.078), but it never again approached the levels reached prior to 1926. There was no similarly convincing downward trend in CPUE at Port Hobron, with CPUE-I values ranging from 0.33 to 0.82 during the n-year lifetime of the fishery. However, the mean value for the last three years of the Port Hobron fishery (0.43 for 1935-37) was substantially less than the means for the two preceding three-year periods (0.69 for 1932-34 and 0.63 for 1928-30).

Catches and CPUE values were highest during the middle months of the whaling season at both stations, June to September at Akutan and June to August

at Port Hobron. The differences could be due either to seasonal changes in weather conditions or to fluctuations in whale density. These possibilities should be borne in mind while interpreting year-to-year changes in CPUE, as skewness of effort toward a particular part of the whaling season could affect CPUE calculations significantly.

In studies of other whale fisheries a decrease in mean length of whales caught has been interpreted as a sign of depletion. No significant decrease occurred in mean lengths of whales taken at Akutan and Port Hobron, post-1923.

The average distance from the Akutan station to the catch position of fin and humpback whales was significantly greater during 1934-39 than during 1924-30. Catches of blue and humpback whales were made at a significantly greater average distance from Port Hobron in 1932-37 than in 1926-30. Such changes can be taken as indicative of reduced availability.

Size (tonnage) and power (hp) of the seven catcher-boats involved in the Akutan and Port Hobron fisheries were similar. Although a crude CPUE analysis was done to evaluate their relative efficiencies, no major differences were found that could help to explain changes in fishery-wide CPUE.

Cumulative catches demonstrate that at least 3,000 large mysticetes and 100 or more sperm whales were on the grounds of each station when they began operations.

Large catches were made contemporaneously in other areas from what were probably the same stocks as those fished at Akutan and Port Hobron. In addition, very large catches were made by pelagic expeditions in the North Pacific after World War II. Thus, the apparently low density of large whales on the former Akutan whaling grounds today is likely due to the combined efforts of several fisheries spanning many years before, during, and after the period when the two stations considered here were in operation.

INTRODUCTION

Several modern shore-whaling operations exploited whales in the southeast Bering Sea and northern Gulf of Alaska during the first half of the twentieth century (Tønnessen and Johnsen, 1982). One, based at Akutan Island from 1912 through 1939, involved whales within an approximately 100 nm (185 km) radius of the station on both the Bering Sea and North Pacific sides of the Aleutian Islands. The other, operating from Port Hobron (on Sitkalidak Island, off southeast Kodiak Island) from 1926 through 1937, hunted within an approximately 100 nm (185 km) radius of the station in the Gulf of Alaska (Figure 1). Seven different catcher-boats, similar in design and capabilities, were used at these two stations (Table 1; Figure 2). Akutan and Port Hobron had a total combined landed catch of approximately 8,545 whales, mainly humpback (Megaptera novaeangliae), at least 3023; fin (Balaenoptera physalus), at least 2962; blue (B. musculus), at least 1050; sperm (Physeter macrocephalus), at least 569; and right (Eubalaena glacialis), at least 21. In an earlier paper, we summarized published and archival. data on these fisheries and compiled information on their catches (Reeves, Leatherwood, Karl and Yohe, 1985).

Recent aerial surveys have indicated low levels of whale abundance on and near the former whaling grounds (Leatherwood, Bowles and Reeves, 1983; Stewart, Yochem, Karl, Leatherwood, and Laake, 1985 MS). Can this apparent scarcity of whales be explained, at least in part, by over-exploitation in local shore-whaling operations over 40 years ago? In the present paper, we analyze the Akutan and Port Hobron catch and effort data in an attempt to identify and describe trends in apparent availability of whales.

Use of catch-per-unit-of-effort (CPUE) calculations to support inferences about whale stock size is controversial (e.g. Allen, 1980c; Cooke, 1985). In general, a significant decline in CPUE usually can be taken to indicate a reduction in stock size, whereas the lack of a significant decline in CPUE could mean several things. The stock or stocks being fished could be capable of sustaining the level of removals. Factors such as experience of personnel or technological improvements could be enhancing the efficiency of the catcher-boats, thus preventing a decline in CPUE in spite of decreased whale abundance. Since whale distribution almost certainly is not uniform or random, "schooling effects" could mask changes in population abundance (Allen, 1980a, b).

There are several complicating factors in the Akutan and Port Hobron fisheries. One is their multispecies character. It is possible that as a preferred species, like the blue whale, became scarcer, the whalers redirected their efforts to catching less desirable species, such as fin and humpback whales. As noted previously (Reeves et al., 1985), regulations appear to have begun affecting whaling activities at Akutan by 1935. For example, the Akutan station manager noted in his Weekly Manufacturing Report for 16 September 1939 that the Aberdeen had reported seeing 20 humpbacks 50 mi southeast of Rootok Island which were "all too small". Thus, it is necessary to bear in mind that during the second half of the 19301s, some whales which were encountered (e.g. right whales and under-sized humpbacks) were not taken because of legal restraints. This factor would likely have had a negative effect on CPUE.

Finally, there is reason to believe that contemporaneous shore fisheries elsewhere in Alaska, off British Columbia, Washington, and California, and in the western Pacific (Tønnessen and Johnsen, 1982) were also removing whales from the stocks fished off Akutan and Port Hobron (for evidence of stock identity, see Rice, 1974; Ivashin and Rovnin, 1967; Kawakami and Ichihara, 1958; Nasu, 1974; Ohsumi and Masaki, 1975; Darling and McSweeney, 1985). Thus, it is unlikely that declines in CPUE were due only to overfishing at Akutan and Port Hobron; rather, they probably were due, at least in part, to a more widespread whaling effort.

Recognizing the many limitations implicit in CPUE analyses, we nevertheless made several CPUE calculations for these two stations. A steep or consistent decline in CPUE would at least provide a basis for beginning to explain the apparently low density of large whales in the region today. On the other hand, if CPUE did not decline significantly in either fishery, it would become necessary to look closely at other possible explanations.

MATERIALS AND METHODS

Nature of Materials

The principal source for data used in the present analysis was the William S. Lagen Collection in the Manuscripts and University Archives Division, University of Washington Libraries, Seattle. Details on the contents of that collection were provided by Reeves et al. (1985). Here we use the same terminology for unpublished items, and anyone wanting more bibliographic detail is referred to that paper[1]. For the present study the most important items were Station Tallies (sequential listings of details on all whales landed, which provided most catch data, supplemented in some years by other sources), Weekly Manufacturing Reports (chronological summaries of station activities which provided information on arrivals and departures of the catcher vessels at the stations - Figure 3), and Catcher-Boat Logs (journal notes by the vessel captain or another officer providing details of whaling activity).

Station Tallies were available for the years 1924-30 and 1934-39 at Akutan and 1926-30 and 1932-37 at Port Hobron. Weekly Manufacturing Reports were available for the years 1919-20, 1922-30 and 1934-39 at Akutan and 1935-37 at Port Hobron. The sample of Catcher-Boat Logs available for Akutan is very limited for years before 1926, and for *only* one year after 1925 is there complete coverage (i.e. all vessels for the entire whaling season) (Table 2). The Port Hobron logbook sample provides spotty coverage for early years and more complete coverage for later years (Table 2).

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[1] All materials assembled for these studies have been donated to the Alaska Historical Library, Juneau, AK.

Data Extraction Procedures

Details on the whale catches from 1926-on were extracted from Station Tallies and stored in a computer. Relevant to the present paper, these included date, position, species, total length, and sex of all whales landed at the two stations. To facilitate sorting of catch data for CPUE analyses, a coded entry for each whale caught was used to indicate whether or not a Catcher-Boat Log was available for the vessel and period in question.

In the Weekly Manufacturing Reports, the station manager noted times of arrival at and departure from the station by each catcher-boat during the course of the whaling season (Figure 3). These times were extracted from the reports and corrected for daylight hours by reference to the appropriate "Sunrise and Sunset" tables for Kodiak and Cold Bay, prepared by the Nautical Almanac Office, U. S. Naval Observatory, Washington, DC. Thus, for a given vessel we could calculate the Gross Daylight Hours at Sea, at least for years covered by an available Weekly Manufacturing Report. The reports contain some information on weather conditions, boat activities such as time spent in anchorage away from the station (e.g. at Dutch Harbor, Chernofsky Harbor, etc.), and repair operations. However, because this information was provided only sporadically and in an inconsistent format, we did not attempt to correct the Gross Daylight Hours at Sea any further.

Data extracted from Catcher-Boat Logs were encoded and stored in a computer.. All catcher-boat activity was classified as either Transiting, Searching, Chasing, Heaving-in, or Towing time. For ease of analysis, times were. rounded to the nearest half hour. Unless otherwise noted in the logbooks, it was assumed that vessels were always traveling at full speed. Although not finally used in analysis, information on vessel speed was extracted, encoded, and stored in the dichotomous format Full vs. Less than Full.

Transiting was difficult to define and infrequently assigned. If a vessel was found to have maintenance problems at sea, for example, its direct trip into port for repairs was considered Transiting time. Also, if a vessel assumed a direct course toward a protected anchorage to await an improvement in weather or sea conditions, its trip to the anchorage was scored as Transiting time.

Searching was the most common activity. We generally assumed that, even if the chances of finding a whale may have seemed slight during the trip out from the station to a favored bank or grounds, the crew was Searching and prepared to give chase. Often after a kill, the carcass would be flagged or anchored, and the vessel would resume Searching. A difficulty of definition which frequently arose was how to assign time spent Towing, when the possibility existed of encountering and chasing a whale while en route to the station. Such situations required the reader to make a subjective judgment. In general, the whalers tried to deliver whales to the station within 48 hours after they were killed (for example, see notations on bottom of Figure 3). Also, whales were often towed at night and in inclement weather. There seemed to be less of an inclination to search while two or more whales were in tow, and when more than 24 hours had elapsed since the whale(s) in tow was (were) killed. As pointed out by Rørvik (1980), some Searching can also occur during Chasing and Heaving-in, but we had no way of making such a distinction.

Chasing was easily defined in most logs. Keepers of the logs usually noted times when Chasing began and ended, whereas, they did not generally state explicitly when they were looking for whales (Searching) or Transiting. In some logbooks, Chasing is noted infrequently or not at all. Thus, a period of apparent Searching rather than Chasing immediately precedes each kill. so that the failure to specify Chasing times in some logbooks would not affect our results, we lumped Searching and Chasing times for our analyses, even though in some CPUE analyses Chasing is considered part of handling time (e.g. Allen, 1980c; Cooke, 1985).

Heaving-in periods were considered to begin when a whale was struck. There were unusual instances, usually involving blue whales, of Heaving-in periods lasting three or more hours. Most were in the range of 0.5-1.5 hours. Heaving-in ended when the whale was noted to be "alongside" or when the whale was 'flagged" and left to be picked up later.

Towing began once the killed whale was "alongside". As noted above, a Towing period could be short (ca 0.5 hr) when a carcass was taken to a nearby bay and temporarily anchored while the vessel resumed Searching and Chasing unencumbered. Also, periods of apparent Towing could be interrupted when the carcass was 'flagged" and a new chase begun. In the latter instances, we re-assigned the apparent Towing period as Searching time. Towing periods ended when the vessel arrived at the station or delivered its catch to a buoy in the station's harbor.

For all our analyses (see below), we defined Transiting, Heaving-in and Towing as handling time. Along with time spent at anchor or in port, handling time was considered to be 'off-effort". Thus, Searching time and Chasing time are what constituted effort.

In addition to data on catcher-boat activity, we extracted from the Catcher-Boat Logs information on weather and sea state. The logbooks contain such information in varying degrees of detail. In order to accommodate this variability, we devised three broad categories, to one of which all periods of whaling activity were assigned: Good to Excellent: Smooth to moderate seas; clear to hazy visibility; cloudy, partly cloudy, or overcast, but with no mist or rain; light and variable to moderate winds. Acceptable: Choppy sea; misty or rain squalls; fog banks or patches; fresh to strong winds; small to large swell. Unacceptable Rough sea; heavy rain; " thick" or foggy; gale-force winds; 'heavy" or very strong winds.

Analytical Approaches

CPUE Calculations

Our examination of trends in the Akutan fishery was partly based on calculations of CPUE by year. Three basic methods, each employing a progressively more refined measure of effort, were used to calculate CPUE. We have labeled them, according to the unit of effort used, as follows:

CPUE-I : Catch Per Gross Catcher Day

Catch is defined as total whales landed by all catcher boats in the year (Tables 3 and 4; also see Reeves et al., 1985, Tables 1 and 2). A few catches (4 at Akutan and 9 at Port Hobron) of non-target species, such as gray whales (Eschrichtius robustus), sei whales (B. borealis), minke whales (B. acutorostrata), and killer whales (Orcinus orca), are included. The whalers' motivation for taking occasional specimens of non-target species is not clear to us. In the Weekly Manufacturing Report of Port Hobron for 3 July 1937 it is noted: "Sei whale caught for Govt Inspection ran almost as much oil as Finback." No correction has been made for whales struck but lost. Not only was this component a very small part of the kill (estimated as 1.8 percent by Reeves et al., 1985), but we assume the struck-but-lost rate *was* relatively constant over the life of the fishery and thus would have had little effect on comparisons among CPUE values.

Effort for each vessel in a given season is defined as the number of days from the first day it departed the station for whaling to the last day it returned to the station (Table 2). Overall effort at the station is defined as the sum of days for all vessels operating there in a season. This measure of effort is uncorrected for day length, weather conditions, idleness caused by accident or equipment failure, or handling time.

CPUE-II: Catch Per Gross Daylight Hour at Sea

Catch is defined as total whales landed by all catcher boats in each year for which Weekly Manufacturing Reports were available.

Effort is defined as the total hours away from the station during daylight hours for all vessels whaling from the station that year, based on arrival and departure times given in the Weekly Manufacturing Reports.

CPUE-III: Catch Per Hour of Searching and Chasing

In this *case* it was possible to calculate three separate values, each corrected in different ways for weather conditions.

A. Catch was defined as total whales landed by catcher-boats during periods for which logbooks were available, effort as total hours those vessels spent Searching and Chasing.
B. Catch and effort were defined as in "A" above but eliminating catches and effort in weather conditions classified as unacceptable (Category 3, above).

C. Catch and effort were defined as in "A" above but eliminating catches and effort in weather conditions classified as acceptable (Category 2) and unacceptable (Category 3).

Other Analyses

Four further aspects of the two fisheries were examined. We looked for changes over time in (1) length-frequency of whales caught, (2) species composition of the catch, and (3) geographical distribution of all catches relative to the station. Where appropriate, we tested annual differences statistically to evaluate their significance. Total monthly catches of each species, by sex, were tabulated and graphed. These data were not treated statistically, but rather were examined for impressions of seasonal changes in availability.

RESULTS AND DISCUSSION

CPUE-I

During the first three years of the Akutan fishery (1912-15), when only two vessels were operating (Table 2), CPUE-I was greater than 1.0 whales caught per Gross Catcher Day (Table 3). A steep decline in CPUE-I (to 0.55) occurred in 1916, when a third catcher-boat was added to the fleet (Figure 4). After 1916, there were only two years in which CPUE-I was above 0.70 (1919 and 1925), and it never rose above 0.51 after 1925. Although there appears to have been a downward trend in whale availability from 1925 to 1930, CPUE-I remained relatively stable from 1934 through 1939. The 3-year hiatus in whaling at Akutan from 1931 to 1933, said to have been caused by low oil Prices (Bower, 1932, p. 70), was preceded by three of the leanest years in the history of the fishery, in terms of both total catch (127-160 whales per year) and CPUE-I (0.24-0.30). Catches and CPUE-I showed some improvement after whaling resumed in 1934 (Figure 4).

CPUE-I was the only CPUE treatment attempted for Port Hobron (Table 4, Figure 5). During the eleven years of this fishery, CPUE-I values were never as high as they were in the early years at Akutan. The highest levels, 0.72-0.82, were attained in 1930-34, at about the middle of the Port Hobron station's active lifetime. CPUE-I reached its lowest levels during the fishery's last three years.

CPUE-II

Trends in CPUE shown by this approach are virtually identical to those shown by CPUE-I (Table 3, Figure 4).

CPUE-III

As this type of CPUE analysis depends on the availability of Catcher-Boat Logs, little could be done for years prior to 1926. Calculations based on the Unimak's 1917 season, the only vessel-season substantially covered by a Catcher-Boat Log before 1924, resulted in much higher CPUE-III values than those

obtained for 1924-39. Note that we do not consider the results for 1923 to be meaningful, as they are based on only the last month of the Unimak's whaling season that year (Table 2). Results for 1924-39 show no definite trend of increasing or decreasing CPUE.

As shown on Figure 4, the three alternate approaches - CPUE-III A, B, and C - give consistent results even though each uses a different measure of effort. Hunting efficiency clearly was higher in favorable than in unfavorable weather conditions, but there is no reason to believe, based on these data, that appreciation of trends in CPUE is enhanced by correcting for weather. There appears to be no particular advantage in correcting for either handling time or weather conditions.

Comparisons

We were unable to conclude that any one of our three approaches to calculating CPUE, was better than another, at least for showing overall trends in whale availability. It is unfortunate that there is such meager coverage by Catcher-Boat Logs for years prior to 1926 and that Weekly Manufacturing Reports are not available for years before 1919. These inadequacies in the data make it impossible to corroborate the dramatic decline indicated by CPUE-I for Akutan after 1915.

CPUE Results from VanDeVenter (1938)

VanDeVenter (1938), the Coast Guard inspector at Akutan in 1938, used company records to calculate catch per day per boat (essentially our CPUE-I) for 1924-38 (Table 3). As the records to which he had access did not include information on sperm whales, his CPUE was based only on the catches of mysticetes. Although his CPUE indices are, as a consequence, consistently lower than ours, they nevertheless follow a similar curve. VanDeVenter noted that after the peak in catch per day per boat attained in 1925, a 'steady decline" was evident through 1930, when an 'all-time low' of 0.16 was reached. He attributed the suspension of operations after the 1930 season to "the poor showing made that year"; this contrasts with the statement by Bower (1932, p. 70) that the suspension was due to "the low prices on whale oil". VanDeVenter's calculations showed some improvement after whaling resumed in 1934, but by 1938 the CPUE was back down. In the Coast Guard inspector's opinion, the CPUE data "should not be considered as too conclusive as the weather plays a great part in the success of the individual season." Our weather-corrected CPUE (III B and C) indices are consistently higher than the uncorrected values (CPUE-III A). The weather in 1938 was "extremely unfavorable", and VanDeVenter considered the relatively poor catch that year to be 'due to this cause and not to an increasing scarcity of whales". In 1939 the catch did improve, giving some of the higher post-1934 indices for Akutan (Table 3).

Characteristics of Catcher-Boats

It is widely recognized that CPUE can be affected by changes in catcher-boat efficiency (Allen, 1980c, p. 66-7). According to Rørvik et al. (1976, p. 23), efficiency is determined by the time required to catch whales on the grounds and by the time needed to steam between the grounds and the factory ship or land station. These authors felt that tonnage and speed influenced catching time more than transiting time, and that these factors would thus make a greater positive difference in pelagic whaling than in shore whaling. In the Icelandic fin whale fishery, they found that a high percentage of operation time was spent in traveling to and from the grounds and thus that catcher efficiency did not necessarily increase in proportion to vessel tonnage.

Since a varying suite of catcher-boats operated at Akutan and Port Hobron from year to year, it is important to establish the vessels' equivalence or interchangeability. Otherwise, CPUE would likely be affected significantly according to which boats were assigned to a station in a given year.

The seven vessels involved in the fisheries had similar power ratings, all between 325 and 375 hp (Table 1). Tonnage varied somewhat more widely, from 116 (Aberdeen) to 151 gross tons (Unimak). We do not know how speed capabilities of the seven vessels compared. No major improvements in whaling technology (e.g. use of aircraft to spot whales, ASDIC, etc.) were introduced, to our knowledge, during the course of the two fisheries. Although the fleet appears to have been fairly homogeneous with respect to size and power of the vessels, we attempted to test its homogeneity using actual catch results, as recommended by Cooke (1985).

