POPULATION CHARACTERISTICS OF HUMPBACK WHALES IN GLACIER BAY AND ADJACENT WATERS: 1997

by
Christine M. Gabriele, Janet L. Doherty and Alexander G. Andrews III
Glacier Bay National Park and Preserve
P.O. Box 140
Gustavus, Alaska 99826

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ABSTRACT

We photographically identified 85 individual humpback whales (*Megaptera novaeangliae*), including 9 calves, in Glacier Bay and Icy Strait between May 24 and August 31, 1997. This is the highest number of whales documented since the monitoring program began in 1985. Two different statistical analyses demonstrated an increasing trend in Icy Strait but not Glacier Bay whale numbers. Thirty-six whales were 'resident' in Glacier Bay and 23 were 'resident' in Icy Strait for more than 20 days. Conversely, 26 whales (10 in Glacier Bay and 16 in Icy Strait) were sighted on just one day. We identified capelin (*Mallotus villosus*) as likely humpback whale prey on five occasions in the study area in 1997, and have determined that prey patches near whales tend to occur at 14-28 m from the surface, with an average vertical extent of 14 meters. We re-sighted 2 juvenile whales that had not previously been identified in the study area, bringing the 1974-1997 total number of returning offspring to 22. The annual proportion of the population composed of known-age whales first sighted as calves appears to be increasing in the study area, as the maturing progeny of area females return and utilize their mothers' home range.

INTRODUCTION

This report summarizes the findings of the National Park Service's (NPS) annual humpback whale monitoring project during the late spring and summer of 1997, the thirteenth consecutive year of consistent data collection in Glacier Bay and Icy Strait. The relationship between vessel traffic and humpback whale distribution, abundance and behavior in Glacier Bay National Park has been a concern since the late 1970's when the possibility of vessel-induced habitat abandonment was first raised (Jurasz and Palmer 1981). In the early 1980's, research on whale prey distribution, underwater sound and whale behavior in the presence of vessels attempted to determine whether changes in whale distribution were linked to prey distribution and/or vessel presence. Researchers found that humpback whales change their behavior in the presence of vessels (Baker et al. 1982; Baker et al. 1983; Baker and Herman 1989) and that there is substantial spatial and temporal variability in whale prey distribution (Wing and Krieger 1983; Krieger and Wing 1984, 1986). Researchers also documented underwater sound generated by various types of vessels operating at a range of speeds (Malme et al. 1982; Miles and Malme 1983). The NPS concluded that any of these factors alone or in combination could influence whale distribution.

In order to investigate the issue further, the NPS initiated an annual monitoring program in 1985 to systematically characterize the humpback whale population in Glacier Bay and Icy Strait. The study area encompasses both Glacier Bay and Icy Strait because whales frequently move between these areas within and between years. Park biologists document the number of individual whales, their residence times, spatial and temporal distribution, reproductive parameters and feeding behavior. Human-whale interactions including strandings, entanglements in fishing gear and vessel disturbance are documented opportunistically. These data are used to monitor longterm trends in the population's abundance, distribution, and reproductive rates. Since 1993, the monitoring program has also documented the water depth and temperature in areas used by whales, to supply information on humpback whale habitat characteristics. In addition, whale distribution data are used each summer to determine when and where NPS "whale waters" regulations should be implemented.

The whales that use Glacier Bay and Icy Strait are part of the southeastern Alaska feeding herd, estimated at 404 whales (95% confidence limits 350 to 458) between 1979 and 1992 (Straley 1994). Site fidelity to the study area is high; approximately 70% of the whales identified in a given year have been identified in two or more years in the Glacier Bay/Icy Strait region, including 15 whales first identified as calves (Gabriele 1997). The number of whales using Glacier Bay and Icy Strait from 1985 to 1996 ranged from 41 to 79, with a mean value of 55.8 (s.d = 10.7) (Gabriele 1996). In 1996 a small, statistically significant increase in whale numbers was detected over the period 1985-1996 in the Icy Strait region. This trend was strongly influenced by the 1996 count; when the 1996 datapoint was removed from the analysis the statistical significance of the trend disappeared (Gabriele 1996). Variability in whale numbers in the study area from 1985 to 1992 did not appear to be attributable to the observed variability in monitoring effort (Gabriele et al. 1995a).

The monitoring program documents the feeding ecology of whales in the study area and its relationship to population composition and numbers. Whale movement throughout southeastern Alaska is presumed to be linked with prey availability which also likely influences the number of whales in the study area (Baker et al. 1990; Straley and Gabriele 1995; Straley 1994). Whales in the study area typically feed alone or in pairs, primarily on small schooling fishes such as capelin (*Mallotus villosus*), juvenile pollock (*Theragra chalcogramma*), sand lance (*Ammodytes hexapterus*) and Pacific herring (*Clupea harengus*). Large aggregations of feeding whales are rarely observed in the study area (Wing and Krieger 1983; Krieger and Wing 1984, Krieger and Wing 1986, Baker 1985, Gabriele 1997). Most whales in the study area feed below the water's surface, bubblenetting and lunge feeding infrequently (Jurasz and Jurasz 1979, Perry et al. 1985).

An intriguing stable 'core group' of 4-12 whales which feeds cooperatively in Icy Strait has been documented since 1981 (Perry et al. 1985). Observations of this group provide insight into whales' use of specific resources within the study area. The question of how and why stable groups form is especially interesting because stable associations are not observed among a well-documented population of North Atlantic humpback whales (Clapham 1993, Weinrich 1991, Weinrich and Kuhlberg 1991). In 1981-1983 whales #577, #587, #155, #573, #166 and #581 were present in the group when Perry et al. (1985) made the first qualitative description of the core group. Attempting to derive quantitative criteria for group membership, Gabriele (1997) defined a 'core group member' as an individual that was sighted in the group for more than 25% of the group's sightings in a given year, in more than one year. A 'core group sighting' was defined as a pod containing 3 or more whales, with at least 3 of the individuals being those identified as core group members. Using those definitions, the current core group members are whales #221, #236, #539, #577, #587, #155, #573, #166, plus two known-age whales (# 186, #353) who have joined since 1990 (Gabriele 1997). Male #186 and female #353 are the offspring of well-documented cows (#530, and #581, respectively) who have infrequently associated with this group since 1985. Forty-three other whales have associated briefly (on one to five occasions) with the group.