Catches by each vessel during 1924-39 were extracted from Station Tallies; Gross Catcher Days were determined for each vessel for the entire period 1924-39, using information in Table 2. In ascending order, the resulting crude CPUE indices for the seven vessels were: Westport 0.549, Aberdeen 0.587, Unimak 0.602, Tanginak 0.617, Kodiak 0.620, Moran 0.658, and Paterson 0.716. It is not possible to evaluate these differences statistically. There is no obvious correlation between the known characteristics of vessels (Table 1) and their respective efficiency ratings. The above CPUE values could be influenced by many factors, among them the capabilities of captains, gunners and other crew members, and the time at which each vessel entered the fishery. Those that entered late may have benefited from the previously accumulated knowledge about whale distribution; on the other hand, they may have been hunting less abundant and more wary stocks of whales than had their predecessors.

Changes in Mean Length of Whales Caught

Declines in the mean length of fin whales caught off Norway (Jonsgaard, 1958) and of blue and fin whales taken in the Antarctic (Laws, 1960, 1962) have been interpreted as evidence of declining stocks. There was no obvious downward trend in mean lengths of males or females of any species at Akutan or Port Hobron after 1924 (Figures 6 and 7). Regressions on mean lengths of male and female blue, fin, humpback, and sperm whales, by year, at both Akutan and Port

Hobron resulted in low correlation coefficients (all between -0.27 and- +0.27) and very low R values (<0.0721). Thus, this index does not indicate that any of the stocks exploited at the two stations was depleted.

Catch Composition

The Akutan and Port Hobron whale fisheries were principally for balaenopterids, even though sperm whales were preferred over balaenopterids by Alaska shore whalers before the early 1920's (Reeves et al., 1985). Right whales always were highly valued, but their low numbers on the whaling grounds meant that they had little effect on catch composition. At Akutan, blue whales predominated in two and humpbacks in three of the 20 years for which catch data by species are available. In all other years, fin whales comprised the highest percentage of the catch. No dramatic or consistent changes in catch composition are indicated by Figure 8. The increase in percentage of sperm whales after 1934 appears to be associated with a slight increase in the percentage of blue whales, which may mean that the catcher-boats began working farther offshore at that time. On average, blue whales and sperm whales were taken farther offshore at Akutan than were fin whales and humpbacks (see below; also see Birkeland, 1926, p. 131).

The Port Hobron station clearly specialized in catching humpbacks (Figure 9). In all years except 1937, humpbacks comprised the highest percentage of the catch. Fin and blue whales were consistently next behind humpbacks, until 1935-37 when sperm whales increased in importance. There is no ready explanation for the high percentage of humpbacks in the Port Hobron catch, other than to assume that they were much more common on the whaling grounds than were the other species. Judging by the bonus schedule for the period 1925-39, blue whales and right whales were always more valuable than humpbacks; humpbacks were never more valuable than fin whales; and for most of the period 1926-37, sperm whales exceeded humpbacks in value (Reeves et al., 1985, Table 5).

The percentage of blue whales in the catches at both stations was consistently lower than those of fin whales and humpbacks. Since a blue whale was twice as valuable to the whalers as a fin whale or a humpback (Reeves et al., 1985, Table 5), it is fair to conclude that blue whales were generally less available (or at least less catchable) than fin whales and humpbacks on both stations' grounds between 1917 and 1939. VanDeVenter (1938, p. 2) considered his chart showing percentage of catch by species at Akutan (mysticetes only) to indicate "the percentage of the total number of whales appearing on the grounds as represented by each species." He concluded that 'beyond this, little of value can be determined other than the fact that the Finbacks predominate and that the Blues seem to be holding their own."

Changes in Average Distance From the Station to the Catch Position of Whales

Individual humpbacks, and possibly some other mysticetes, return annually to a specific part of the summer feeding grounds (Baker and Herman, 1984; Mayo, 1983; Katona et al., 1980; Darling and McSweeney, 1985). If this was trUe of

the stocks fished at Akutan and Port Hobron, those individuals homing on areas closest to the whaling stations probably would have been encountered and killed first. The catcher-boats could have made their catch closer to the station in the earliest years of the fishery, but would have had to range farther from port as groups of whales occupying nearby areas became depleted or exterminated. Such a trend presumably would increase the amount of time required at sea and thus would be reflected in most CPUE analyses (unless the efficiency of catcher-boats was improving). It should also be possible to detect such a trend simply by plotting the average distances from the station to the catch positions of whales over time (e.g. Mitchell et al., 1981).

There were differences between species in the distances of catch positions from the stations (Table 5). Blue whales (n = 415) were taken at a mean distance of 51 ± 16 nm from Akutan and 54 ± 17 nm (n = 166) from Port Hobron. On average, fin whales were taken much closer to the station than blue whales at Akutan ($\bar{x}$ = 39 nm, s.d. = 21.5, n = 1217) but not at Port Hobron ($\bar{x}$ = 57.5 nm, s.d. = 22, n = 410). Humpbacks were taken relatively close to both stations, at a mean distance of 37 ± 16 nm (n = 775) at Akutan and 35 ± 16 nm at Port Hobron (n = 1387). Sperm whales were taken at about the same distance from shore as blue whales at Akutan ($\bar{x}$ = 51 nm, s.d. =15, n = 360; also see Birkeland, 1926, p. 131) but substantially farther away than all other species at Port Hobron ($\bar{x}$ =66 nm, s.d. =7, n = 79).

Data on kill positions were available only for years after 1923. Thus, for statistical comparisons we designated a middle period (1924-30) and a late period (1934-39) for Akutan (Figure 10); an early period (1926-30) and a late period (1932-37) for Port Hobron (Figure 11). A two-way univariate analysis of variance indicated significant increases in average distance for blue whales and humpbacks at Port Hobron (in both cases, $p < 0.001$). The average distances from the Akutan station of kills of fin and humpback whales were significantly greater after 1934 than they were during 1924-30 (in both cases, $p < 0.001$). Sperm whales were killed at shorter distances in the late period than they were in the middle period.

If, as suggested by Mitchell et al. (1981), evidence of the whaling grounds shifting farther away from the station can be taken to indicate decreased availability of whales, then these data show a reduced availability of blue whales and humpbacks at Port Hobron and a reduced availability of fin whales and humpbacks at Akutan during the periods covered by Station Tallies.

Seasonal Differences in Catch

The Akutan and Port Hobron catch data suggest a strong seasonal pattern of matchability, with highest catches made in June-September or June-August, respectively (Tables 6 and 7). Regardless of whether this pattern is due to variable density of whales or to climatic factors, it is necessary to consider its possible effect on CPUE. For example, CPUE-I at Port Hobron reached the highest levels in 1930 (0.79), 1933 (0.82), and 1934 (0.72), all years when whaling began after 14 May and ended before 14 September (except for two vessels which began on 8 May in 1930) (Table 2).

It is possible that the relatively low catches in May, September (Port Hobron only), and October are due to a relative lack of whaling effort in these months. However, we calculated CPUE by month using Gross Catcher Days (from Table 2) to denote effort (i.e., CPUE-I), for both stations. Differences in CPUE between months followed essentially the same pattern as catches (Tables 6 and 7). Thus it can be assumed that high CPUE values for years when the whaling season was truncated at either or both ends can be attributed in part to the relatively good weather of the middle months or to increased whale densities caused (perhaps) by migratory influxes.

At Akutan, the catch of blue whales was highest in June and August, while that of fin whales peaked in August and September. The apparent availability of humpbacks was fairly constant from June through September, that of sperm whales from June through August (Figure 12). At Port Hobron, most blue whales were taken in June-August, most fin whales in July-August. Humpbacks were consistently available from May through October, but a strong peak in catch occurred during July (Figure 13).

Cumulative Catch

The changes in trajectory of the lines shown in Figures 14 and 15 give some idea of year-to-year changes in the catch of each species. Since such changes could be due to variation in effort, Gross Catcher Days were plotted on the same graph for ready comparison.

There is no evidence, except perhaps for blue whales, of a steep decline in population size over the course of the Akutan fishery. Thus, any estimate of "initial" (1911) population size based on cumulative catches in this fishery is likely to be very conservative, and so to offer little insight on the status of stocks. Nevertheless, considering the low densities of whales seen on the whaling grounds recently (Leatherwood et al., 1983; Stewart et al. 1985 MS), even very conservative estimates of 'initial" population size may help to demonstrate depletion. For each of the four major species and the right whale, we summed catches over a peak 10-year period at Akutan, at Port Hobron, and at the two stations combined (Table 7). Because of the low net recruitment rate assumed for most large mysticetes and the sperm whale (0.07 or less), it is possible to disregard recruitment over a 10-year period, particularly when it is clear that substantial numbers of whales remained at the end of the period, as evidenced by the continuing catches. From these totals, we estimate there were at least 500 blue whales, 1,500 fin whales, 1,000 humpbacks, and 300 sperm whales on the Akutan whaling grounds in 1917, after four years of intensive whaling. On the Port Hobron grounds, there were at least 45o blue whales, 1,000 fin whales, 1,500 humpbacks, and 100 sperm whales when that fishery opened in 1926. In other words, a minimum of about 3,000 large mysticetes and 100 or more sperm whales was present on each of the grounds in the early years of the fisheries.

SUMMARY AND CONCLUSIONS

Considered together, results of this study suggest that the availability of large whales to the Akutan whaling station declined after the first several years of whaling, then remained stable or declined more gradually through the late 1920's. The three-year period of closure, 1931-1933, seems to have made a slight positive difference in whale availability. A less dramatic decline in whale availability appears to have occurred at Port Hobron, although the low CPUE levels in the fishery's last three years could well mark the beginning of what would have been a downward trend had whaling continued.

It is interesting to consider how whaling at these two stations might have affected the current status of eastern North Pacific whale stocks. The right whale is probably the most seriously depleted species (Scarff, in press). Although catches on the Northwest Coast and Kodiak grounds during the nineteenth century were likely of sufficient magnitude to have caused a severe decline in the population (e.g. Townsend, 1935; Rice, 1974, p. 187-8), small catches during the twentieth century may have helped to prevent the population's recovery. The 29 captures of right whales from Northeastern Pacific shore stations between 1910 and 1951 (Reeves et al., 1985, Table 7; Marsh and Cobb, 1910, p. 53) and one additional strike from Akutan in 1928 (Reeves et al., 1985, Table 8), together with the nine captures made by Japanese pelagic whalers east of 180 during 1961-3 (Omura et al., 1969), could have been enough to suppress an already-small stock. Given the infrequency with which the Akutan and Port Hobron whalers encountered right whales, the lack of sightings during recent surveys (Leatherwood et al., 1983; Stewart et al., 1985 MS) is not surprising.

An unfortunate aspect of our analysis is the inability to separate CPUE values by species. As the blue whale unquestionably was a preferred species at both stations, any trend in CPUE overall can reasonably be assumed to reflect a corresponding trend in this availability. Thus, the early decline in CPUE at Akutan may indicate a local decline in this species' availability. It is significant, in our opinion, that the highest annual catches of blue whales at Akutan were made during the four years 1917-20 (Reeves et al., 1985, Table 1). Although according to Birkeland (1926, p. 30-1) blue whales were taken at Akutan only after September 1915, it would be useful to know the catch by species for 1915 and 1916, as it might illuminate further the question of whether a local reduction in blue whales actually occurred. [Note that the per-vessel blue whale catch declined from 21 for the five years 1917-20, 1922 to 6 for the five years 1923-27.] The substantial catches elsewhere from what may have been the same stock - e.g. 623 by Japan east of 180 in 1954-62 (Nishiwaki, 1966, Table 2) and at least 591 off British Columbia in 1913-65 (Pike and MacAskie, 1969, Appendix I) - confound any attempt to evaluate separately the impact on it of Alaskan shore whaling.

The blue whale's current status in the North Pacific is less certain than the right whale's. We suggested earlier that some recovery has occurred on the eastern side (Leatherwood et al., 1982), although no quantitative support for such an opinion was available at the time. Doi et al. (1967) estimated that the summer population of blue whales on the three main pelagic grounds (collectively including the waters from 140 W to 160 E, north of 40 N) declined from about

2,430 in the mid-1940's to about 1,420 in 1964. Rice (1974, p. 179) reasoned that a blue whale population of about 6,000 would have been required to sustain the combined catches at Baja California, California, British Columbia, and Alaska during 1924/25 to 1928/29, averaging 289. He concluded that blue whales "were never very abundant in the eastern North Pacific, and their population size has not decreased very markedly" (Rice, 1974, p. 180). More recently, Rice (1978, p. 35) estimated a current population of about 1,500 blue whales in the entire North Pacific (cf. Chapman, 1973, p. 32).

The historically low density of blue whales in the southeast Bering Sea (Omura, 1955; Berzin and Rovnin, 1966) makes it neither surprising nor particularly significant that Leatherwood et al. (1983) saw none there. On the other hand, the relatively intensive coverage by Stewart et al. (1985 MS) of the southern edge of Davidson Bank, an area where blue whales were often caught by the Akutan whalers (Reeves et al., 1985) was expected to result in at least a few blue whale sightings; no blue whales were seen.

The catch data suggest that there were more fin whales in the vicinity of Akutan historically than there were blue or humpback whales. Also, fin whales appear to have been the most widely dispersed of the large mysticetes in this region. Although the average distance form the station at which fin whales were caught by the Akutan boats increased with time, there is no evidence of a similar change at Port Hobron. While the stock of fin whales may have been reduced by whaling at these two stations, the substantial catches by Japanese pelagic whaleers between 53° - 56° N and 165° - 171° W during 1954-62 (Nemoto, 1963; Nishiwaki, 1966; Nasu, 1966) and by Soviet pelagic whalers in Aleutian waters after 1957 (Berzin and Rovnin, 1966) indicate that there was no long-term depletion directly attributable to shore whaling at Akutan and Port Hobron. Fin whales clearly survive in the Gulf of Alaska and southeast Bering Sea in appreciable numbers, judging by the sightings reported by Leatherwood et al. (1983; and contained references) and Stewart et al. (1985 MS). It remains to be seen whether full recovery will result from the international protection given this species in the North Pacific beginning in 1976.

The average distance from the station of humpbacks caught at both Akutan and Port Hobron increased with time. This is consistent with data showing that individuals of this species tend to home, year after year, on specific summer feeding grounds. A sedentary fishery would be expected to deplete a local population of humpbacks in short order (e.g. see examples mentioned by Mitchell and Reeves, 1983). Rice (1977) has carefully reviewed the catch history of humpback whales in the North Pacific after 1912. Japanese and Soviet Pelagic expeditions took over 3,800 humpbacks from the vicinities of Kodiak and the eastern Aleutian islands during 1952-65 (Rice, 1977, Figure 4), which is somewhat more than the documented total of 3,083 taken at Akutan and Port Hobron combined from 1912 to 1939 (Reeves, et al., 1985, Tables 1 and 2).

It has been proposed that the humpbacks throughout the North Pacific belong to one stock (Darling and McSweeney, 1985). If they do, then catches and sightings from all areas should be taken into account when assessing population trends. Rice (1977) gave 15,000 as a crude estimate of the North Pacific humpback population before 1905, when modern commercial whaling began. His

analysis shows that about 18,000 were killed from 1905 to 1929, reducing the population to about 6,000. Continuing catches thereafter until 1960 may have been sustainable, but the killing of over 5,000 humpbacks from 1960 to 1965 reduced the population to about 1,000 (Rice, 1977). A "minimum abundance estimate for the northeast Pacific" of about 1,500 humpbacks in 1982 is based on analyses of photo-identification data (Darling and McSweeney, 1985).

The catches of sperm whales at Akutan and Port Hobron were sufficiently low, particularly in comparison to catches in the North Pacific by nineteenth-century whalers (Townsend, 1935; Best, 1983; Tillman and Breiwick, 1983) and modern factory-ship and shore-based whalers (Ohsumi, 1980), as to regard them as inconsequential to the status of sperm whale stocks.

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Table 1. Characteristics of catcher treats built in Seattle, Washington, and used at Akutan and Port Hobron, Alaska. All were steel-hulled and steam-powered, had a single screw, and were "fixed for burning oil". Source: Merchant Vessels of the United States. U.S. Department of Commerce, Bureau of Marine Inspection and Navigation: Reports 5 (1935), 7 (1937) and 8 (1938).

	Tonnage		Dimensions						CPUE		
Name of Vessel	Gross	Net	Length	Breadth	Depth	Year Built	Crew	Horsepower	Akutan	Port Hobron	Overall
Aberdeen	116	59	88.0	19.0	11.5	1919	10	370 -	0.375	0.429	0.414
Kodiak	148	101	100.0	19.2	12.4	1912	10	375	0.328	0.227	0.327
Moran	120	77	87.3	18.0	11.4	1911	1 0	325	0.330	0.386	0.377
Paterson	119	m	87 .3	18.0	11.4	1911	10	325	0.362	0.423	0.370
Tanginak	151	71	97.9	17.7	11.8	1907	10	350	0.334	0.350	0.346
Unimak	148	101	100,0	19.2	12.4	1912	10	350	0.316	0.259	0.315
Westport	116	59	88*0	19.0	11.5	1912	11	350	0.293	0.439	0.395

Table 2. Periods of operation by catcher-boats and coverage by catcher-boat logs. Unless otherwise noted, the sources are catcher-boat logs (including a few engine-room logs), Weekly Manufacturing Reports, or Station Tallies. x = vessel not whaling; dates given as month/day; shading of box indicates period covered by an available catcher-boat log. A = Aberdeen, K = Kodiak, M = Moran, P = Paterson T = Tanginak, U = Unimak, W = Westport.

Station	Akutan							Port Hobron						
	A	K	M	P	T	U	W	A	K	M	P	T	u	w
2922	x	06/03-1[4]0/21	x	X	x	06/03-10/21[1]	x	x	x	x	x	x	x	x
1913	x	x	x	x	x	,	,	x	x	x	x	x	x	x
1914	x	05/15-10/10[2]	x	x	x	05/15-10/10[2]	x	x	x	,	x	x	x	x
1915	x	05/10-09/30	x	x	x	OS,1O-O9DO	X	x	x	x	x	x	x	x
2926	x	05/10-09/30[2]	x	x	0 5 / 1[2]	0-09/30 05/10-09/30[2]	x	x	.?	x	x	,	x	x
1917	x	05/10-10/25[2]	x	x	05/10-10/25[2]	05/10-10/25[1] 08/01-09/19	x	x	x	x	x	x	x	x
1918	x	05/19-10/16[2]	x	05/19-10/16[2]	05/19-10/16[2]	05/19-10/16[2]	x	x	x	x	x	x	x	
1929	x	05/22-10/04	x	05/31-10/03	05/31-10/03	05/22-10/03	z	x	x	x	X	X	x	x
1920	Z	05/04-M/14	,	05/04-10/14	05/04-10/22	05/04-10/12	X	x	x	x	,	x		
2922	x	05/22-1 0/26	x	05/16-10/26	x	05/28-10/26	x	x	x	x	x	x	x	x
2223	x	05/01-10/16	x	05/02-10/16	05/02-10/16	05/02-10/16 09/01-10/04	x	,	x	x	x	x	,	x
1924	x	05/17-10/08	x	05/17-10/07	05/19-10/07	05/25-10/07 05/25-07/01 [W1]	x	x	x	x	x	x	x	x
1935	07/24-10/08	05/25-10/08	07/24-09/03	05/25-10/06	05/25-10/06	05/25-10/06	x	x	x	x	x	x	x	x
1926	05/24-07/14	05/30-10/02	06/01-07/13	05/29-10/01 05/29-10/01	06/12-08/27 06/10-08/27	05/26-09/30 05/24-10/01	05/28-10/01 05/12-07/01	07/17-10/31[4] 09/23-10/31	1V1O-1W31 07/20-1 W27 ,			09/03-11/01 09/03-11/04	10/06-11/01 10/06-11/01	10/08-10/31
1927	x	05/29-10/02	x	05/31-10/03 05/31-08/01	.	05/28-10/02	05/27-10/02	05/25-10/05	x	05/27-10/05	x	05/26-10/07 08/09-10/07	x	.
1928	x	06/01-49/25	x	05/26-09/28 05/26-09/28	x	05/30-29/28	05/29-09/28 05/29-09/28	05/23-10/10 10/01-10/30	x	05/09-10/08	x	05/11-10/10 07/24-10/10	x	x
1929	x	05/29-10/18 05/29-10/13	x	05/30-10/19 08/01-10/20	x	05/28-10/19 05/29-10/19	05/30-10/19 05/30-10/19	05/23-10/15 05/23-10/15	x	05/25-10/08	x	05/25-10/09 08/20-08/06	x	x
1930	05/27-09/20 05/28-09/21	05/27-09/20	08/19-09/12	05/27-09/21 05/27-08/16	08/19-09/12	05/27-09/12	08/18-09/12	x	x	05/16-08/14	x	05/08-08/12	x	05/08-08/14
1932	x	x	x	x	x	x	x	05/17-09/16	x	05/19-09/22	05/20-09/21 05/20-09/21	x	x	05/17-09/21 05/17-09/21
1933	x	x	x	x	x	x	x	06/30-09/08	x	06/26-09/08	06/28-09/11 06/28-09/11	x	x	x
1934	x	05/25-09/30 04/28-07/26	09/09-09/29	05/25-10/02 05/28-10/02	x	05/25-09/29	05/25-09/29 05/28-09/29	05/15-09/12 05/15-09/24	x	05/17-08/12	x	05/17-09/13 05/17-08/13	x	x
1935	x	05/15-10/02 05/15-10/03	x	05/17-10/02 05/17-10/02	x	05/16-10/03 04/15-10/03	05/16-10/02 05/01-10/07	05/09-09/24 04/25-10/10	x	05/08-09/26 05/08-09/26	x	05/08-09/16	x	x
1936	x	05/22-09/29 05/22-09/29	x	05/22-09/29 05/20-09/30	x	05/22-10/01 05/22-10/01	05/22-09/13	04/27-09/15 07/13-09/29	x	04/28-08/24 04/28-07/13	x	05/26-08/19	x	x
1937	08/18-09/29 08/18-09/29	05/21-09/29 07/25-09/29	08/15-09/30 08/12-10/01	05/12-09/30 08/12-10/01	x	05/13-09/30 08/13-09/30	x	05/08-08/13 05/08-08/13	x	05/06-08/12 05/06-08/12	x	05/07-08/12 05/07-08/12	x	x
1938	06/02-10/05 06/03-10/12	06/06-10/06 06/08-10/05	06/02-10/05 06/04-10/06	06/03-10/06	x	06/06-10/06 06/06-10/05	x	x	x	x	x	x	x	x
1939	06/08-10/09	06/08-10/10 08/01-10/10	x	06/10-10/09 08/16-10/08	x	x	x	x	x	x	x	x	x	x

Footnotes:

[1] Chamberlain and Bower [2933, p. 62).
[2] Dates arbitrarily assigned.