METHODS

Vessel Surveys: We conducted our study in Glacier Bay and Icy Strait from May 24 through August 31,1997. We observed and photographed humpback whales from a 5 m Boston Whaler powered with a 60 hp outboard engine. The main body of Glacier Bay (a rectangle defined by four corners: Bartlett Cove, Point Carolus, Geikie Inlet and Garforth Island) was surveyed approximately 3 days per week (Fig. 1). We surveyed the east and west arms of Glacier Bay when other vessels reported whale sightings. Upper bay surveys extended as far north as Russell Island in the West Arm and Adams Inlet in the East Arm.

We performed one to two Icy Strait surveys per week, with the greatest survey effort along the shoreline of Chichagof Island from Mud Bay to Pinta Cove. Several surveys included Lemesurier Island, Gull Cove, the mouth of Idaho Inlet and the north and west shorelines of Pleasant Island. We surveyed the mouth of Glacier Bay while in transit to Icy Strait from Bartlett Cove. To minimize the potential impact that monitoring efforts might have on whales, we generally did not conduct surveys in the same area on consecutive days. However, if

circumstances such as time, weather, or the presence of other vessels interfered with obtaining whale identification photographs, we sometimes returned to the same area the following day. From 1985 to 1995, one biologist conducted the study. In 1996, the number of NPS biologists contributing to the project increased to two, and in 1997 three biologists worked on the project.

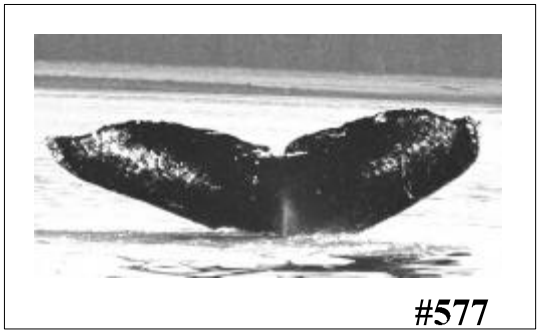
At the beginning of each whale observation we recorded the latitude and longitude coordinates of the 'pod' determined with either a Rockwell PLGR or Trimble Pathfinder Global Positioning System (GPS) using the NAD27-Alaska datum. A *pod* of whales was defined as one or more whales within 5 body lengths of eachother, surfacing and diving in unison. We also recorded on datasheets other information pertaining to the pod, including the number of whales, their activity (feed, travel, surface active, rest, sleep, unknown), a sketch of the markings on their tail flukes and dorsal fin, photographs taken, whale identity (if known), a general description of water depth, temperature and any prey patches observed on the echo-sounder, as well as details pertaining to feeding behavior (if applicable). We opportunistically monitored and recorded underwater sounds with a hydrophone and DAT recorder.

Habitat Characteristics: At the start of each pod observation we measured sea surface temperature and water depth with a Raytheon V850 dual-frequency color video echo-sounder. The temperature sensor was calibrated with a scientific thermometer and was accurate within 0.1^{o} C. Depth measurements were rounded to the nearest meter.

Prey Assessment: We qualitatively described the depth, density and morphology of prey patches appearing on the echo-sounder screen. We used standardized gain and chart-speed settings on the echo-sounder (gains for 50 kHZ and 200 kHz transducers were set at 75%, chart speed was set at 9) to ensure that images observed on different sampling occasions would be comparable. Qualitative descriptions of prey patches were categorized into five types: *Scattered* appeared like falling snow, a *layer* was a horizontal linear aggregation, a *patch* a was nondiscrete, shapeless aggregation, a *ball* was a discrete, curvilinear form and a *mass* completely filled the echo-sounder screen, such that the observer could not determine the shape of the aggregation. We attempted to identify whale prey using a Fisheye underwater video camera (Andrews 1997). We used field guides (Hart 1973; Kessler 1985; Eschmeyer et al. 1983) to taxonomically identify samples that were collected opportunistically at the surface or that were recorded on video.

Individual Identification: Each whale's flukes have a distinct, stable black and white pigment pattern that allows individual identification (Jurasz and Palmer 1981; Katona et al. 1979). We took whale fluke photographs with Nikon cameras (models N6006, 8008 and N90S) equipped with motor drives, databacks and 300 mm lenses (Fig. 2). We photographed the ventral surface of the tail flukes of each whale with 1600 ASA black and white film. Photographs of the dorsal fin supplemented the identification of individuals. Panda Lab in Seattle, Washington processed and printed the film. We analyzed the contact sheets and field notes to determine the date and location where each whale was photographed.

Figure 2. Sample whale fluke identification photograph



We compared photographs of individuals to previous NPS photographs and other available catalogs (Jurasz and Palmer 1981; Perry et al. 1985; Perry et al. 1988; Straley and Gabriele 1997; Uchida and Higashi 1995; von Ziegesar 1992) to determine the identity and past sighting history of each whale. Many whales are referred to by an identification number issued by the Kewalo Basin Marine Mammal Laboratory (KBMML) catalog of North Pacific humpback whales (Perry et al. 1988). Identification numbers lower than ID# 950 coincide with those in the KBMML catalog, but those ID#s higher than 950 are unique to the combined catalogs of Glacier Bay National Park and University of Alaska Southeast researcher Jan Straley (Straley and Gabriele 1997). Whales first photo-identified by Jurasz and Palmer (1981) are also referred to by their nicknames (Appendix 1).

We assigned temporary identification codes to whales that had not been previously identified in Glacier Bay and Icy Strait, denoting the film roll and frame number of the identification photograph, for example GB97-12(36). Temporary codes were replaced with permanent identification numbers if the whale was identified on more than one day, or if it had been identified elsewhere or in previous years. Calves were assigned ID#s if adequate photographs of the flukes were obtained. Whales that were recognizable as unique by high quality dorsal fin photographs but with no corresponding fluke photograph taken in 1997 or previous years were not assigned ID#s but were counted as distinct individuals. After photographic analysis was complete, we added the whale's identity and sighting data from the field notes to a Microsoft Access database containing Glacier Bay and Icy

Strait whale sighting histories from 1977 to 1997, and the season's best photograph of each individual was printed and catalogued.

Whale Counts: After all of the photographs were analyzed, we counted the number of distinct individual whales in the sample. Separate counts were made of Glacier Bay and Icy Strait for the total monitoring period and for a 'standardized period' (after Perry et al. 1985) from 9 July to 16 August. The standardized period was chosen by Perry and co-workers to coincide with the study dates in 1982-1984 to allow valid comparisons of counts between years. Although the standardized period is substantially shorter than the current NPS monitoring season, and the beginning and ending dates have no particular biological significance, the standardized counts are on average 76% of total counts (s.d. = 7, range =64-83%). Continued use of the standardized period is currently the only way of comparing whale counts in 1982-1984 to subsequent years (Gabriele et al. 1995a). We also determined the number of whales that were 'resident' in Glacier Bay, Icy Strait and the combined area. A whale was defined to be resident if it was photographically identified in the study area over a span of 20 or more days (Baker 1986).