Table 3. Calculations of Catch-Per-Unit-of-Effort (CPUE) For Whaling At Akutan, Alaska, 1912, 1914-20, 1922-30, 1934-39. (See text for explanation of units and calculations.)

Year	Gross Catcher-Days	Total (a Whales Landed	CPUE-I	Catch per Boat per day (b	Uncorrected Catcher-Hours	Total (a Whales Landed	CPUE-II	Corrected Total Catcher-Hours	Whales Landed	CPUE-IIIA	Corrected Total Catcher-Hours	Whales Landed	CPUE-IIIB	Corrected Total Catcher-Hours	Whales Landed	CPUE-IIIC
1912	282	310	1.09													
1914	2%	307	1.04													
191.5	288	307	1.07													
1916	432	237	0.55													
1917	507	285	0.56					413.5	57	0.132	394.5	56	0.142	186.5	29	0.155
1918	604	310	0.51													
1919	523	419	0.80													
1920	652	291	0.45													
1922	474	325	0.69													
1923	636	355	0.56					65.0	2	0.031	57.5	2	0.035	12.0	2	0.167
1924	567	284	0.50	O*46	6,989	284	0.0406	409.5	18	0.044	3%.5	18	0.045	221.0	11	0.050
1925	661	4%	O*75	0.68	8,047	4%	0.0616									
1926	678	339	0.50	0.51	8,938	339	0.0379	2,342.5	111	0.047	1,897.5	105	0.055	725.5	57	0.(J79
1927	510	208	0.41	0.40	6,039	208	0.0344	713.0	30	0.042	448.0	23	0.047	231.5	12	0.052
1928	488	146	0.30	0.26	6,252	146	0.0234	2,510.5	72	0.029	1,%7.5	69	0.035	908.0	41	0.045
1929	574	160	0.28	0.26	7,276	160	0.0220	5,184.0	134	0.026	4,104.5	130	0.032	1,662.0	59	0.035
1930	537	127	0.24	0.16	5,782	127	0.0220	1, 820.0	60	0.033	1,331.5	53	0.040	555.0	34	0.061
1934	537	228	0.42	0.40	6,531	228	0.0349	2,602.0	97	0.037	1,959.0	93	0.048	732.5	48	0.066
1935	562	257	0.46	0.38	7,042	257	0.0365	4,217,5	205	0.049	3,282.0	191	0.058	1,418.0	110	0.078
1936	510	197	0.39	0.26	6,740	197	0.0292	4,102.0	163	0.040	3,100.5	143	0.046	1,238.0	66	0.053
1937	505	256	0.51	0.40	6,324	256	0.0405	3,794.0	182	0.048	3,085.0	164	0.053	1,593.0	98	0.062
1938	624	173	0.28	0.27	8,052	173	0.0215	5,070.5	136	0.027	3,648.5	131	0.036	1,327.0	53	0.040
1939	347	171	0.46		4,669	171	0.0366	1,207.5	66	0.055	1,071.0	65	0.061	629.5	35	0.056

a) From Reeves et al. (1985).
b) From VanDeVenter (.1938). Sperm whale catches were not included in these calculations.

Table 4. Calculations of Catch-Per-Unit-of-Effort (CPUE) for whaling at Port Hobron, Alaska, 1926 - 1930, 1932-1937. (See text for explanation of units and calculations.)

Year	Gross Catcher Days	Total Whales Landed (a	CPUE-I
1926	401	242	0,60
1927	401	272	0.68
1928	447	256	0.57
1929	421	225	0.53
1930	287	228	0.79
1932	503	270	0.54
1933	222	182	0.82
1934	329	237	0.72
1935	413	137	0.33
1936	347	188	0.54
1937	295	120	0.41

a) From Reeves et al. (1985)

Table 5. Average distances from the station to the catch positions of whales

AKUTAN	All Years n (a	All Years $\bar{x}$	All Years S.d.	1924-30 n (a	1924-30 $\bar{x}$	1924-30 s.d.	1934-39 n (a	1934-39 $\bar{x}$	1934-39 s.d.	Probability That Distances Changed Significantly
Blue	**415**	51.0	16.0	**227**	52.5	16.9	188	50.1	14.8	**N.S.**
Fin	**1217**	39.0	21.5	**717**	34.8	19.9	500	46.1	22.1	**p<.001**
Humpback	755	**37.0**	16.0	543	35.1	16.4	232	**43.9**	12.8	**p<.001**
Sperm	360	51.0	15.0	111	54.5	13.7	249	**50.3**	**15.4**	**p<.050**

PORT HOBRON	All Years			1926-30			1932-37			
Blue	166	54.0	17.0	68	47.4	**18.2**	**98**	59.2	14.6	**p<.001**
Fin	**410**	57.5	22.0	**96**	58.9	25.3	**314**	57.9	21.4	**N.S.**
Humpback	**1387**	35.0	16.0	**900**	31.3	13.1	487	43.5	18.2	**p<.001**
Sperm	79	66.0	9.5	15	65.5	9.3	64	66.6	9.8	**N.S.**

(a Does not include animals for which location of catch was not recorded.

Table 6. Monthly catches at Akutan, by species and sex, and catch per gross catcher day, by month, 1924-39.
Sources : Station Tallies, William S. Lagen Collection (catch) and Table 2 (&fort).

Month	Blue		Fin		Humpback		Sperm		Total		Total Whales	Gross Catcher Days	CPUE-I
	Males	Females	Males	Females	Wales	Females	Wiles	Females	Males	Females			
May	14	10	17	12	6	5	26	0	63	27	90	346	0.26
June	92	47	73	103	59	80	110	0	334	230	564	1572	0.36
July	50	35	127	133	111	117	113	0′	401	265	686	1655	0.41
August	64	53	241	253	111	134	85	0	501	440	941	1741.	0.54
September	29	29	209	227	86	102	32	1	356	359	715	1574	0.45
October	0	1	3	12	15	14	2	0	20	27	47	291	0.16
Total	249	175	670	740	388	452	368	1	1,675	1,368	3,043	7,179	

Table 7. Monthly catches at Port Hobron, by species and sex, and catch per gross catcher day, by month, 1926-37.
Sources: Station Tallies (catch) and Table 2 (effort)

Month	Blue		Fin		Humpback		Sperm		Total		Total	Gross	CPUE-I
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	Whales	Catcher Days	
May	18	4	12	9	68	88	7	0	105	101	206	481 (1	0.43
June	30	22	42	59	188	175	38	0	298	256	554	849	0.65
July	26	23	90	79	293	249	12	0	421	351	772	988	0.78
August	25	21	66	70	145	145	13	0	249	236	465	876	0.55
September	12	20	13	11	54	52	11	0	90	83	173	571	0.30
October	2	1	3	1	45	46	0	0	50	48	98	241 (2	0.41
Total	113	91	226	229	793	755	81	0	1,213	1,075	2,288	4,056	---

1) Includes 7 days in April in 1936
2) Includes 2 days in November in 1926

Table 8. Cumulative retches of the five major species for peak decades.

	Akutan		Port Hobron		Akutan & Port Hobron	
	Period	Cum. Catch	Period	cum. Catch	Period	Cum. Catch
Blue	1917-1926	508	1927-1936	212	1927-1936	460
Fin	1917-1926	1,501	192%1937	436	1927-1936	1,030
Hump	1918-1927	998	1926-1935	1,530	1927-1936	1,634
sperm	1930-1939	290	1928-1937	87	1930-1939	366
Right	1923-1S82	7	1926-1935	11	1923-1932	16

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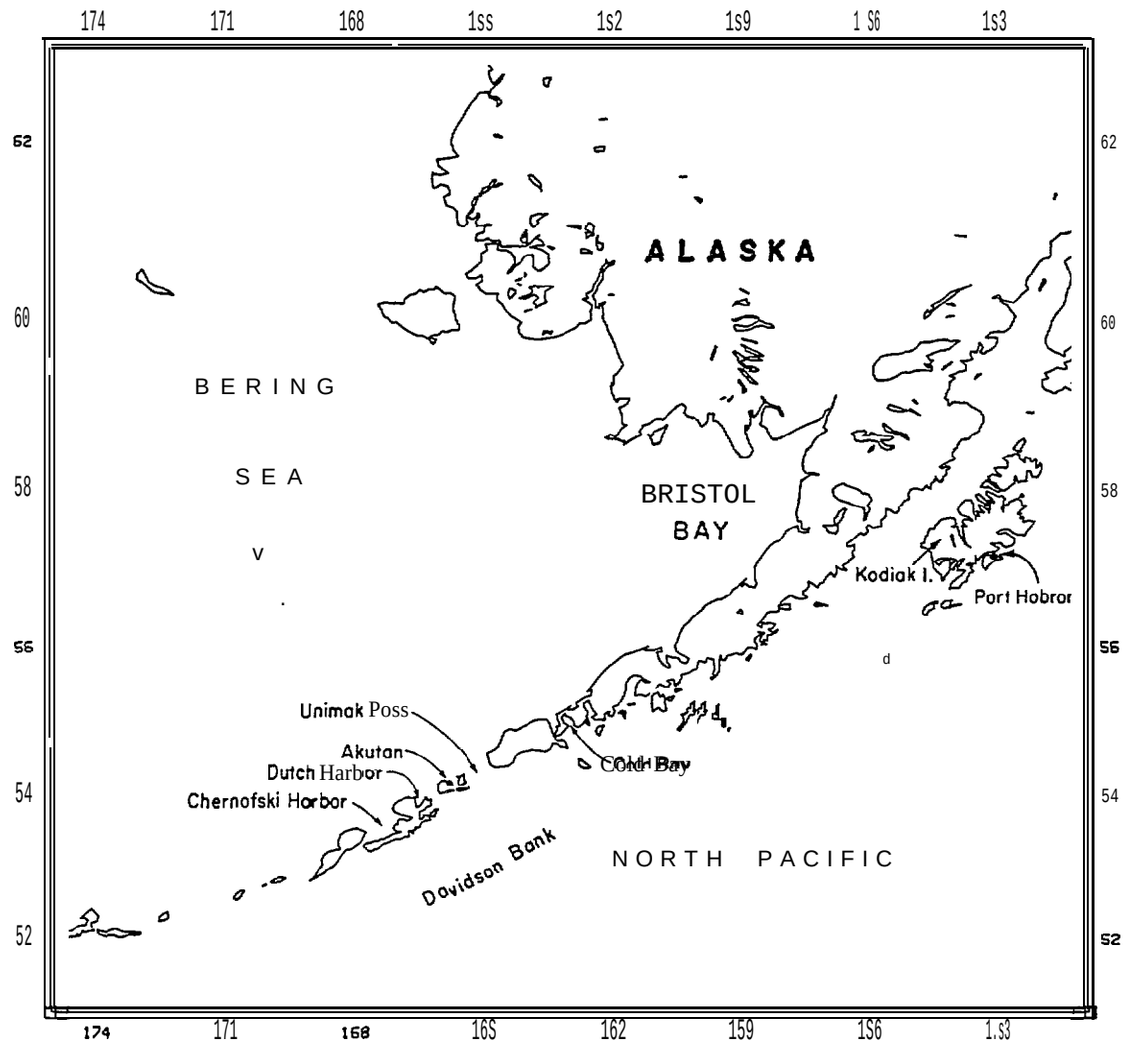


Figure 1. Locations of the shore whaling stations at Akutan and port Hobron, Alaska.

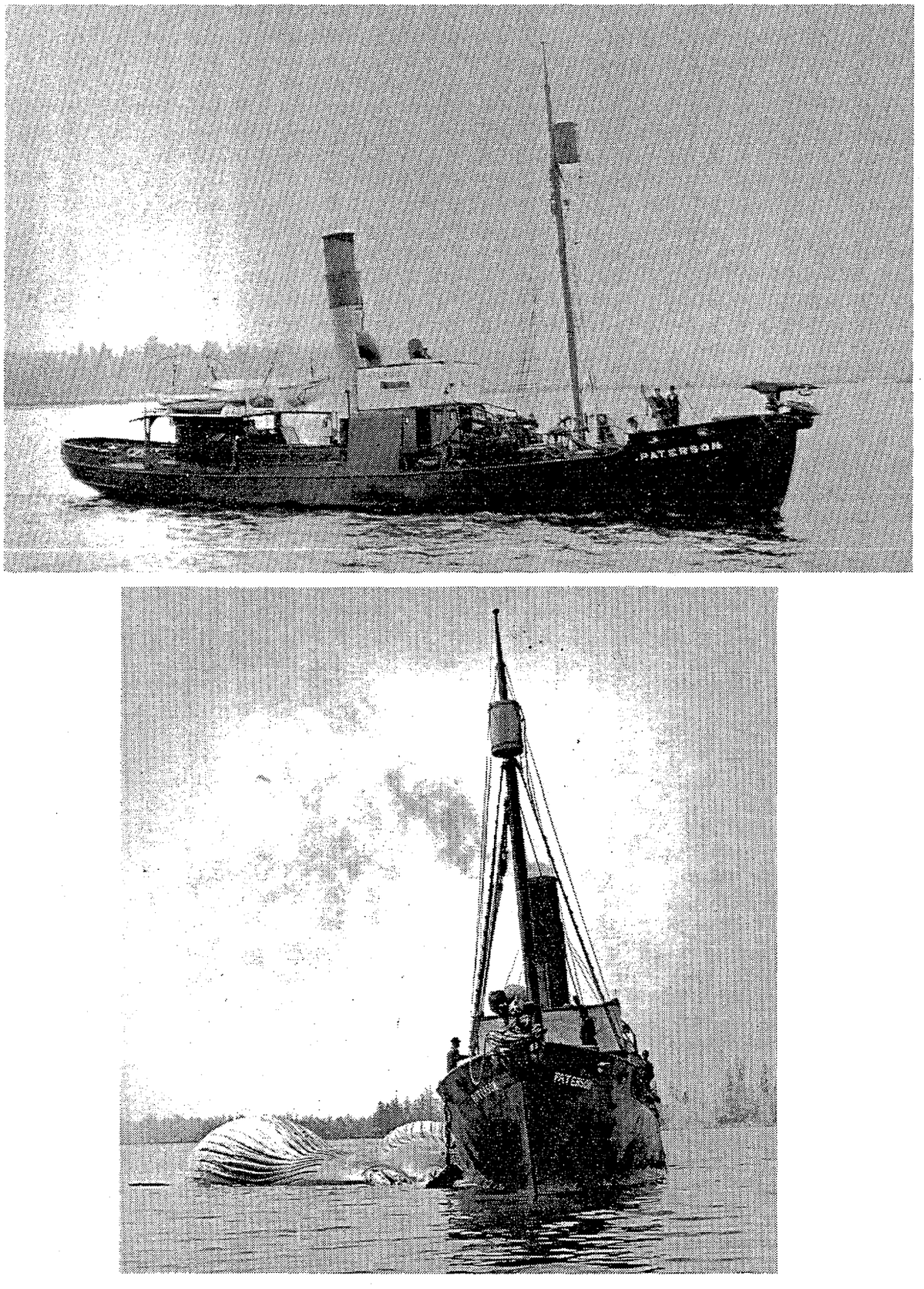


Figure 2. The F/V Paterson, one of seven catcher boats used at Akutan and Port Hobron, shown underway (top) and with two dead humpback whales in tow (bottom) (Photos courtesy of Alaska Historical Library, Juneau).