Statistical Analysis: We investigated the trend in whale numbers during the study and the effect of survey effort on the number of whales identified, using several statistical methods as described in Gabriele (1996). Our general approach was to plot whale count data by year and fit the data with a least-squares regression line, which is useful in visualizing the potential trend. However, because these data may violate the assumptions of parametric statistics (Zar 1984), we used the non-parametric correlation coefficient Spearman's *rho* to assess the strength and statistical significance of the correlation. We used the nonparametric Mann-Whitney U and Kruskal Wallis to test differences between means. The alpha level used to assess statistical significance was $p < .05$.

RESULTS

Whale Counts: Eighty-five individual humpback whales were photographically identified in Glacier Bay and Icy Strait between 24 May and 31 August 1997 (Table 1). During the standardized period from 9 July to 16 August (Perry et al. 1985) 40 whales were counted in Glacier Bay, 34 in Icy Strait and 66 in Icy Strait and Glacier Bay combined (Table 1). Both the total and standardized counts for Glacier Bay and the entire study area are the highest ever recorded during the monitoring program.

Three of the 85 whales (1 unknown cow/calf pair and adult female #801) were identified solely by photographs of their dorsal fin rather than fluke photographs. Female #801's dorsal fin was matched with photographs from previous years. The unidentified cow and calf both have uniquely shaped dorsal fins that allowed them to be definitively distinguished from all other whales in the 1997 sample. We obtained just dorsal fin photographs from two additional cow/calf pairs, but their dorsal fins were similar to those of other 1997 cow/calf pairs so they were not counted as distinct individuals. We are able to identify an increasing number of whales by their dorsal fin alone, as our catalog of dorsal fins grows. This probably does not influence whale counts, because in most cases we get at least one fluke photograph of a whale for the season and include it in the annual count on that basis. However, using dorsal fin identifications allows us to augment the sighting histories of individuals whose dorsal fins we recognize from other observations accompanied by a fluke photograph.

Figure 3 shows whale numbers observed between 1985-1997. No significant correlation between whale count and year was found for Glacier Bay (Fig. 3b). However, in the study area as a whole, and in Icy Strait, there were statistically significant trends of increasing whale counts over the years (Fig 3a,c). No difference between average whale counts in 1985-1990 vs. 1991-1997 was detected in Glacier Bay, but in Icy Strait and the combined Glacier Bay/Icy Strait area, more whales were identified, on average, in the latter half of the study (Fig. 4).

The May through August 1997 survey effort of 83 surveys (Table 2) and 454 hours total (Table 3) was substantially higher than the 1985-1997 average of 60 surveys and 331 hours. There was no statistically significant correlation between the number of hours surveyed and the number of whales identified in Glacier Bay, Icy Strait or the study area as a whole (Fig. 5).

Seasonal Distribution: Although we observed whales throughout Glacier Bay and Icy Strait (Fig. 1) the highest numbers were seen in lower Glacier Bay, near Flapjack Island and Sturgess Island. Bartlett Cove whale use was highest in June and July, whereas Flapjack Island showed a strong peak in July and moderate use in August, September and October. Whale use of Ripple Cove and Point Carolus peaked strongly in July. Sightings reported by Park staff and visitors (not shown in Fig. 1), include 1 to 4 whales consistently in Blue Mouse Cove during July and August and 1 to 5 whales among the Beardslee Islands in July and August (M.Goodro, pers. comm). In June, campers reported humpbacks consistently near Russell Island and in Queen

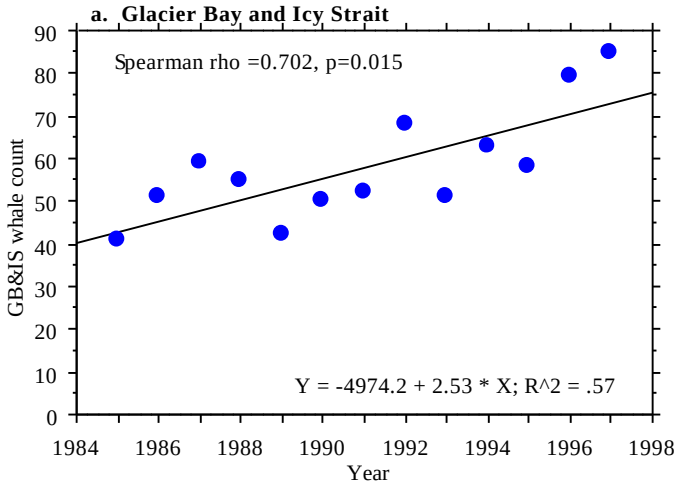
Inlet (K. Bosworth, pers. comm.). One humpback was reported in Hunter Cove, in the East Arm of Glacier Bay.

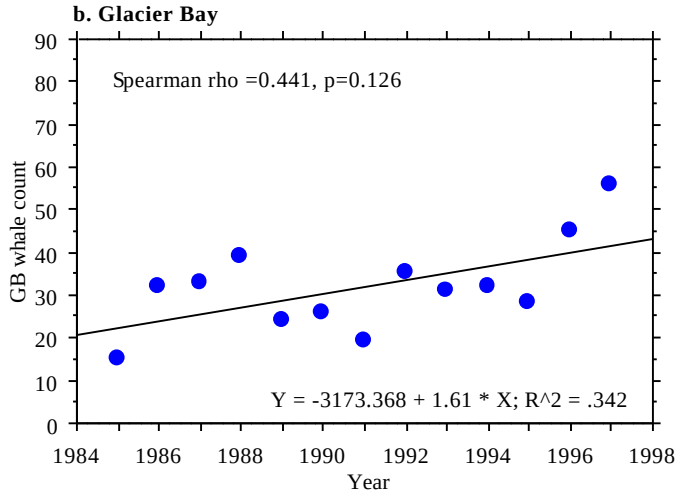
Table 1. Standardized and total counts of humpback whales in Glacier Bay and Icy Strait, 1982-1997