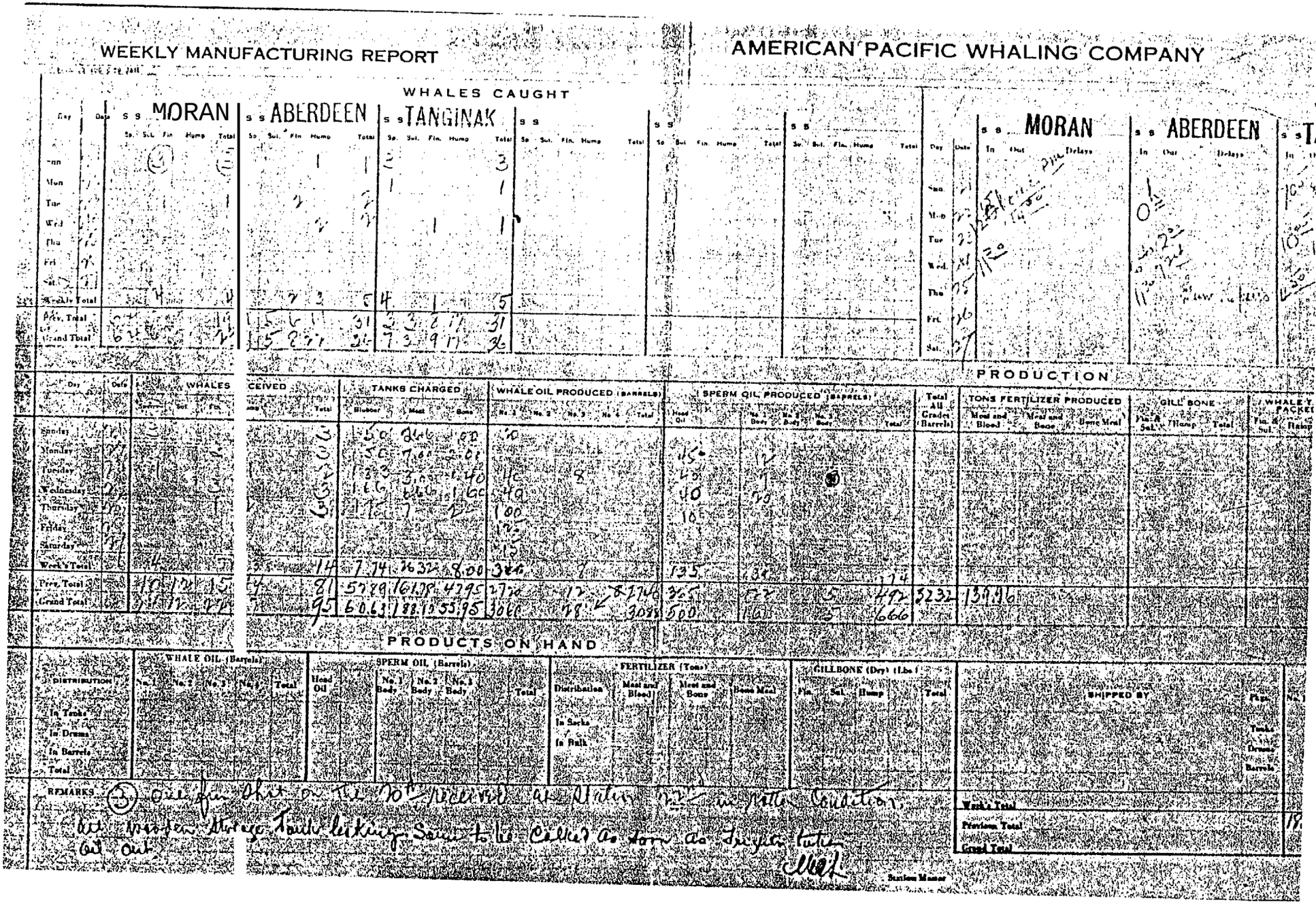
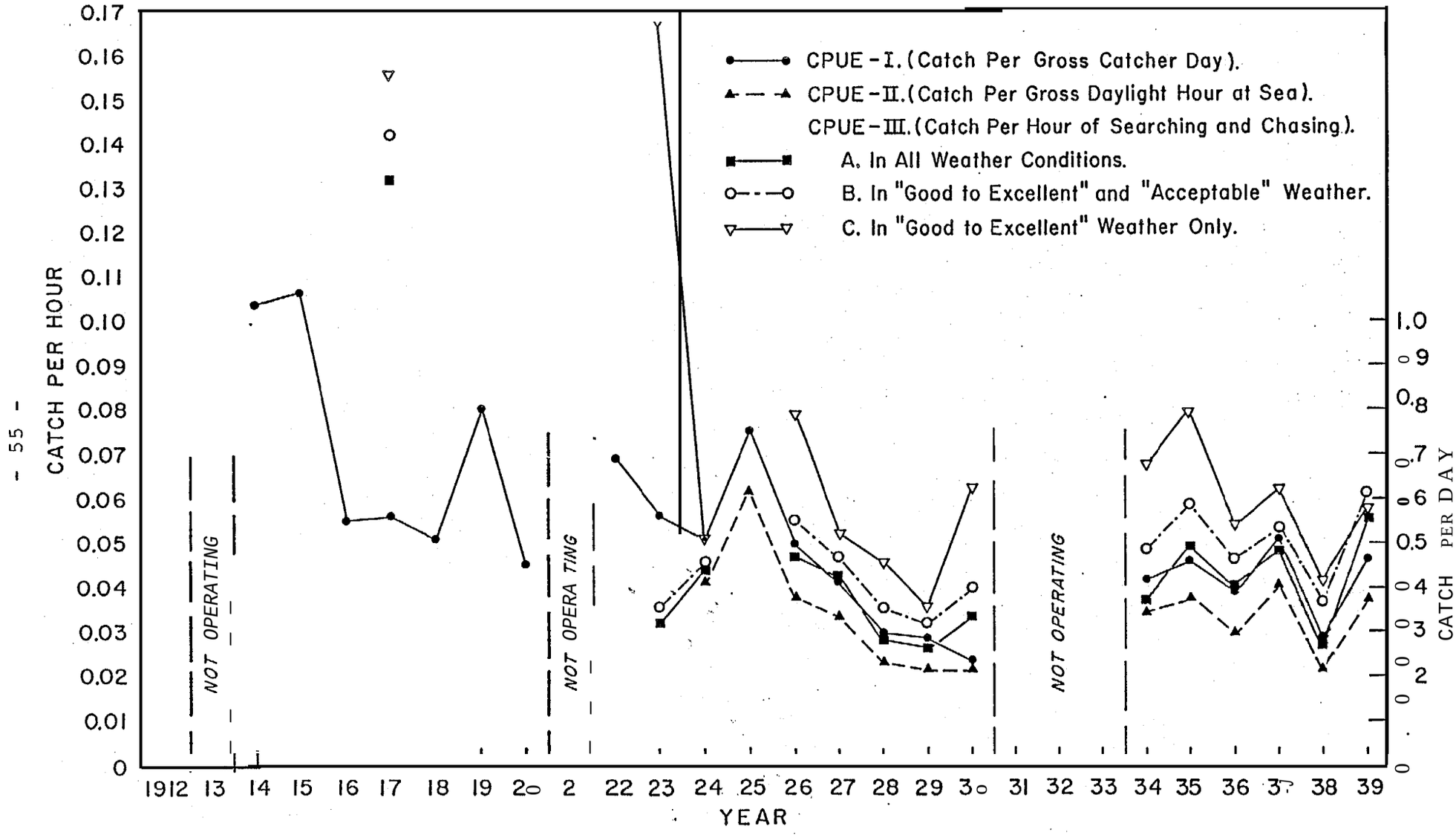


Figure 3. Pages from an Akutan Weekly Manufacturing Report.

Figure 4. Catch-per-unit-of-effort at Akutan, 1912-39 (see Table).



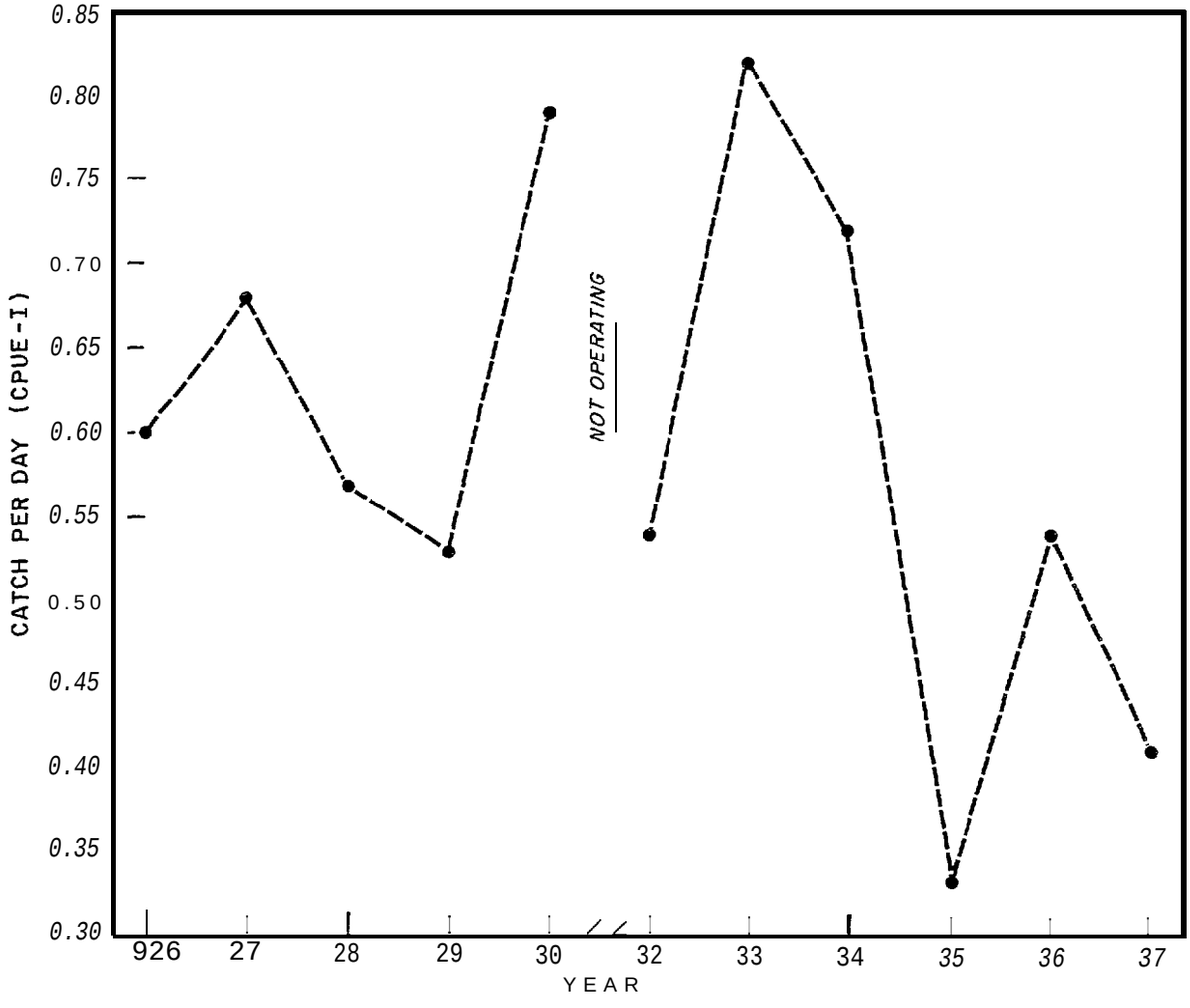


Figure 5. Catch-per-unit-of-effort at Port Hobron, 1926-37 (see Table 4).

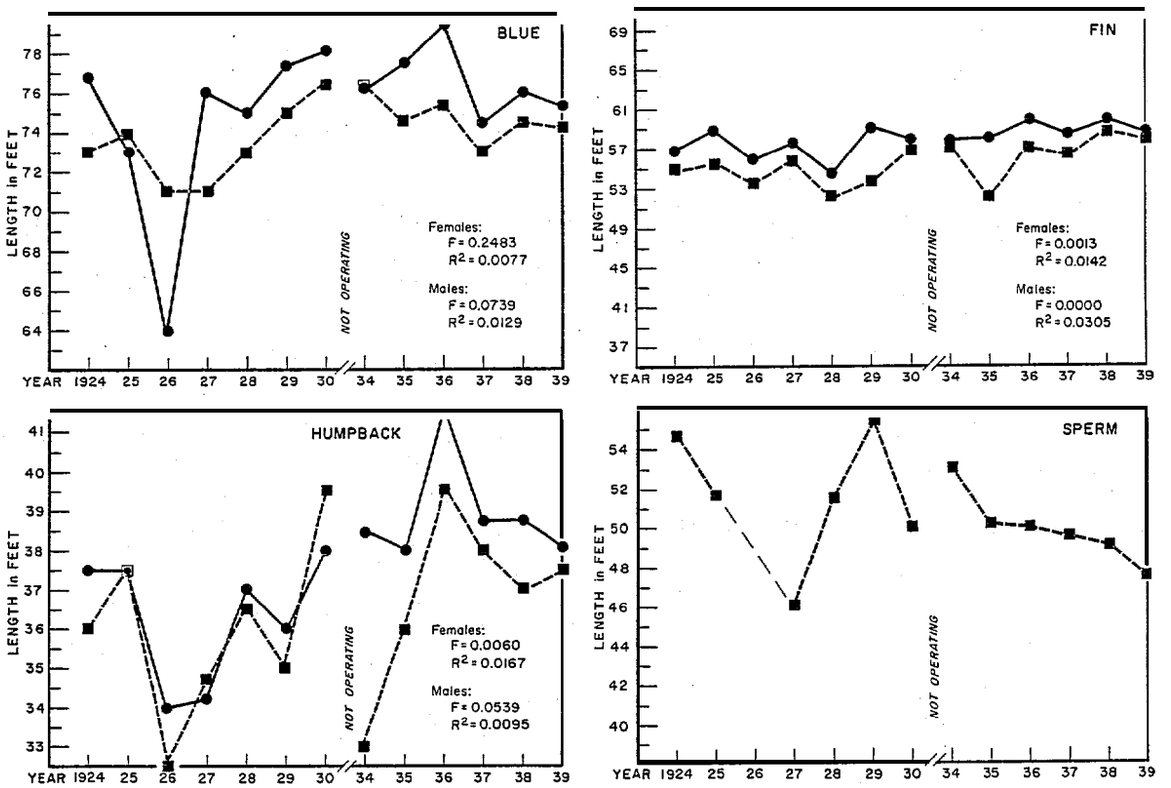


Figure 6. Mean lengths of whales taken at Akutan (● = Females; ■ = males).

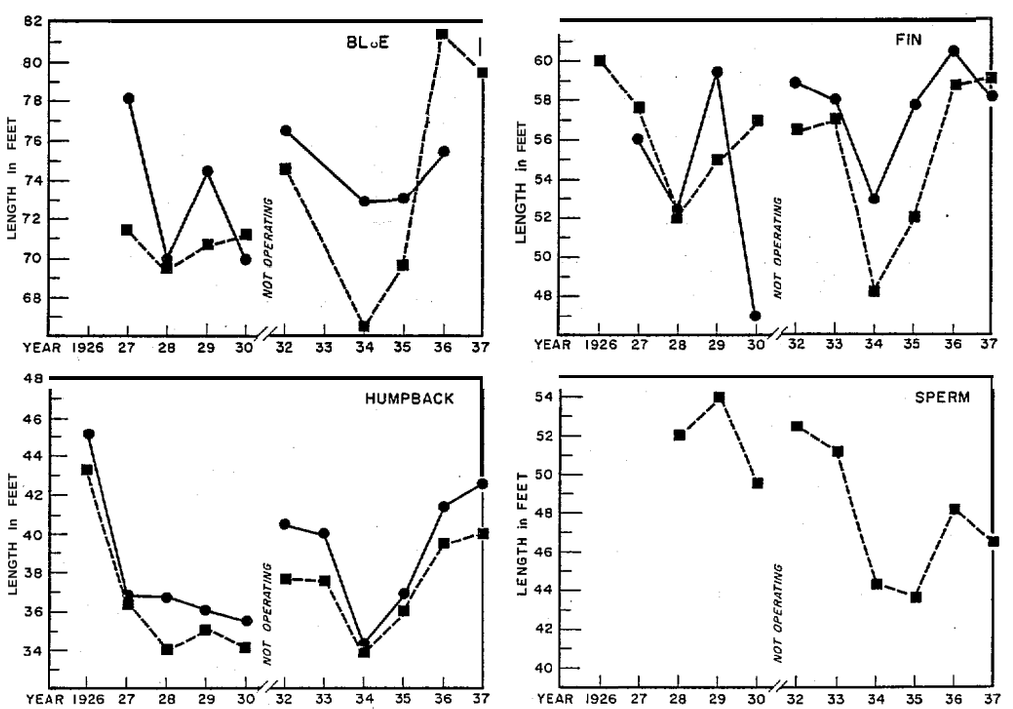
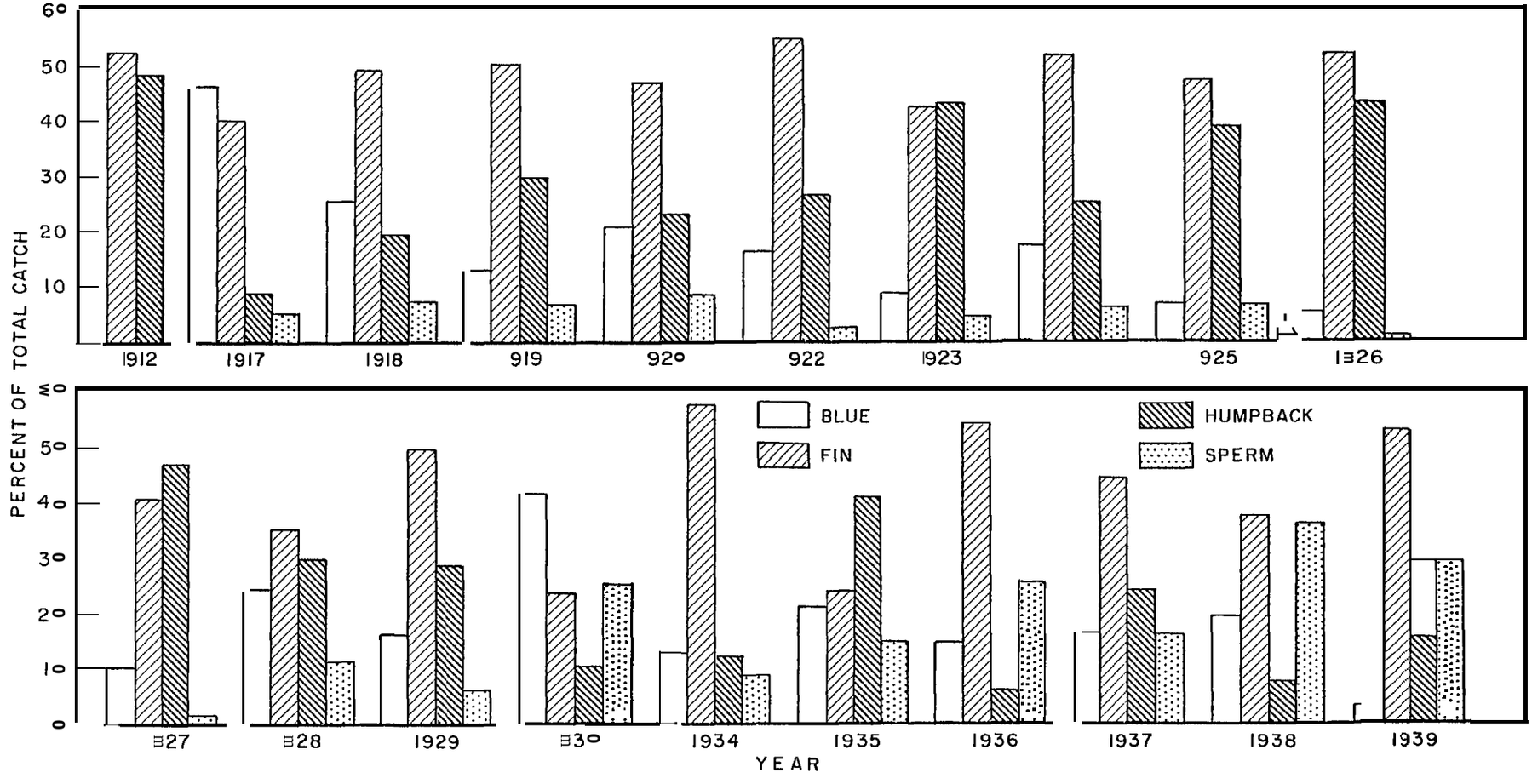


Figure 7. Mean lengths of whales taken at Port Hobron(● = Females; ■ = Males).

Figure 8. Percent composition of the four major species in the whale catch at Akutan, by month.



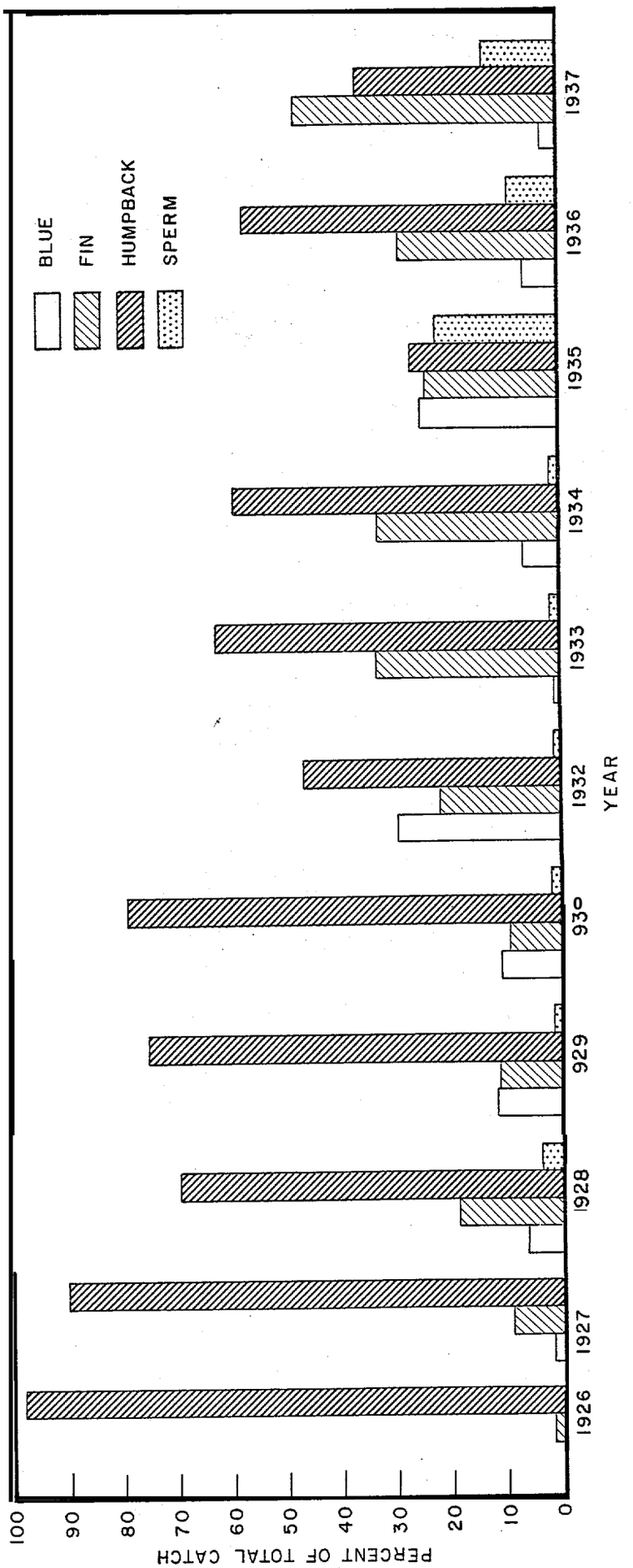


Figure 9. Percent composition of the four major species in the whale catch at Port Hobron, by month.

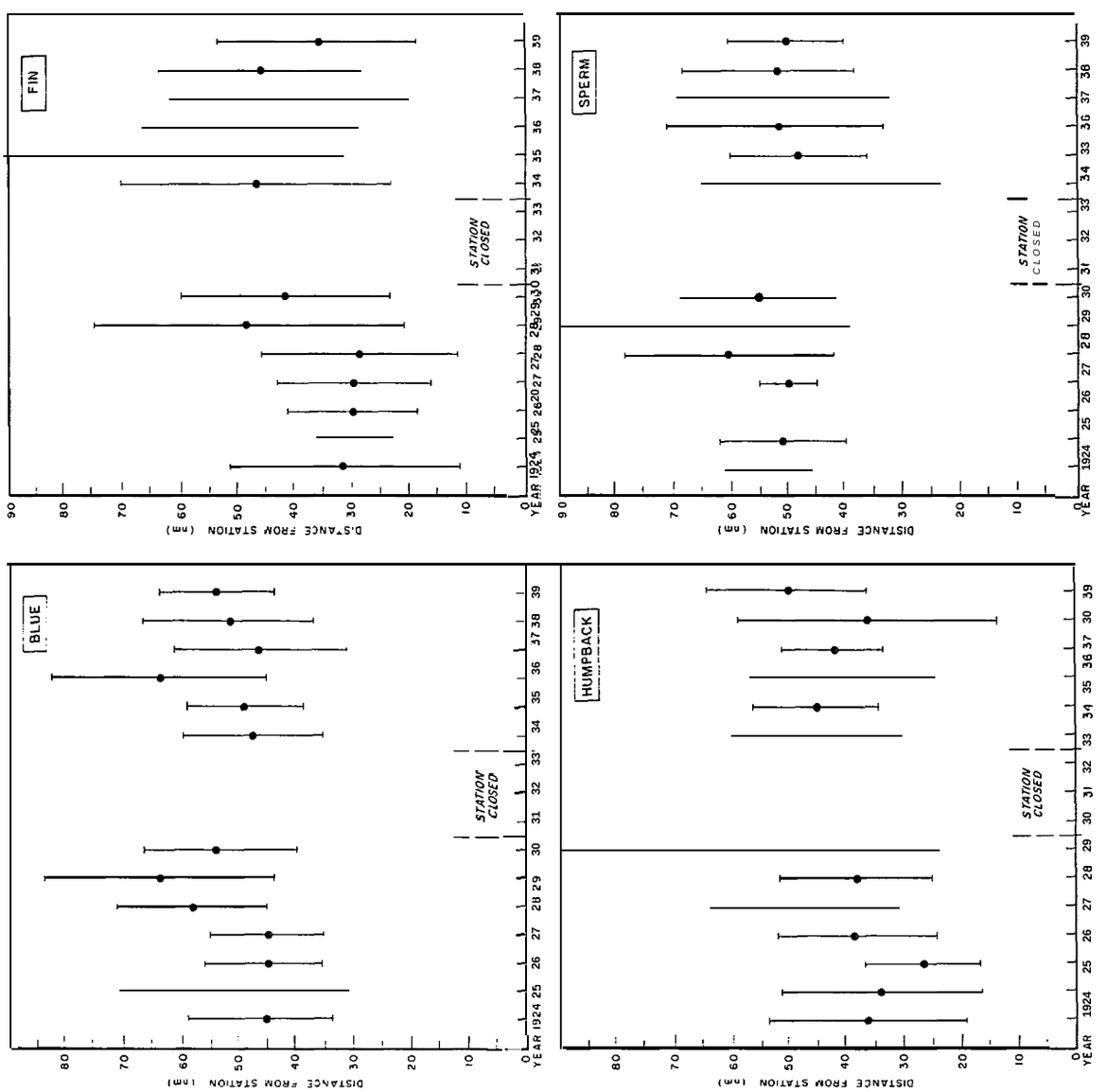


Figure 10. Distances from the Akutan station of whales killed 1924-39

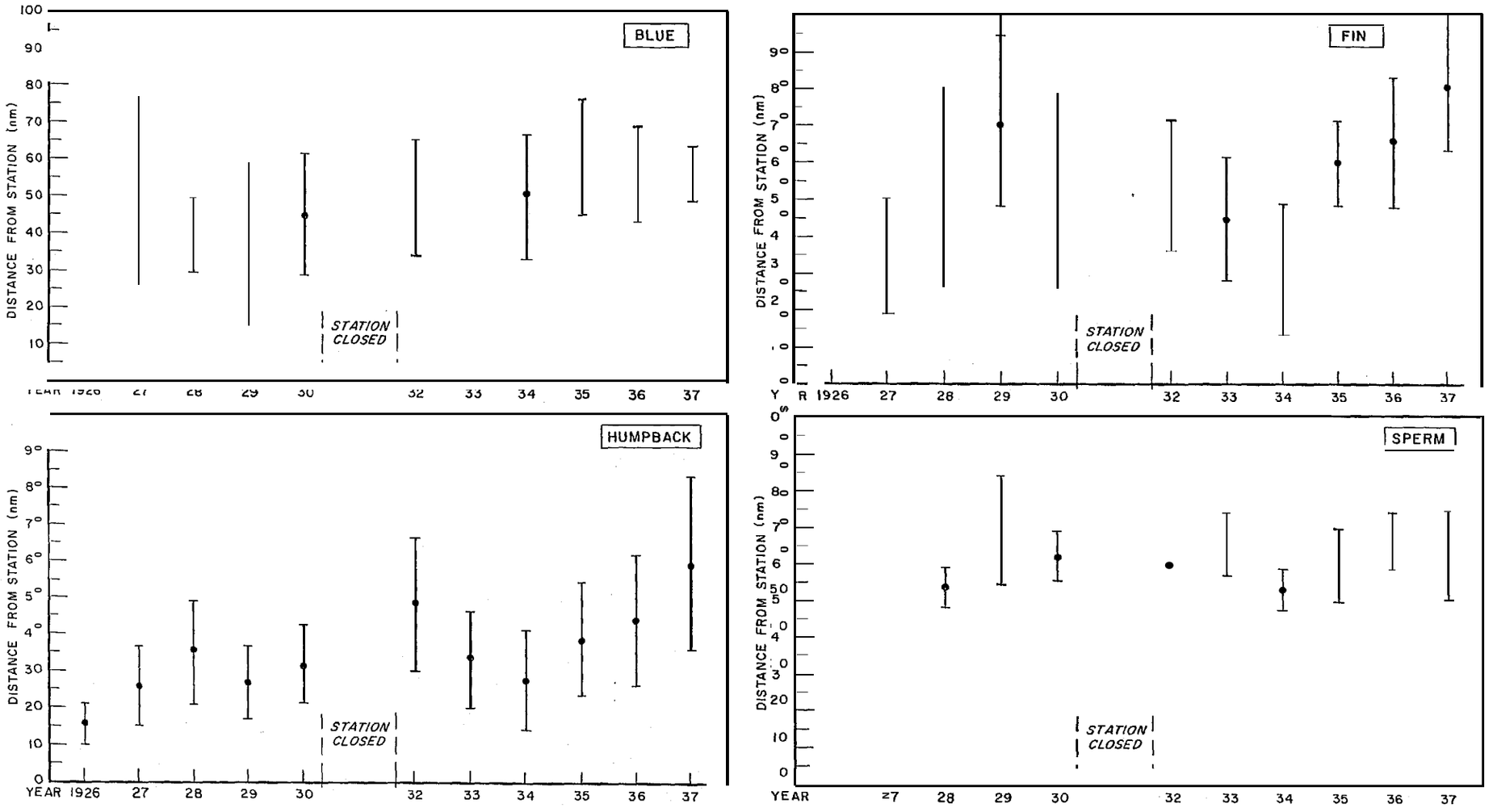


Figure 11. Distances from the Port Hobron station of whales killed, 1926-37.

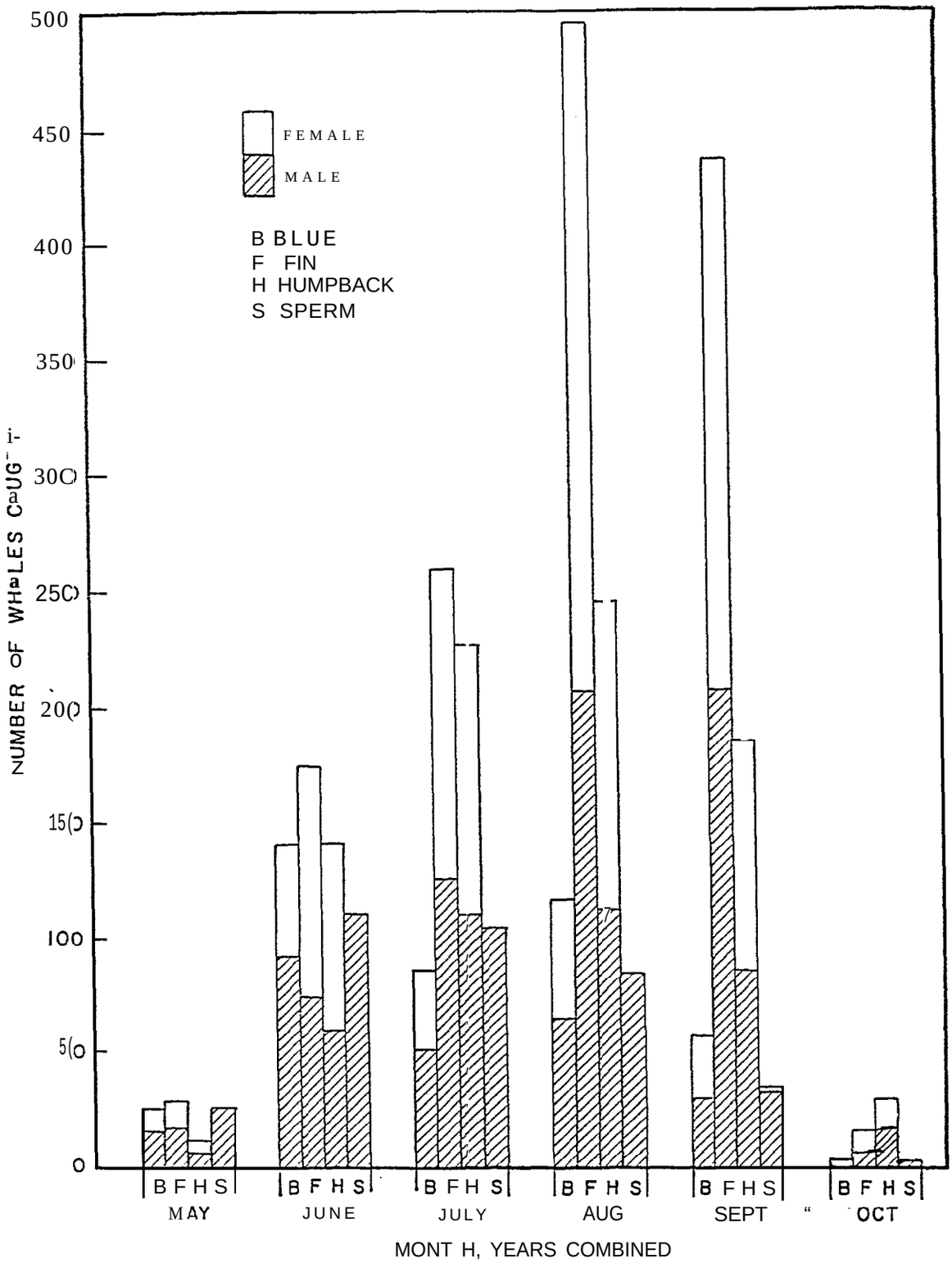


Figure 12. Catches, by month, of the four major species at Akutan, 1924-39. Source: Station tallies; see Table 6.

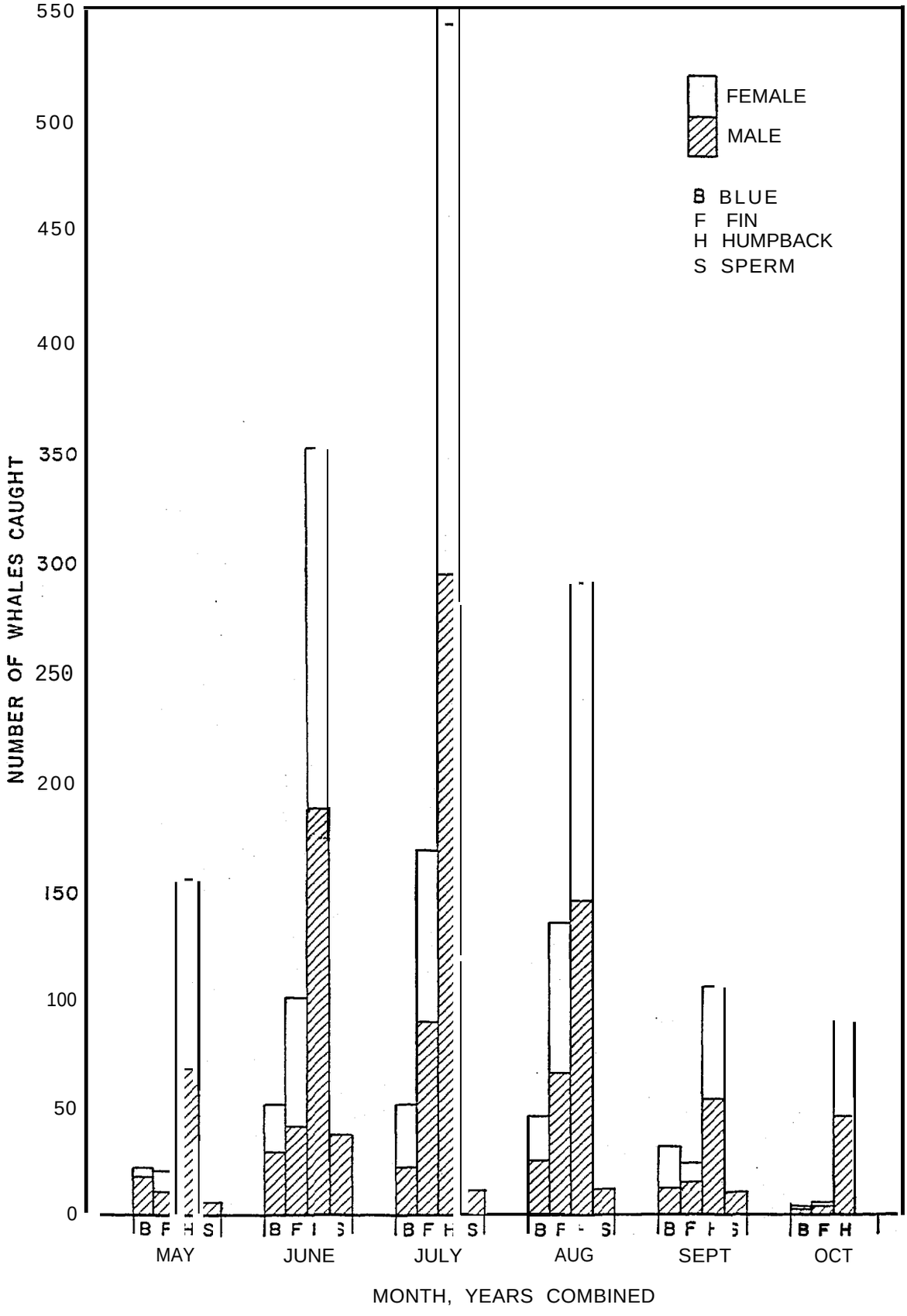


Figure 13. Catches, by month, of the four major species at Port Hobron, 19260 37. Source: Station tallies; see Table 7.

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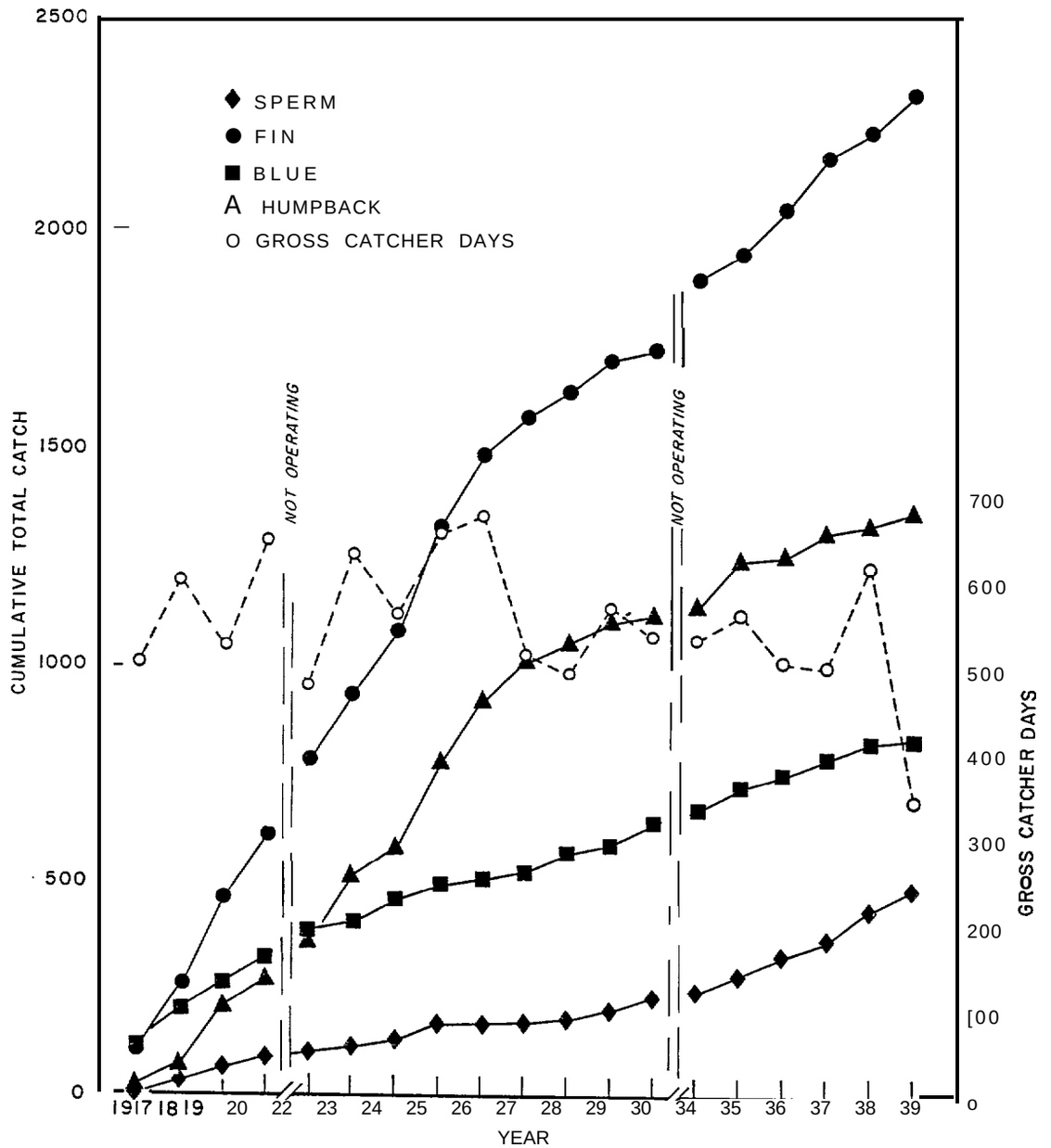


Figure 14. Cumulative catch totals, Akutan.