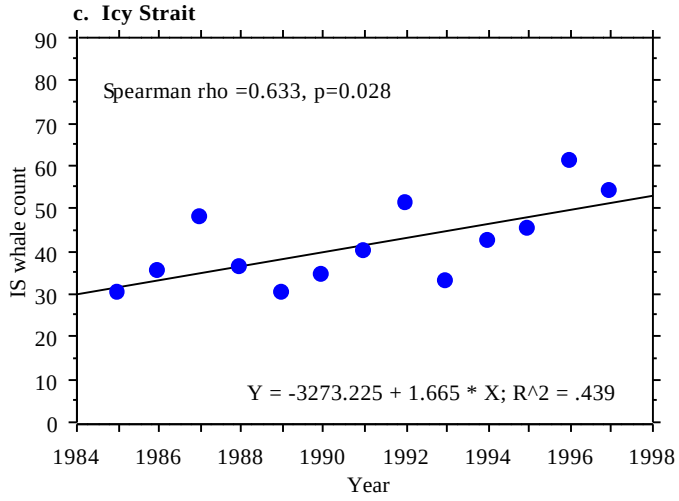
Year	Glacier Bay		Icy Strait		Glacier Bay & Icy Strait	
	Standardized Count	Total Count	Standardized Count	Total Count	Standardized Count	Total Count
1982	22	22	15	15	33	33
1983	10	10	9	9	17	17
1984	24	25	21	22	39	39
1985	10	15	19	30	27	41
1986	26	32	27	35	42	51
1987	28	33	34	48	49	59
1988	17	39	29	36	41	55
1989	20	24	19	30	33	42
1990	16	26	24	34	36	50
1991	16	19	34	40	45	52
1992	27	35	38	51	51	68
1993	23	31	25	33	42	54
1994	17	32	29	42	44	63
1995	18	28	26	45	37	58
1996	37	45	43	61	64	79
1997	40	56	34	54	66	85

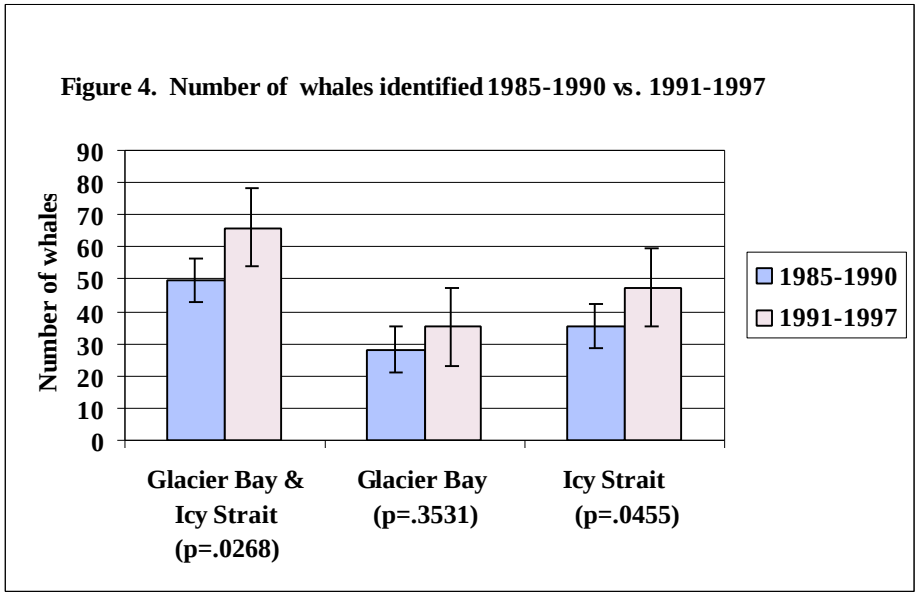
Note: Total counts refer to the number of whales (adults and calves) identified during the entire monitoring season. Standardized counts refer to the number of whales sighted between 9 July and 16 August each year. The combined count for Glacier Bay and Icy Strait is typically smaller than the sum of Glacier Bay and Icy Strait counts because some whales are identified in both areas.

Figure 3. Number of whales identified in Glacier Bay and Icy Strait: 1985-1997









Point Adolphus was by far the most heavily used whale habitat in Icy Strait (Fig. 1). Point Adolphus was used throughout the season, but whale numbers there peaked strongly in July and remained high in August and September. Mud Bay showed very little use except in July, when we identified several whales there. We observed 5-8 single, fast-moving whales lunge feeding in 40-52 m of water in the middle of Icy Strait for a brief period in July, as noted in previous years. Four or more whales were present in the mouth of Idaho Inlet in May and June, and a few in August, but the area was not as populated as in other years.

Local Movement and Residency: Twenty-five of the 85 total whales (29%) were common to both Glacier Bay and Icy Strait in 1997. Twenty-nine whales, including 5 cow/calf pairs, were sighted exclusively in Icy Strait and 31, including 1 cow/calf pair, were observed exclusively in Glacier Bay. Three cow/calf pairs used both Glacier Bay and Icy Strait. Thirteen individuals (14%), made one or more round trips between areas (Appendix 1). Whale #1042 was photographed by a visitor on a tourboat in Chatham Strait on June 30, 1997 (A. Morof, pers. comm.), three days prior to the first of several Icy Strait sightings of this whale in July and August (Appendix 1).

Table 2. Number of humpback whale survey days per month in Glacier Bay and Icy Strait, 1985-1997

Year	Glacier Bay					Icy Strait				
	May	June	July	Aug	Sept	May	June	July	Aug	Sept
1985	0	10	11	10	0	0	7	4	3	1
1986	0	13	17	6	0	0	5	3	6	2
1987	3	12	12	5	1	2	5	7	7	2
1988	0	11	12	12	7	0	5	7	5	3
1989	3	17	14	16	1	1	6	6	7	4
1990	6	16	18	14	0	4	5	6	8	0
1991	7	14	17	13	6	3	7	6	4	3
1992	3	19	17	12	7	2	4	5	4	1
1993	2	10	13	7	1	1	3	3	5	1
1994	1	9	10	13	1	0	5	4	8	1
1995	3	10	11	10	2	2	4	4	7	2
1996	4	11	17	16	3	2	5	10	3	1
1997	5	17	21	19	3	2	4	7	6	4

Thirty-six (64%) of the 56 whales that entered Glacier Bay remained 20 or more days, long enough to be considered resident (after Baker et al. 1983). Twenty-three (40%) of the 60 Icy Strait whales were considered resident in that area during the study and 56 of 85 (66%) whales were resident in the combined Glacier Bay - Icy Strait area. Twenty-six (31%) of the whales in the study area were identified on just one day: 10 in Glacier Bay and 16 in Icy Strait. The sightings of whales that were seen on just one day are spread throughout the season and do not appear to represent a pulse of whales arriving together in the study area (Appendix 1).