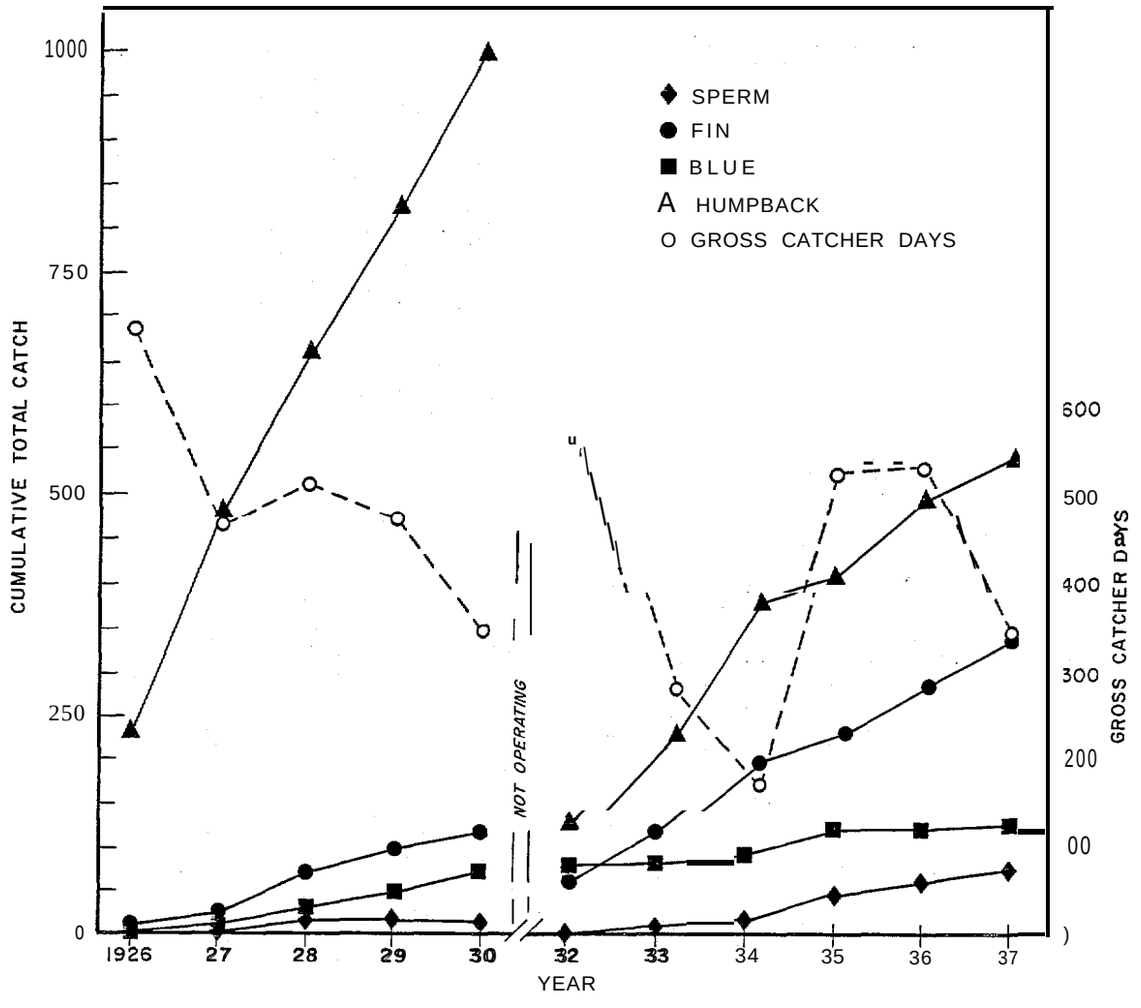
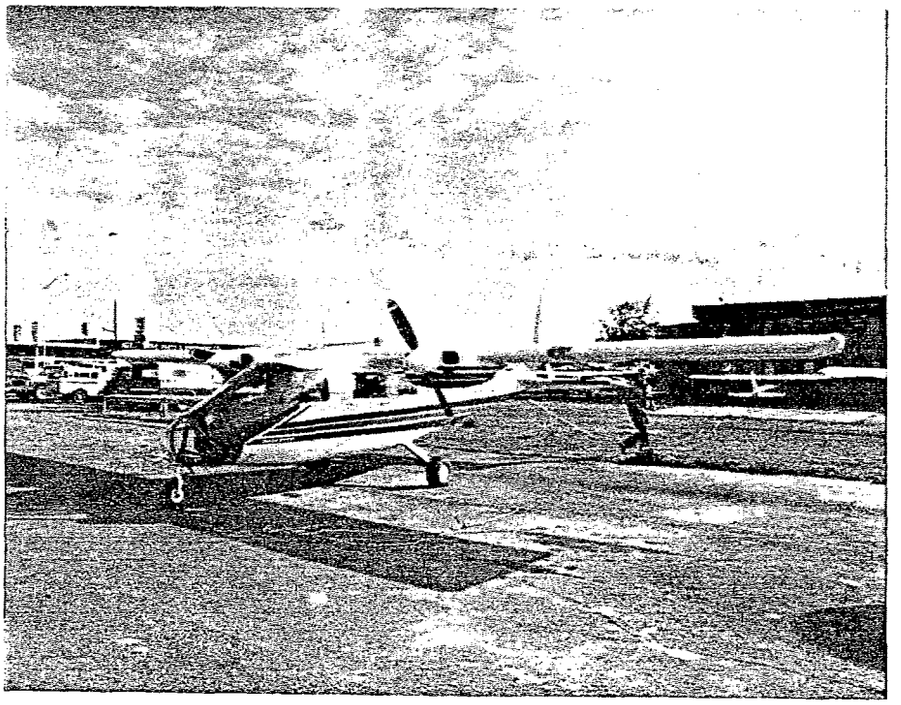


Figure 15. Cumulative catch totals, Port Hobron.

IV. AERIAL SURVEYS OF THE FORMER AKUTAN, ALASKA WHALING GROUNDS

The report on this portion of subject contract was submitted to the sponsor in May 1985 and was subsequently presented at the 36th annual meeting of the IWC Scientific Committee held at Bournemouth, U. K. between 24 June and 13 July 1985. On 1 June the manuscript was also submitted to Arctic for consideration for publication. The revised draft, incorporating all reviewers comments, is presented here in its entirety.



The plexiglass-nosed Partenavia Observer used in the aerial surveys of the former Akutan Whaling grounds.

AERIAL SURVEYS OF THE FORMER AKUTAN, ALASKA, WHALING GROUNDS

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ABSTRACT

Randomized aerial surveys were flown between 26 July and 26 August 1984 to search for cetaceans, and incidentally for other marine mammals, in two areas of Alaska: one on both Bering Sea and Pacific Ocean sides of the Aleutian Islands near the defunct Akutan shore-whaling station, which operated from 1912 through 1939; the other overlapping continental slope and shallow continental shelf waters between the Aleutians and the Pribilof Islands. Surveys were made at altitudes between about 500 ft (152.4m) and 750 ft (228.6m) from a Partenavia P68 Observer with a plexiglass nose bubble which permitted center-line viewing. Searches covered some 4,130 nm, including some 2,380 nm of transects. Sightings were made of Dall's porpoises (47 sightings, 131 individuals), killer whales (8, 26), gray whales (10, 14), fin whales (3, 11), harbor porpoises (4, 7), minke whales (1, 1), unidentified beaked whales (1, 6), individuals of three pinniped species [Steller sea lions (62; 2,792), harbor seals (26; 1,010) and northern fur seals (2, 2)] and sea otters (38, 534). A Fourier series model was used to estimate density of Dall's porpoises as 115 individuals (CV=0.263) per 1,000 nm^2 (3,422.5 km^2) on the whaling grounds and 30.8 individuals (CV=0.870) Per 1,000 nm^2 (3,422.5 km^2) in the open Bering Sea. These estimates are comparable to those previously reported for Dall's porpoise for the same general areas of the eastern Bering Sea (49.5-97.2 animals per 1,000 nm^2). There *were* too few sightings of other cetaceans to permit calculation of meaningful density estimates. At least four species of great whales (blue, fin, humpback and sperm) were sufficiently abundant during the first four decades of this century to support significant whaling activities within about 100 nm (185 km) of Akutan (more than 5,300 whales caught during 23 years of whaling between 1912 and 1939). Although previous studies showed a downward trend in catch-per-unit-of-effort and an increase in distance traveled to take whales, whales were still being taken at relatively high rates (0.28-0.51 whales per gross catcher day) at the end of the fishery in 1939. Populations of fin, humpback and blue whales were probably reduced by shore and pelagic whaling conducted in the North Pacific since 1939. The low number of sightings on the present surveys is interpreted cautiously that populations on and near the whaling grounds remain depressed from such activities.

INTRODUCTION

Between 1912 and 1939 whaling operations were conducted from a shore station on Akutan Island, in the eastern Aleutian Islands, Alaska (Figure 1). Between May and October in the years 1912, 1914 through 1920, 1922 through 1930 and 1934 through 1939 two to seven vessels hunted whales within an approximately 100 nm (185 km) radius of the station, on both Bering Sea and Pacific Ocean sides of the Aleutian Islands and in Unimak Pass. Catches consisted mainly of fin (Balaenoptera physalus) (at least 2,498), humpback (Megaptera novaeangliae) (1,510), blue (B. musculus) (835), and sperm (Physeter macrocephalus) (482) whales, with occasional takes of right whales (Eubalaena glacialis) (9) and other species (Reeves, Leatherwood, Karl and Yohe, 1985). Trends in availability to the whalers of the four key species within and among years (Leatherwood, Reeves and Karl 1985), interpreted in the context of other data available for the area (Leatherwood, Bowles and Reeves, 1983), suggest that: 1) Fin whales formerly were present on both sides of the chain from April through early September. In July and August they were found primarily in the Bering Sea, where they were relatively abundant near Unalaska and Akutan islands. The southeast Bering Sea apparently was an important Spring/Summer feeding ground. By August or early September, the population center had shifted to the North Pacific. Migration between the two areas apparently concentrated in Unimak and Akutan passes; 2) Humpback whales were present in greatest numbers from June through August, in the Pacific, in Unimak Pass and in the Bering Sea just north of the pass; 3) Blue whales were most abundant from June through August, almost exclusively on the Pacific side of the islands; 4) Sperm whales, all adult males, were found in the Pacific near Akutan Island and rarely in the Bering Sea, largely in July.

Analysis of trends in the Akutan fishery (Leatherwood et al., 1985a) indicated some depletion of the stocks. Both fin and humpback whales were taken at greater distances from the station in later than in earlier years, indicating reduced availability. Overall there was a downward trend of catch-per-unit-of-effort, also taken to mean stocks were declining somewhat. Nevertheless, significant numbers of whales apparently were still available to the whalers in 1935-39 as 0.28-0.51 whales per gross catcher day were taken in the last five years of operation. Whaling continued in the North Pacific after the closure of the Akutan station in 1939, and it is generally accepted that subsequent intense episodes of whaling in the northeastern Pacific from shore stations and pelagic fleets left most great whale stocks in the broader area depressed (e.g., Rice, 1974; Tillman, 1977).

In 1982 and 1983, a series of eight aerial surveys of the southeastern Bering Sea and Bristol Bay was flown to determine geographic and seasonal. distribution and relative abundance of cetaceans. Surveys covered only about 1.9% of the enormous area (ea. 185,000 nm^2) (633, 162.5 km%) per survey and were often flown in less than ideal survey conditions (see Leatherwood et al., 1983, Table 2, p. 9, Table 4, p. 42). With the exception of gray whales (Eschrichtius robustus), for which it was possible to estimate density in portions of the southeastern Bering Sea in May and June (Leatherwood et al., 1983, Table 10, p. 67.), few great whales were seen (Leatherwood et al., 1983, Table 7, p. 57). Three possible explamtions of the apparently low density of

whales in the area overall, and particularly in the portions of the surveyed area where some species formerly occurred in much greater abundance, are: 1) the low density survey coverage and generally poor survey conditions; 2) highly localized whale distribution near the Aleutians where aerial survey coverage was low and previous whaling effort had concentrated; and 3) there were few great whales present in the eastern Bering Sea during survey periods in 1982 and 1983.

In 1984 we flew high coverage, low-altitude aerial surveys of the former Akutan whaling grounds at precisely the time of year when the greatest abundance of whales was expected on the grounds, as determined from historical whaling records (see Reeves et al., 1985). We also flew surveys of lower density in an area straddling the continental slope between the whaling grounds and the Pribilof Islands, near scheduled oil and gas exploration and developments.

METHODS

Survey Design, Transect Selection and Placement

Surveys were designed using a stratified random sampling scheme to balance the need for a random sample with practical logistical and operational constraints. The former whaling grounds, defined by reference to Reeves et al. (1985, Figures 11 and 12), were divided into two blocks, one south (block 1) and one north (block 2) of the chain but with a common southwest to northeast oriented boundary, essentially along the axis of the islands, between them (Figure 1). Each block was subdivided into 3 zones of equal width. The sizes of blocks and zones *were* defined such that amount of searching in each zone *or* combination of zones for which density estimates were reported (i.e. 1 + 2 & 3) was roughly proportional to its area. This feature permits blocks and zones to be combined for density estimates.

The boundary between blocks 1 and 2 was scored at 0.25 nm (0.46 km) intervals. Before beginning surveys, eight sets of three numbers each were selected at random and without replacement. These represented the starting points of 48 transects (24 in each block, 8 in each zone) to be flown NW to SE or SE to NW, parallel to the zones' long boundaries.

A third block (block 3) was defined between Unimak Pass and the Pribilof Islands, in waters overlapping coastal, continental shelf and pelagic areas (Figure 1) in which at least fin, sei (B. borealis), minke (B. acutorostrata), humpback, gray, right and bowhead (Balaena mysticetus) whales and various other smaller marine mammals had been reported recently (Leatherwood et al., 1983). This rectangular block was divided into 2 zones, each approximately 40 x 100 nm (74x185 km). The western margin of each zone was scored at 0.25 nm (0.46 km) intervals, and 8 sets of transects were selected for each, as described above. Transects were to be flown East to West parallel to the long block and zone boundaries.

Conduct of Surveys

All surveys were flown in a Partenavia P68 Observer (Figure 2), a high wing, twin engine aircraft, with a clear plexiglass nose, which afforded a clear and continuous view of the transect-center-line, and a 24 in (6I cm) plexiglass bubble window on each side adjacent to the observers seats. The forward observer, seated in the co-pilot's position, was dedicated to observing along the transect-center-line. Side observers, who could also see the center-line, searched outward from the line.

Surveys were flown at altitudes between about 500 and 800 ft (150 and 245 m) and a ground speed of 110 knots (185 km hr). As in our previous aerial surveys of cetaceans (e.g., Leatherwood, 1979; Leatherwood and Reeves, 1983; Leatherwood, Hammond and Kastelein, 1985) transects were only initiated in sea surface conditions of Beaufort 3 and below, as rougher conditions are considered to affect significantly the probability of seeing cetaceans (e.g. Leatherwood and Show, 1980; Scott and Gilbert, 1982, Tables 6 and 7). If conditions deteriorated during a survey to Beaufort 4 or higher and remained so for 5 minutes or more the transect was terminated. If possible, such transects were resumed when conditions improved or were re-flown on subsequent days.

Data on effort and sightings were collected from transects (the randomly selected lines that provided the basis for density estimation - such periods were logged as 'on-effort") and during transits (straight lines connecting transects with one another or with the shoreline; routes flown along land masses and between the base of operations, Dutch Harbor, and starting or ending points of transects; and any survey lines completed under unacceptable conditions. Transits were logged as 'off-effort". Data were also recorded during the ferry flights between Anchorage and Dutch Harbor. All data were logged using an Epson HX-20 computer linked to the aircraft navigation system (Loran-C, Model AVA-100A, ARNAV Systems, Inc.) by means of an RS-232 connection. Location (latitude and longitude), local time, magnetic heading and ground speed were recorded automatically once per minute and whenever a report of a sighting was entered. Environmental conditions, including sea state (as Beaufort number), sun glare, and characterizations of weather and visibility, were entered periodically, as they changed, and when sightings were entered.

For each marine mammal sighting the following information was recorded: the angle (α) formed between the horizon and a line to the animal(s) when the aircraft was perpendicular to the sighting (measured, to the individual or to the center of the group of individuals, with a hand-held Suunto clinometer and later used to calculate perpendicular sighting distance); species; the cue prompting the sighting; behavior; total number of animals; number of calves; swimming direction; and observer making sighting. Data were stored on microcassettes and later transferred to a WICAT computer at Hubbs Marine Research Institute for analysis.

Perpendicular distance to each sighting was calculated as

$$x = H \tan (90 - \alpha)$$

where H is aircraft altitude, in meters.

Data Analysis

Density and abundance estimates were calculated using line transect techniques (following Burnham, Anderson and Laake, 1980) and program TRANSECT (Laake, Burnham and Anderson, 1979). Highlights of the method as applied in this instance are summarized below.

The probability density function (pdf) of the perpendicular distances, f(x), was estimated from calculated distances and evaluated at zero (f(0)). The result was used in the following expression for density

$$D = \frac{n\, f(0)}{2L} \qquad \text{(Equation 1)}$$

where n is the number of observations and L is the length (in nautical miles) of the line(s) (or the distance searched). The value of L was calculated from recorded positions and verified by comparison with time and speed calculations. In fact, distances calculated by the two methods differed by only 3%.

Following Burnham et al. (1980) we selected a Fourier series model, a linear combination of cosine functions, which has proven generally useful and has been applied to a variety of recent survey data (e.g., Ratti, Smith, Hupp and Laake, 1983; Hammond and Laake, 1983; Leatherwood et al., 1983; Leatherwood et al., 1985b). It can be expressed as

$$f(x) = \frac{1}{W} + \sum_{k=1}^{m} a_k \cos (k\_))'X/W) \qquad \text{(Equation 2)}$$

where W is the width of the transect, in this case the largest observed perpendicular distance, m is the number of cosine terms used in the model and a_k is the kth parameter estimated from the data. The estimate of f(0) is

$$f(0) \;.\; \frac{1}{W} + \sum_{k=1}^{m} a_k \qquad \text{(Equation 3)}$$

because when it is evaluated at x=0 the cos (0)=1.

For marine mammals that occur in herds, the herd, rather than the individual. animal, must be treated as the observation (Hayes, 1977; Burnham et al., 1980; Quinn, 1980). Therefore, the number of sightings (n) is the number of herds observed. The estimate of density, therefore, is

$$D = \frac{n\, f(0)\, \bar{C}}{2L} \qquad \text{(Equation 4)}$$

which is the product of the density of herds and an average herd size ($\bar{C}$).

An estimate of the sampling variance for density, given by Burnham et al. (1980), is

$$\mathrm{Var}(D) = D^2 \left(CV^2(n) + CV^2(f(0)) + CV^2(\bar{C})\right) \qquad \text{(Equation 5)}$$

where

$$CV^2(n) = \mathrm{Var}(n)/n^2, \qquad \text{(Equation 6)}$$

$$CV^2(f(0)) = \mathrm{Var}(f(0))/(f(0))^2, \text{ and} \qquad \text{(Equation 7)}$$

$$CV^2(\bar{C}) = \mathrm{Var}(\bar{C})/\bar{C}^2 \qquad \text{(Equation 8)}$$

The variance of f(0) is from Equation 3; the variance of C is the standard sampling variance; and the variance of n, based as it is on replicate lines, can be expressed as

$$\mathrm{Var}(n) = \frac{L}{R-1} \sum_{i=1}^{R} \left[l_i \frac{n_i}{l_i} - \frac{n}{L} \right]^2 \qquad \text{(Equation 9)}$$

where R is the number of replicate lines, L is the total line length and l_i and n are the length and number, respectively, of observations for the ith replicate.

The validity of estimates of density from line transect sampling depends on how well the following underlying assumptions are satisfied: 1) the area of interest is sampled randomly or the population is distributed randomly within the area; 2) all animals on or near the transect-center-line are seen; 3) all measurements are made without error; 4) the animals do not move or sampling occurs instantaneously with respect to any movement; 5) sightings are independent events; and 6) the size of a group of animals does not affect its probability of being observed.

RESULTS

On flights made between 26 July and 26 August 1984 we collected data along 4,132.2 nm (7,644.6 km) of survey track, including 2,382.7 nm (4,408 km) "on-effort", i.e. during random transects (Figure 3 top) and 1,709.5 nm (3,162.6 km) "off-effort", i.e., during transits (Figure 3 bottom; Tables 1 and 2). A total of about 23.6 hours was spent searching while on transect (i.e., "on-effort") at an average speed of 114 knots (190 km hr). The vast majority of effort on transect was spent in blocks 1 and 2, where 47 of 48 planned transects were completed. Inclement weather, mostly persistent low clouds and fog which significantly affected survey conditions and safety, permitted us to complete only two of eight transects planned for block 3.

Overall, we saw 206 groups (4,538 individuals) of marine mammals, including 77 groups (199 individuals) of cetaceans (Figure 4), 91 groups (3,805 individuals) of pinnipeds and 38 groups (534 individuals) of sea otters (Figure 5). Sixty-three groups (1,567 individuals) were seen while on transect, 143 groups (2,971 individuals) while 'off-effort", or on transit (Table 3).

For most species seen there were far too few sightings to support density estimates. The only identified baleen whale seen on transect was a single minke whale located off western Unalaska Island (Figure 4). The 11 fin and 14 gray whales recorded were all seen "off-effort", during transit or ferry flights. So also were 20 of the 26 killer whales (Orcinus orca) seen (Table 3).

Only one species, Dall's porpoise (Phocoenoides dalli), was observed in sufficient frequency to permit estimates of density (Table 4). Three such estimates were made: for blocks 1 and 2 combined; for block 3; and for blocks 1, 2 and 3 combined. On first examination, it would appear there were enough sightings of Steller's sea lions, Eumetopias jubatus, to support calculation of density estimates. However, only a few of these animals were encountered "on-effort" at sea. Most were seen in the water, in large groups, very near or on shore at rookeries and haul-out areas at the ends of *transects.* For animals so distributed, careful counts along shore and at known rookery and haul-out sites (e.g., Fiscus, Rugh and Loughlin, 1981; Loughlin, Rugh and Fiscus, 1984) are far preferable to such random checks of the shore line or estimates from small numbers of sightings at sea.

There were too few 'on-effort' sightings of Dall's porpoises to eStimate f(0) reliably (see equations *2* and 3); so, after discarding all sightings made under unacceptable conditions we combined the remaining "on-" and "off-effort" sightings, as described below, to derive the sightability function. Such an approach is valid if the factors affecting f(0) are not significantly different between the 2 sets of sightings. The 3 factors most likely to affect f(0), and their characterizations for the present surveys, are: 1) sea state - the proportions of distance flown under various sea states were relatively consistent between all effort in blocks 1 and 2 combined and effort on transect in block 3. As remaining flights, those "off-effort" in block 3 and those during ferrys, were made almost entirely in the one category of good sea state conditions (Table 1), sightings from them were excluded from calculations to estimate f(0); 2) visibility conditions - the proportions of distance flown

under various visibility conditions were relatively consistent among all flights in blocks 1 and 2 combined and block 3 (Table 1); so, all sightings from them were included in calculations to estimate f(0); 3) altitude - nearly all (91.8%) transects were flown at altitudes between about 700 and 800 ft (225 and 245 m). Therefore, sightings from "off-effort" were included in calculations to estimate f(0) only if they were made while flying within this range of altitudes. Proceeding in this manner, we were able to use 42 sightings of Dall's porpoises to estimate f(0).

All of these 42 sightings of Dall's porpoises resulted in recording of clinometer angle. The distribution of distances calculated from those measured angles indicate little bias due to rounding. This does not imply that measurements are free from error, only that such error is random and negligible. Therefore, rather than being grouped into distance intervals, the calculated perpendicular distances were used as exact distances to estimate f(0) and to derive a Fourier series fit for sightings of Dall's porpoises (Figure 6).

Density estimates were made using the above described estimates of f(0), the number of 'on-effort" sightings (n), and the average herd size (C) in all "on-effort" sightings (Figure 7). There was little variation in herd size between blocks 1 and 2 combined and block 3, as evidenced by the low coefficients of variation (Table 4). Even so, separate estimates were calculated for blocks 1 and 2 combined and block 3 because there was considerably more effort in proportion to area in the former than in the latter. The resultant estimates were 115.0 $\pm$ 0.263 animals per 1000nm^2 (3,422.5 km^2) in blocks 1 and 2 and 30.8 $\pm$ 0.870 in block 3, (Table 4).

To construct an overall estimate, we weighted the individual block estimates by the relative sizes of the areas as

$$D = \frac{(A_1+A_2)\,(D_1+D_2) + A_3 D_3}{A_1+A_2+A_3} \quad \text{(Equation 10)}$$

DISCUSSION

Gray whales appear to have recovered from the effects of the most recent episode(s) of whaling, earlier this century, and are believed to be at or near their pre-exploitation stock size of 15,000 - 20,000 (Reilly, 1984). The vast majority of that population is north of Unimak Pass annually from April - June through November - December (see contributors to Jones, Swartz and Leatherwood, editors, 1984). With respect to our survey areas, gray whales are peripheral, moving through Unimak Pass and close along the shores of Unimak Island and the Alaska Peninsula during migrations. Gray whales were not taken by Akutan whalers (Reeves et al., 1985).

Minke whales of the northeastern Pacific have never been exploited (a few were taken at Akutan - Reeves et al., 1985) so they are at present regarded as an Initial Management Stock (INS) and believed to be abundant overall (IWC, 1983:97). Their pouplation size is not known. They were the balaenopterids seen most frequently on recent aerial and vessel surveys in southeastern Bering Sea and Bristol Bay (Leatherwood et al., 1983) and have been often recorded as occurring year-round, particularly in shallow shelf waters, of the Bering Sea, Gulf of Alaska and northern North Pacific. We expected to see some minke whales in both study areas although minke whales apparently concentrate *in* the northeastern portions of Bristol Bay in late summer. Further, minke whales usually produce no visible blow and are only seen very close in the track line and while on surface.

Darling and McSweeney (1985) estimated there are a minimum of 1,500 humpback whales in the Northeastern Pacific. Rice (1978) reports that humpbacks, though present on the Asian winter grounds, are now scarce in that area. Apparently animals from both populations occur in Alaskan waters (Nishiwaki, 1966), but there are still only sporadic records in the southeastern Bering Sea and along the Aleutians near Unimak Pass (Leatherwood et al., 1983). Humpbacks were the second most important species to the Akutan whalers, numerically, comprising 30% of the total take (1,510 of 5,027 whales identified to species in 23 years) but comprised 66.7% of the total take at nearby Port Hobron (1,573 of 2,357 taken identified to species in 11 years) (Reeves et al., 1985). From their apparent dispersal during recovery in various portions of the North Atlantic (IWC, 1984:135-6), one would predict widespread recolonization of former grounds in the North Pacific with population growth.

Blue whales (a total of 835 individuals in the life of the station) were taken by Akutan whalers almost exclusively on the south side of the Aleutian islands. Therefore, it was not surprising that no blue whales were seen on previous surveys in the southeast Bering Sea (Leatherwood et al., 1983) or in Bering Sea portions of the present surveys. However, we were surprised that no blue whales were seen even in areas near the southern edge of Davidson Bank, where blue whales were most often killed by the Akuan whalers. The north Pacific stocks of blue whales appear to be depressed from whaling through 1965 but are thought to be recovering at least on the eastern side (Rice 1978; Leatherwood et al., 1982). The total population was thought to have been reduced from 2,430 in the mid 19401s to 1,420 in 1964 (Doi, Nemoto and Ohsumi, 1967) so it is probable that, even with recovery, the stocks are less abundant than they were at least at the start of Akutan whaling.

The status of North Pacific fin whales is unassessed (IWC, 1983:71-100). This was the species most important to shore whalers at Akutan, comprising 49.7% (2,498 of 5,027 whales identified to species) of takes there in 23 years and second most important at Port Hobron, comprising nearly 20% (464 of 2,357 whales identified to species) of takes there in 11 years (Reeves et al., 1985). Further, fin whales were the balaenopterids seen second most often (after minke whales) in recent surveys (Leatherwood et al., 1983). We expected to see them, especially on the continental shelf, during the present surveys.

The status of sperm whales in the North Pacific is problematical and highly disputed. Whatever the correct delineations of stocks, adult males from the eastern and western Pacific 'intermingle(d) in higher latitudes (IWC, 1980:3,4). The stock(s) have been exploited historically and are currently considered an IMS with a catch limit of zero (IWC, 1983:80). We expected to encounter some sperm whales in the deeper water portions of the survey areas.

The other three northern North Pacific great whales are not commonly reported in or near any of the three study blocks so were not expected on these surveys. Bowheads may assemble near St. Matthew Island in Spring (Braham et al., 1980; Brueggeman et al., 1984) but are rarely reported farther south (Leatherwood et al., 1983); right whales are seriously endangered and rarely seen anywhere in the eastern North Pacific (Rice, 1974; Scarff, in press; Reeves and Leatherwood, 1985 MS); and sei whales are generally uncommon north of the Aleutians, being found in pelagic regions farther south (Rice, 1974, p. 181; Leatherwood et al., 1983).

With the above in mind, there were surprisingly few sightings of great whales in or near the roughly 14,400 nm^2 (49,284 km^2) area of study block 1 and 2, or in the 4,000 nm^2 (13,690 km^2) area of block 3 during the 29 field days. By comparison, in surveys by aircraft of portions of an approximately 50,000 nm^2 (171,125 km^2) area within about 180 km of shore off eastern Newfoundland-Labrador in August 1980, Hay (1982) observed 31 groups of humpback whales and 18 groups of fin whales, supporting his estimates of populations of 738 ($\pm$ 221 SD) and 478 ($\pm$ 250 SD) for the two species, respectively. Hay's surveys were designed to cover essentially the whaling grounds used by Canadian whalers from South Dildo and Williamsport, Newfoundland between 1964 through 1971 (Mitchell, 1974; Figure 5-1). From cumulative catches, it has been estimated there were populations of at least 1,500 fin, 1,000 humpback, 500 blue and 300 sperm whales available within a 100 nm (185 km) radius of the Akutan whaling station at some point in the history of the fishery (Leatherwood et al., 1985a). If populations of these 4 species had been present on the Akutan grounds in comparable numbers in July and August 1985 it is reasonable to suppose, from Hay's (1982) experience) that some whales would have been seen. The appreciable number of smaller animals detected suggests large numbers of whales were not missed simply by lack Of vigilance. The results from sightings of Dall's porpoises are a useful case in point. Leatherwood et al. (1983) estimated that there were 97.20 ($\pm$ 49.50 SD) Dall's porpoises per 1,000 nm^2 (3,422.5 km^2) (in study blocks) between the north side of the Aleutians and about the southern latitude of the Pribilofs, from longitude 166° W to longitude 170 W. From the present surveys we calculated three estimates: 30.8 (CV=0.870) individuals per 1,000 nm^2 (3,422.5 km^2) in block 3 and 115 (CV=0.263) individuals per 1,000 nm^2 (3,422.5 km^2) in

blocks 1 and 2 combined, and 90.1 (CV=0.251) in blocks 1, 2 and 3 combined (Table 4). The results are certainly comparable.

From the above it would appear that results of the present surveys could be interpreted with some measure of confidence. They appear to support the hypothesis that the relatively low numbers of baleen whales - other than gray and minke whales - seen in the eastern Bering Sea and northern North Pacific near Akutan actually do indicate low density of these animals and are not merely artifacts of low density coverage in less than desirable survey conditions. However, one must be cautious when interpreting a scarcity of sightings of cetaceans from aerial surveys as evidence of their low density in the area(s) under study, unless attention has been paid to problems affecting results of such surveys. The surveys described in this paper avoided many of the shortcomings of previous aerial surveys in the southeastern Bering Sea and Bristol Bay (for discussion, see Leatherwood et al.,1983), shortcomings which prevented the authors of that report from stating conclusively why they observed great whales in such low densities. Improvements were made in four important areas.

First, present surveys used an aircraft with downward visibility, permitting observers to see the transect-center-line and thereby better satisfy the second assumption of line-transect methodology (see section entiled "Data Analysis"). The increased visibility resulted in larger numbers of sightings near the transect-center-line (approximately 25% of all sightings were within 0.04 nm of the line) and gave some assurance that few animals at or near the surface in the near strip at the time of overflight were missed. The absence of data in that strip can significantly affect credibility of estimates.

Second, present surveys were conducted only in acceptable conditions of sea state and visibility (91% of the survey effort was in Beaufort 3 or below, 70% in the 2 best visibility classes) when the probability of detecting animals is highest. This was made possible by the proximity of lines in blocks 1 and 2 to the operational base and the relatively short time required to complete a replicate set of transects in each. Therefore, observers were afforded the luxury of waiting at the operational base for acceptable weather conditions before departing for survey and of surveying on whichever side of the Aleutians offered the best weather conditions. The absence of any lee effect at block 3, the greater distance to that block, and the often significant differences in weather near the chain and weather offshore (making difficult any decisions of when conditions would be acceptable for surveying block 3) resulted in completion of only one of four planned replicates in block 3 in 29 possible survey days. Previous surveys covered large areas, including many for which accurate weather reporting is not available'. The result was a high percentage of time in conditions of unacceptable visibility.

Third, the eight sets of replicates in blocks 1 and 2 were completed within a month, at a time of year when peak catches of fin, humpback, blue and sperm whales were made (Leatherwood et al., 1985a). Further, transects were spaced at narrow distance intervals, affording higher coverage per survey, and overall, during the month, with concomitant higher probability of detecting animals present.

Fourth, special attention was paid to precision in distance estimation (helped by the increase in proportion of sightings close to the aircraft where an error of a few degrees amounts to an error of less than 0.004 nm in the estimated perpendicular sighting distance) and to remaining with groups found long enough to confirm species and number of individuals present. The added time requirea for these last activities is not available on longer surveys in which the aircraft is stretched to safety limits just to complete transects.

One problem which will always exist in aerial surveys of cetaceans is that of estimating numbers of animals missed because they were submerged, and therefore not visible, during the period of the overflight (Leatherwood, Goodrich, Kinter and Truppo, 1982). This problem can only be corrected meaningfully with data, preferably collected at the time of the surveys, on diving frequencies and times for each species seen and their resultant effects on visibility. Submergence is likely a more significant problem in attempts to estimate density of great whales (which usually travel singly or in small groups and remain submerged for long periods), particularly when they occur in low densities, than it is with animals such as Dall's porpoises which travel in larger groups and remain submerged for shorter periods. This problem threatens to confound attempts to interpret conclusively any results from these or other aerial surveys.

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!r-able 1. Distance searched by Beaufort class. Effort was assigned to the category "0-2" if whitecaps were absent, "3-5" if whitecaps were present.

Areas	On-Effort Beaufort 0-2	On-Effort Beaufort 3-5	On-Effort Total	Off-Eff ort Beaufort 0-2	Off-Eff ort Beaufort 3-5	Off-Eff ort Total	Total Beaufort 0-2	Total Beaufort 3-5	Total
Blocks 1 & 2 combined	1,236.3 (59%)	816.8 (41%)	2,053.1	871.7 (66%)	440.1 (34%)	1,311.8	2,108.0 (62%)	1,256.9 (38%)	3,364.9
Blink 3	179.6 (53%)	160.0 (47%)	339.6	115.1 (100%)	0.0 (0%)	115.1	294.7 (65%)	160.0 (35%)	'454.7
Ferry flights between Anchorage & Dutch Harbor	0.0	0.0	0.0	269.3 (95%)	13.3 (5%)	282.6	269.3 (95%)	13.3 (5%)	282.6
Total	1,415.9	976*8	2,382.7	1,256.1	453.4	1,709.5	2,672.0	1,430.2	4,102.2

Table 2. Distance searched by visibility class.

Visibility Class	Blocks 1 and 2 combined On effort	Blocks 1 and 2 combined Off effort	Block 3 On effort	Block 3 Off effort	Ferry Lights Between Anchorage and Dutch Harbor
Mostly obscured < 1 mile	117.1 (6%)	129.0 (10%)	23.8 (7%)		0.0 (0%)
Partially obscured 1-10 miles	697.7 (34%)	395.6 (30%)	71.0 (21%)		0.0 (0%)
Unlimited with some to strong glare	659.5 (32%)	468.7 (36%)	161.0 (48%)		0.0 (0%)
Unlimited with no glare	608.9 (29%)	318.4 (24%)	80.2 (24%)		282.6 (100%)

Table 3. Number of sightings of marine mammals (number of individuals is shown in parentheses).

Species	On Effort		Off Effort		Ferry Anchorage to Dutch Harbor (All off-effort)	Total
	Blocks 1&2	Block 3	Blocks 1&2	Block 3		
Fin whale			3 (11)			3(11)
Minke whale	1(1)					1(1)
Gray whale					10(14)	10(14)
Unid large whale	2(2)		1(1)			3(3)
Killer whale	4(6)		4(20)			8(26)
Unid Beaked whale					1(6)	1(6)
Dall's porpoise	28(69)	3(3)	16(59)			47(131)
Harbor porpoise	2(4)		1(2)		1(1)	4 (7)
Sea otter			2(9)		36(525)	38(534)
Unid phocid	1(1)					1(1)
Harbor seal			14(205)	1(10)	11 (7959	26(1010)
Fur seal	1(1)	1(1)				2(2)
Steller's sea lion	18(1474}	2(5)	41(1312)		1(1)	62 (2792)
Total	57(155 8)	6(9)	82(2619)	1(10)	60(1342)	206(4538)

Table 4. Summary of statistics used in density estimates of Dall's porpoises and their coefficients of variation (CV, in parentheses). Density (D) is expressed as numbers of animals per 1000 square nautical miles.