Habitat Characteristics: We measured sea surface temperature during 303 whale observation sessions in 1997. The average sea surface temperature observed was 9.7 ^{o}C (s.d. =1.556, range =6.6-15.0, Fig. 6). This is approximately 2 ^{o}C higher than both 1994 (mean = 7.572, s.d. = 4.868) and 1995 (mean = 7.452, s.d. = 2.331) averages, (Kruskal Wallis H=95.230, p <.0001). Sea surface temperature data for 1996 are not reported because the temperature sensor we used was malfunctioning and the data we collected and reported (Gabriele 1996) were later determined to be unreliable.

We measured water depth during 305 whale observations (Fig. 7). Groups of whales were found in an average water depth of 58.5 m (s.d =67.9 , range =8-400) and used a broad range of water depths from 20 to 80m somewhat uniformly (Fig 7).

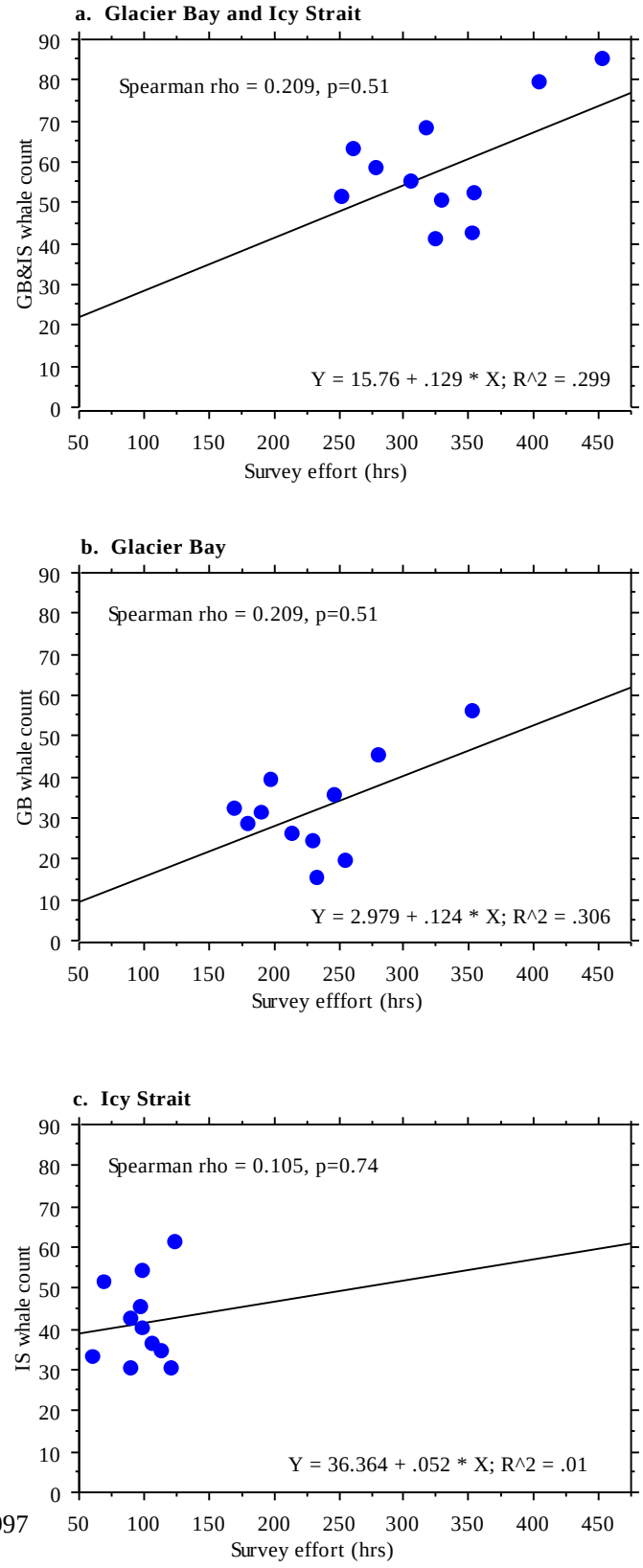
Table 3. Total search and encounter time in Glacier Bay (GB) and Icy Strait (IS), 1985-1997

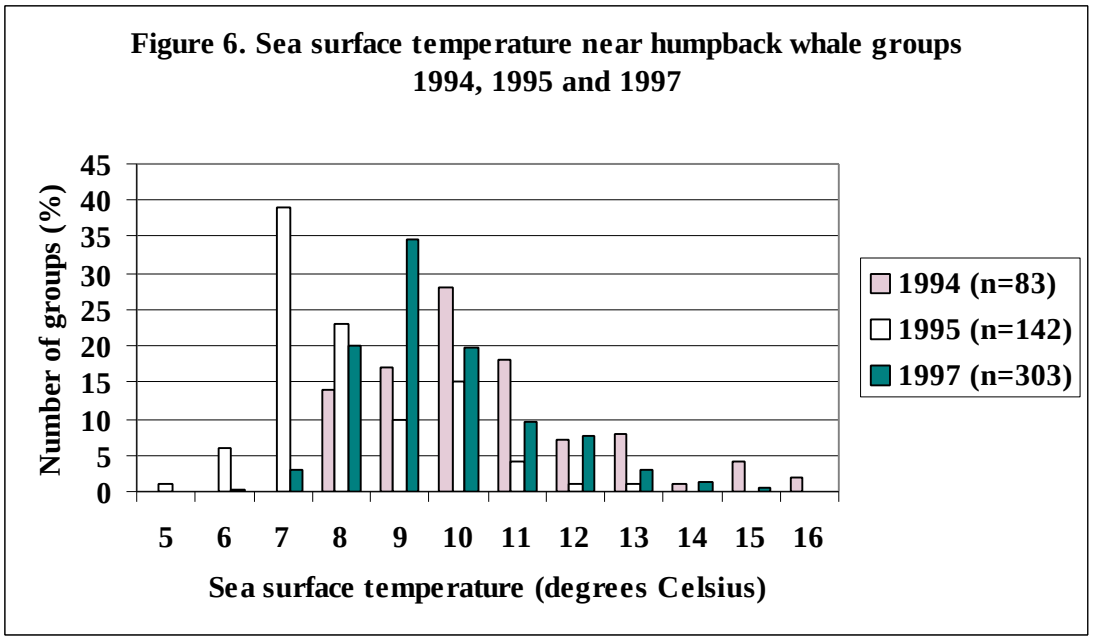
Year	GB (hrs)	IS (hrs)	Total (hrs)	Total Whale Count (GB and IS)
1985	234	92	326	41
1986	-	-	-	51
1987	-	-	-	59
1988	199	108	307	55
1989	231	123	354	42
1990	215	115	330	50
1991	256	100	356	52
1992	248	71	319	68
1993	192	62	254	51
1994	171	92	263	63
1995	181	99	280	58
1996	282	125	407	79
1997	354	100	454	85

Note: Hours of effort for 1986 and 1987 are not available.