Area	n	f(0)	C	D
Blocks 1&2	28 (O .209)	6.957 (0.121)	1.00 (0.000)	115.0 (0.263)
Block 3	3 (0.862)	6.957 (0.121)	2.46 (0.105)	30.8 (0.870)
Total	--	--	--	90.1 (0.251)

LIST OF FIGURES

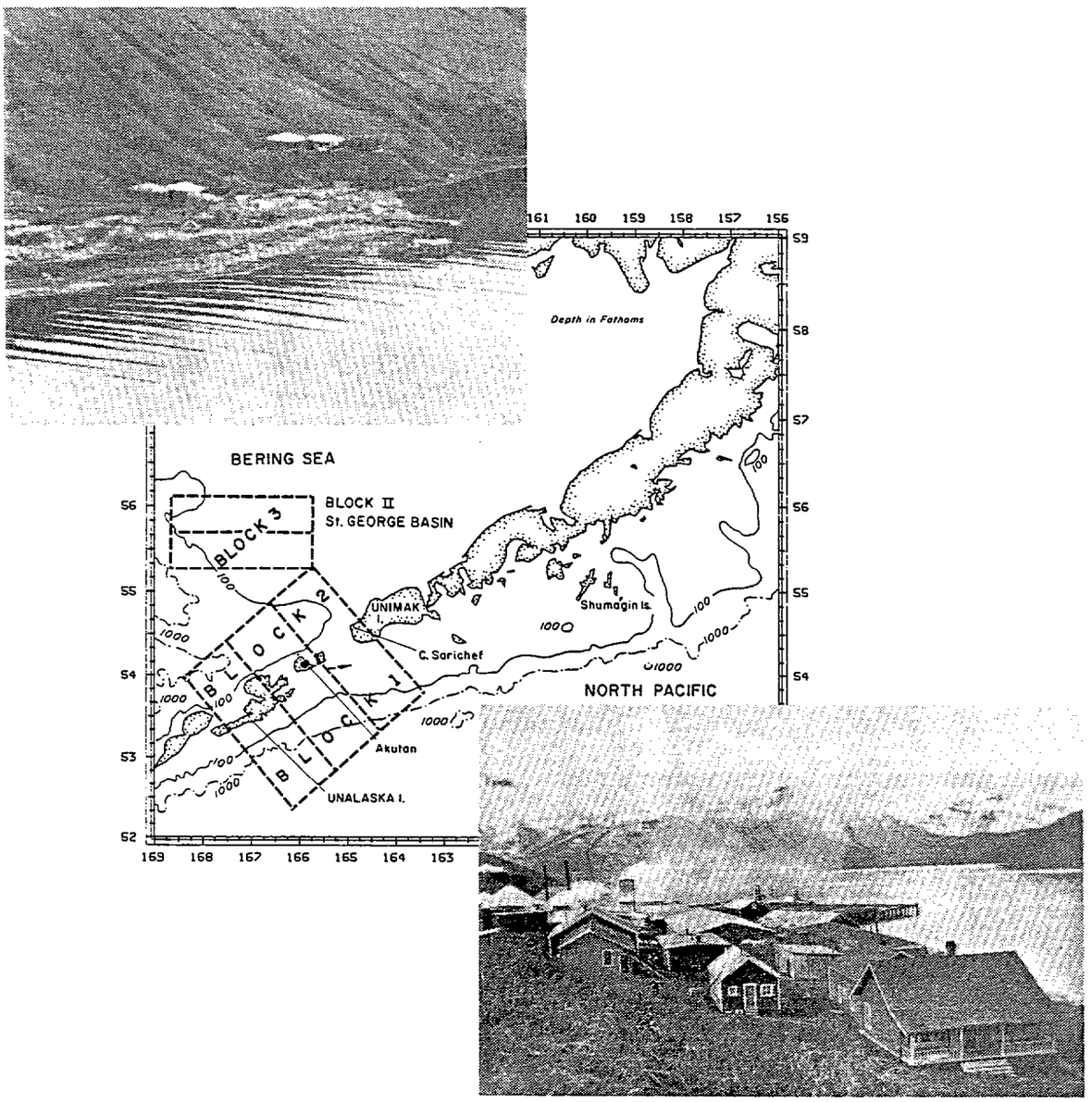


Figure 1. Southwestern Alaska and the eastern Aleutian Islands, showing the location of the shore whaling station on Akutan and the three blocks in which transects were flown. The reset photos show the station in about 1920 (to left) and the site in early August 1984 (lower right). (Photos courtesy of Alaska Historical Library, Juneau - top - and by S. A. Karl - bottom).

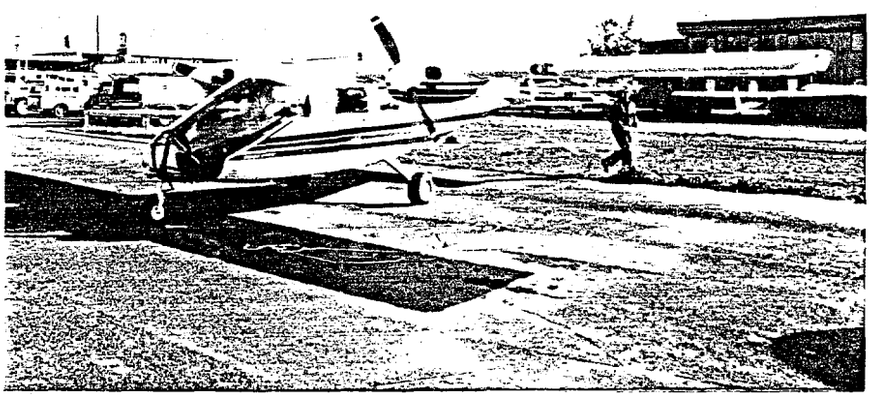


Figure 2. The Partenavia P 68 Observer used in the surveys. Note the clear plexiglass nose, permitting unobstructed viewing of the transect-center-line, and the side bubble window at the starboard observer station (Photo by S. LeatherWood).

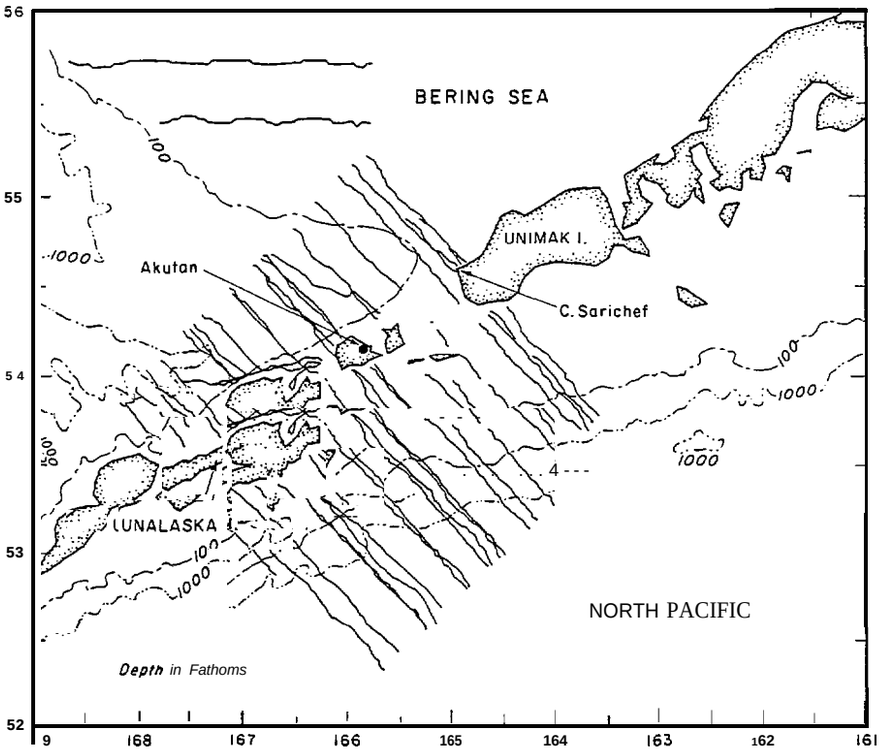
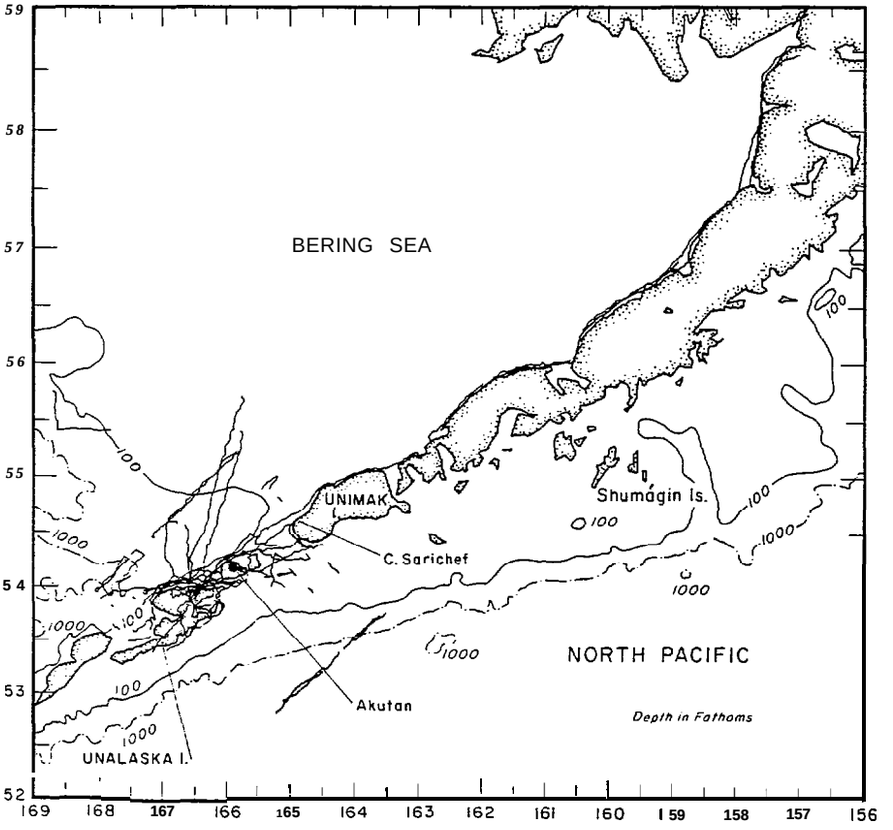


Figure 2 The distribution of transect lines (top) and transits (bottom) - See



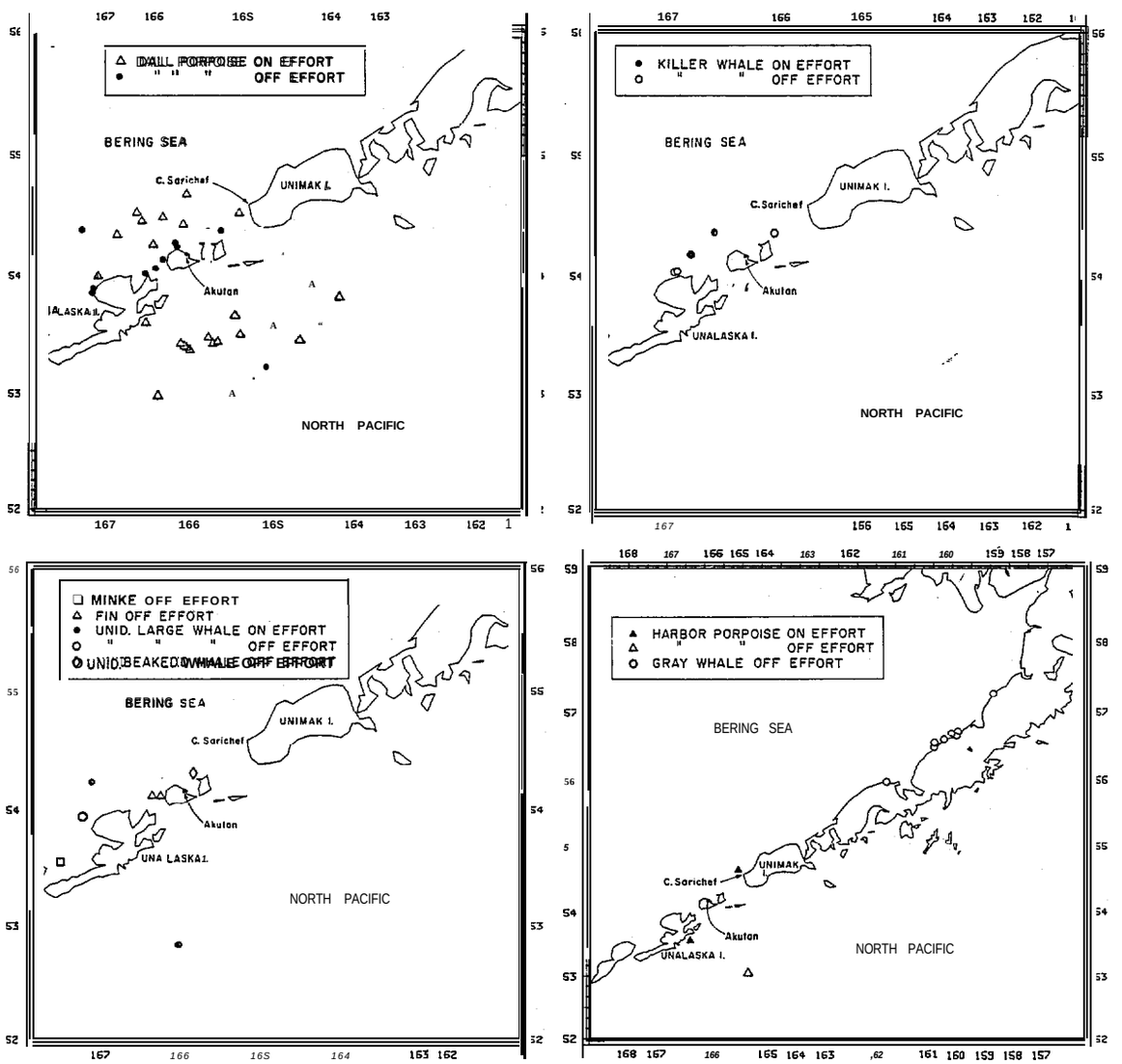


Figure 4. Locations of sightings of cetaceans.

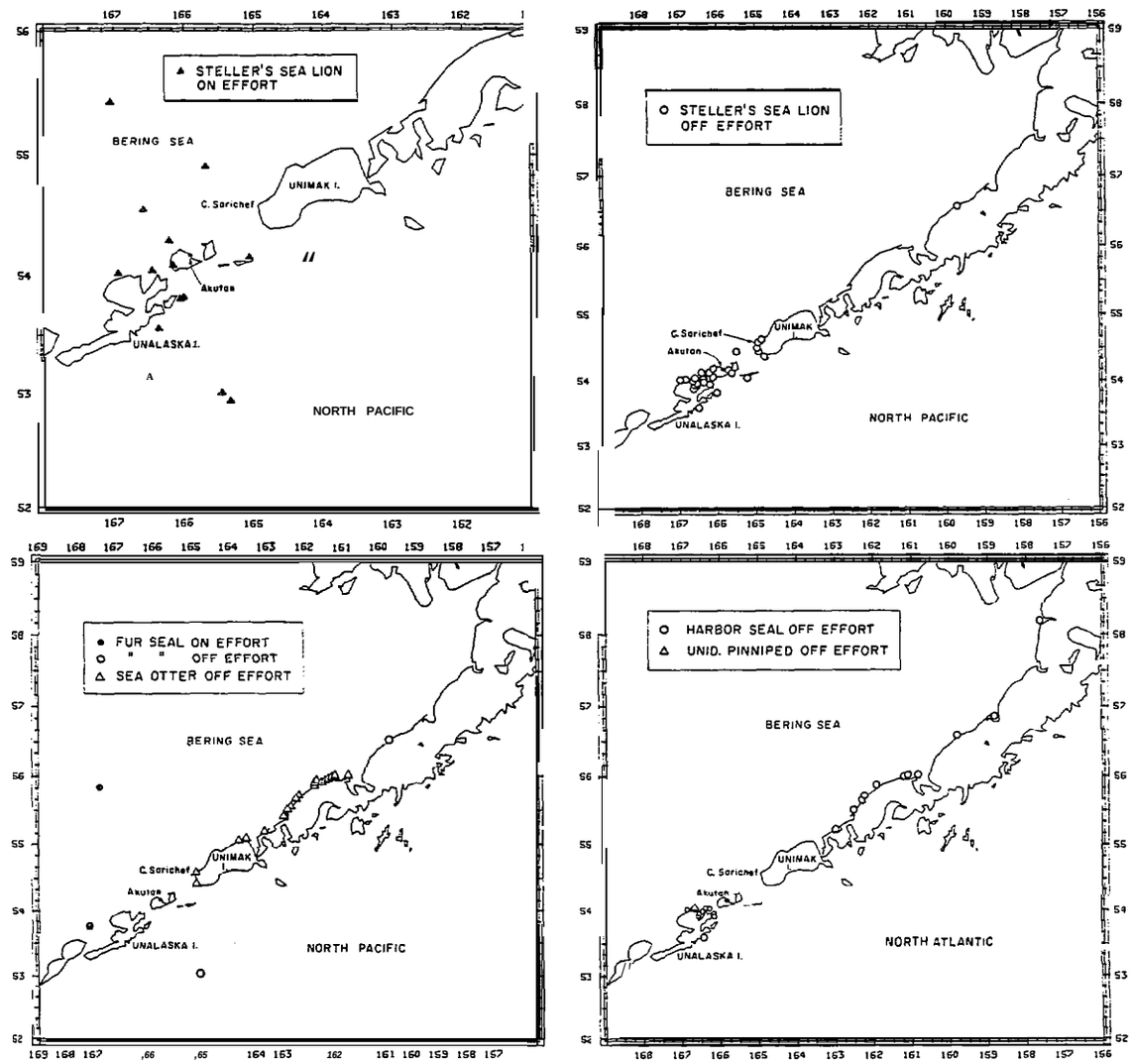


Figure 5. Locations of sightings of pinnipeds and otters.

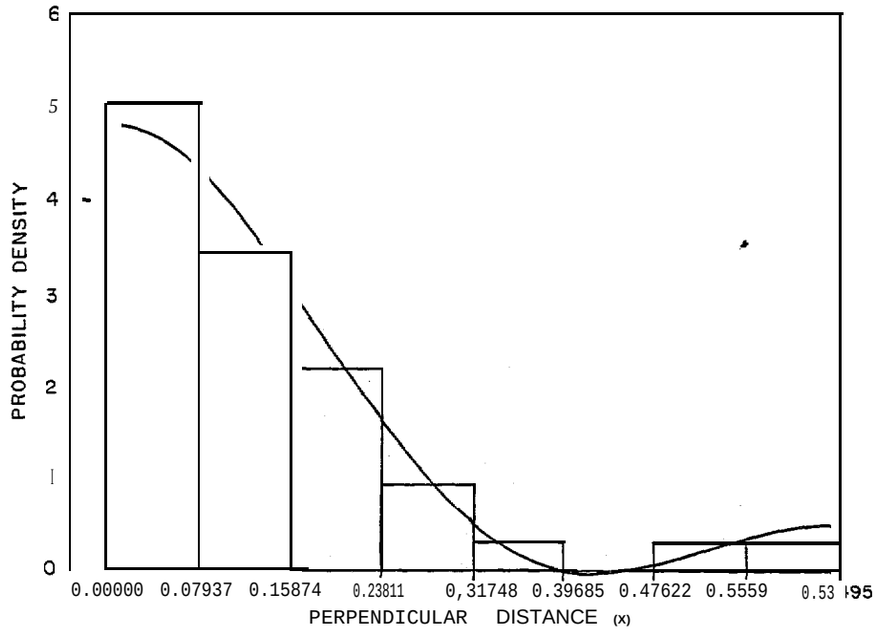


Figure 6. Illustrations of the fit of the Fourier series to the perpendicular distances of the sightings of Dall's porpoises ($f(x) = 1/W + 2.994 \cos(1\pi x/W) + 1.289 \cos(2\pi x/W)$ and $W = 0.374$).

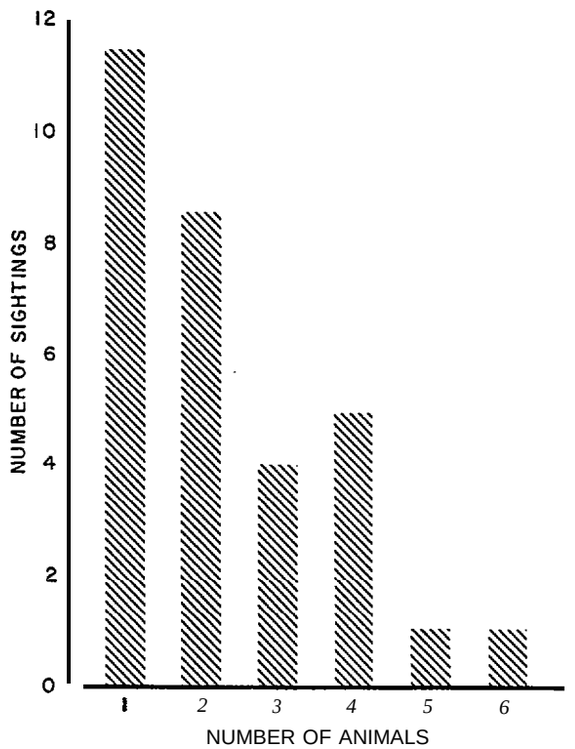


Figure 7. Histogram of the sizes of herds of Dall's porpoises seen on-effort, Blocks 1, 2 and 3 combined.

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