Prey Assessment: Based on 139 qualitiative descriptions of echo-sounder traces (Fig. 8a), the vertical extent of prey patches was highly variable, (range 1-70m). The upper edges of prey patches were at an average depth of 12.9 m (s.d. = 15.12, range 0-55). The lower edges of prey patches averaged 29.4 m (s.d. = 17.69, range 5-70). Fifty observations made in 1996 had an average vertical extent of 22.1m, top depth of 10.9m and bottom depth of 32m (Gabriele 1996, Fig 8b). We could not determine whether whales were feeding on the potential prey patches that we observed with the echo-sounder. In 52% (n=161) of 304

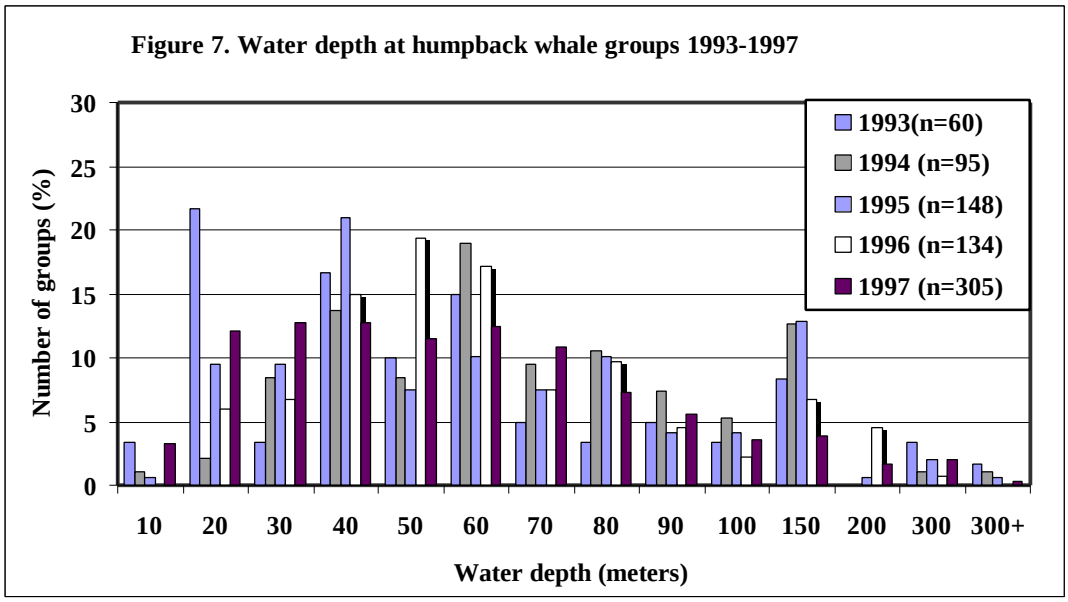
Figure 5. Correlation between number of survey hours and number of identified whales





observations of humpback whale groups, we saw nothing on the echo-sounder screen. During 29 of these cases we observed the whales vertical or lateral lunge feeding, but in the remaining cases we saw no visible feeding behavior. In 13.4% of our observations, the prey patch was ball shaped (n=41). The other two predominant shapes we observed were linear horizontal layers (n=34, 11%) or scattered without appearing to be aggregated at all (n=27, 9%).

Using an underwater video camera, we attempted to determine what type of potential prey was available in the vicinity of whales. We deployed the video camera approximately 15 times between June 23 to August 28 (Andrews 1997), but only observed and video-taped potential whale prey on two of these trials. In both cases the prey were identified as capelin smelt. On July 21, local charter boat captain Jim Kearns (*M/VAlaska Dream*) jigged some bait fish at the site where video footage was recorded. With the use of field guides (Hart 1973; Kessler 1985; Eschmeyer et al.1983), we identified these fish as capelin smelt. The jigged fish matched the video-taped fish in size, shape and overall appearance.



On August 11, we collected a single 13 cm specimen at a site where a whale was lunge feeding in the Beardslee Entrance. We identified this fish as capelin smelt. On two evenings in mid August, Park Ranger Margaret Goodro observed whales feeding under and around the NPS floathouse in Blue Mouse Cove in the midst of schools of translucent, worm-like fish . On August 17, she dip netted several small (~5 cm in length), fish of the same description. These fish were later identified as juvenile capelin probably from a late spring spawning (B. Wing, pers. comm.).

Feeding Behavior: Whales in the study area were most frequently alone (71%) or occurred in pairs 23%. Six percent of groups contained 3 or more whales. We documented the feeding behavior of 192 different groups of whales in 1997. Most whale groups (63%) fed beneath the sea surface, but we observed vertical- or lateral lunge-feeding on 68 (35%) occasions. We observed bubblenet-feeding (Jurasz and Jurasz 1979) on 2 occasions, once from a single whale in Pinta Cove and once from a pair of whales in Hugh Miller Inlet.

The 'core group' fed together from June to early September in the vicinity of Point Adolphus. Juvenile #1306, the 1992 calf of #193 was identified in the group on 2 occasions. Three core group members were accompanied by calves this summer (#353, #587, #573). Core group female #539 and her calf were sighted

Figure 8a. Vertical extent of prey patches near 139 humpback whale groups in 1997

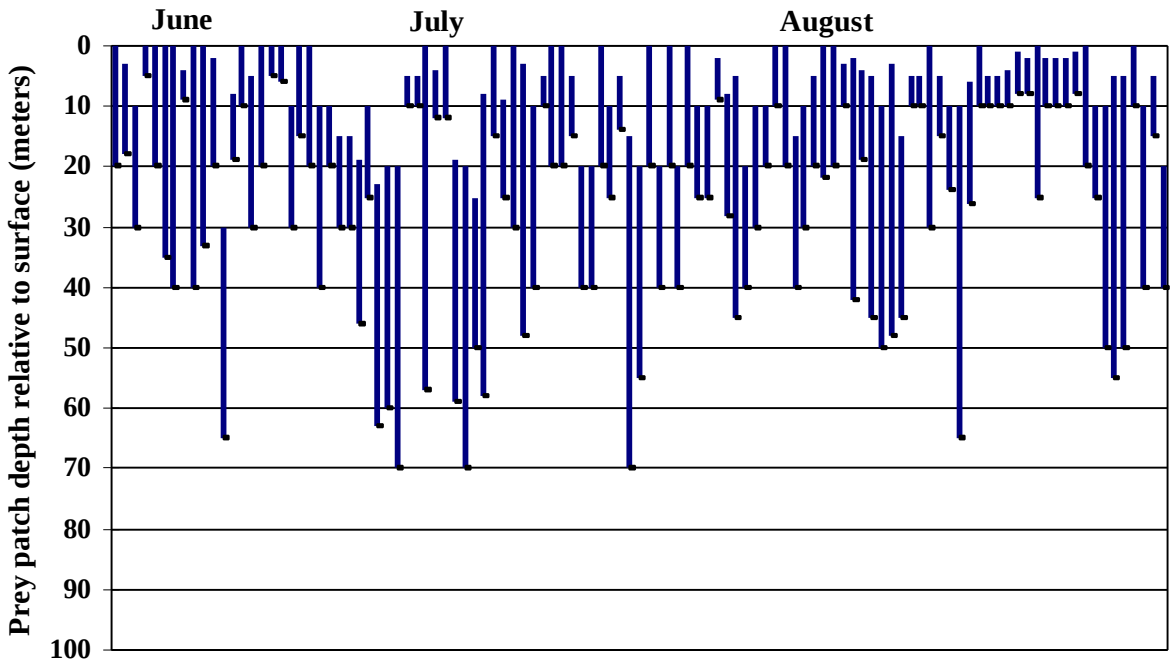
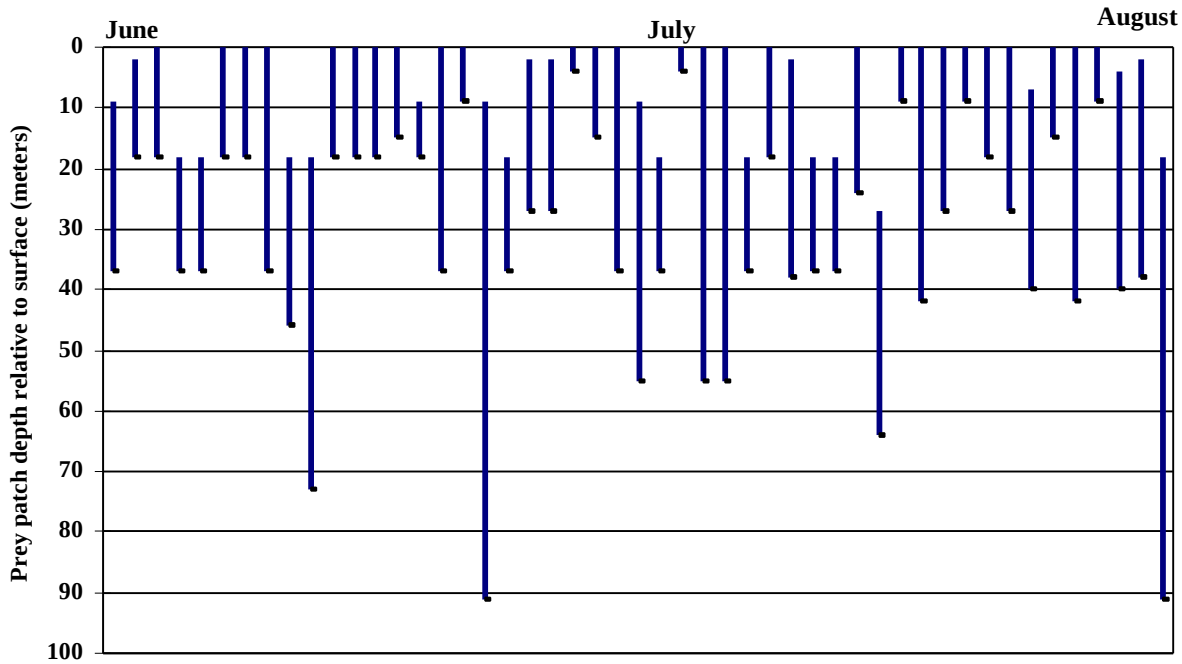


Figure 8b. Vertical extent of prey patches near 50 humpback whale groups in 1996



throughout July and August in Glacier Bay, but were not sighted with the core group. This season the group was sighted regularly but did not contain its full complement of 10 members. Typical core group members male #577, male #166 and female #236 were observed several times in Glacier Bay and Icy Strait in May, June and July but were never sighted with the core group. Whale #221 was sighted once with the core group in July, but was sighted several times away from the group in June, July and August (Appendix 1).

Reproduction and Juvenile Survival: We obtained fluke identification photographs of 8 cow/calf pairs in the study area in 1997, and documented an additional cow/calf pair using only dorsal fin photographs. The dorsal fin photograph of this cow was matched to a dorsal fin photograph from 1991, demonstrating that it was sufficiently distinct to be a *bona fide* individually-identified whale. The dorsal fins of two other cow/calf pairs were photographed, but we could not determine that these individuals were distinct from other whales sighted in 1997. Fluke identification photographs were obtained of 7 calves (Table 4). The crude birth rate of the study population for 1997, computed by dividing the number of calves by the total number of whales, was 10.6% (Table 4). We newly re-sighted whale #1297, the 1992 calf of an unknown mother (Gabriele 1992). We also made the first re-sightings of whale #1298, the 1992 calf of female #587. Our 1997 photographs matched with sightings of #1298 in 1992 and 1993. In the 1993 sighting, yearling #1298 was sighted briefly in the same pod as its mother.

Since 1982, biologists have observed 88 cow/calf pairs in Glacier Bay and Icy Strait, obtained good quality identification photographs of 68 of these calves and documented 22 of them returning to the study area in subsequent years. Seventy-seven (87%) of all calves in the study area have been born to 1 of 16 females that frequent the study area. An additional 16 females are not observed in the study area every year and have been observed here with a calf only 1 or 2 years. In 1997, 2 whales not previously known to be female (#1241 and #387) were identified in the study area with calves. Female #225, who has not been identified with a calf in the study area since 1986 (although she was sighted here in 1986, 1987 and 1990), was sighted repeatedly with her calf in Glacier Bay this season.

Fourteen whales that were first identified as calves were re-sighted in 1997, which accounts for approximately 18.4% of all whales identified in the study area, excluding 1997 calves. In 1982-1997, an average of 10.2% (s.d. = 4.9, range = 3-19) of the population has been comprised of known-age whales. Each year since 1982, biologists have obtained fluke identification photographs from an average of 72% of the calves that were

sighted that year (s.d.=22.28, range =29-100, Table 5). This statistic excludes 1983, when no calves were observed (Table 5). We found no increasing or decreasing trend in the yearly proportion of calves from whom we obtained fluke identification photographs over the years (Fig 9).

Whale /Human Interactions: Whale-watching in Icy Strait near Point Adolphus by people aboard kayaks, skiffs, charter vessels, tour boats and cruise ships, occurred at levels which appeared comparable to recent years. Summer 1997 was the second season in which National Marine Fisheries Service marine mammal watching guidelines recommending a 100 yard minimum approach distance to humpback whales (NMFS 1996) have been in effect. In Glacier Bay, whale aggregations in high traffic areas such as Bartlett Cove made it difficult for vessels to remain more than ¼ mile from whales as required by Park regulations. No humpback whale entanglements or collisions with vessels were observed or reported in Glacier Bay or Icy Strait in 1997.

An injured humpback whale was reported by a private boater (*M/V Sand N' C*) near Point Adolphus on the afternoon of September 9 (W.VanBuren, pers. comm.). The whale was reported to be lethargic and to have a large, white, "smelly" wound on its left side below the dorsal fin. On September 9 and 10 we attempted to find the whale to identify it and to document the wound. We found several whales in the area but could not definitively identify the wounded individual. We obtained dorsal fin photographs of a resting whale that may have been the wounded animal. It remained nearly motionless at the surface during our 30 minute observation session and did not raise its body out of water for us to see its body below its dorsal fin.

DISCUSSION

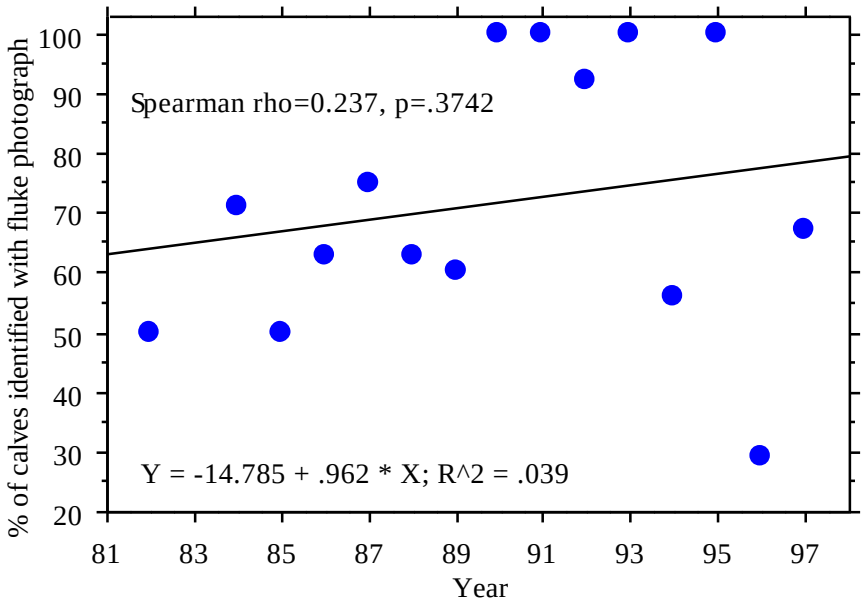
Whale Counts: More whales were identified in the study area in 1997 than in any year since the monitoring program began in 1985 (Table 3). Two different statistical analyses suggest that whale numbers are increasing in Icy Strait and the study area as a whole (Fig. 3,4) although not in Glacier Bay. Because of the unavailability of power tests suitable for nonparametric statistics, we are unsure whether the lack of a detectable trend in Glacier Bay was due to insufficient statistical power or the absence of a trend. However, one might expect that if trends were detectable in Icy Strait, they should also be detectable in Glacier Bay,

Table 4. Crude birth rate of humpback whales in Glacier Bay and Icy Strait, 1982-1997.

Year	#Whales	#Calves	CBR %	#Calves PhotoID'd
1982	33	6	18.2	3
1983	17	0	0	0
1984	39	7	17.9	5
1985	41	2	4.5	1
1986	51	8	15.7	5
1987	59	4	6.8	3
1988	55	8	14.5	5
1989	42	5	11.9	3
1990	50	6	12.0	6
1991	52	4	7.7	4
1992	68	12	17.6	11
1993	54	3	5.9	3
1994	63	9	14.3	5
1995	58	3	5.2	3
1996	79	7	8.8	2
1997	85	9	10.6	7

Note: #Whales = total number of Glacier Bay and Icy Strait whales (including adults and calves), #Calves = number of calves, CBR % = crude birth rate, a percentage computed by #Calves / #Whales.

Figure 9. Proportion of calves whose flukes were photographed: 1982-1997



since the sizes and variances of these samples are comparable. Additional years of whale count data will elucidate this issue.

The increased number of whales observed in the study area does not appear to be attributable to increased effort (Table 3, Fig 5). Previous analysis using data from 1982-1992 suggested that variations in survey effort between 60 and 90 days would have little effect on whale counts (Gabriele et al. 1995). However, we plan to repeat these analyses, including 5 additional years of data, to verify the effect of survey effort on the whale population counts.

Seasonal Distribution: Overall, whale distribution appeared comparable to observations from recent years (Fig 1). Bartlett Cove continues to be important whale habitat as well as an area of high vessel traffic concentration. Jangard (1974 as cited in Pahlke 1985) identified capelin spawning habitat as gently sloping beaches composed of 2.5 –25 mm gravel. Bartlett Cove appears to meet these criteria, which may account for some degree of humpback whale presence there. Using data collected by the NPS coastal mapping inventory in 1995 and 1997, we hope to verify this speculation and examine whale temporal distribution near other putative capelin spawning beaches.

Local Movement and Residency: It appears that many whales moved briefly in and out of the area during the season. The observation of 26 (31%) of the whales in the study area on just one day is comparable to observations from 1994-1996, when 30-43% of the area's whales were identified in the study area on just one day. The large contribution of whales sighted on just one day to the season's whale count suggests that perhaps "whale use days" along with whale counts might provide an interesting basis for between-year comparisons.

Habitat Characteristics: Whales were observed in water depths comparable to those of previous years (Fig 7). The statistically significant 2 ^{o}C increase in the average sea surface temperature in 1997 may be an effect of the ongoing El Nino/Southern Oscillation event documented to be occurring in Alaska waters this year. However, these data must be interpreted cautiously because whale distribution or other factors may be responsible for the observed temperature increase. For example, if more whales were observed in mid-summer when sea temperatures are probably highest, the annual mean temperature could appear higher than usual although the water column characteristics remained the same. A similar effect would be observed if whales

congregated in a part of the study area with higher average sea surface temperatures. Lastly, it is important to note that the 1997 data were collected with a new echo-sounder of the same model as the one used in 1993-1996, and there is a possibility that the temperature sensor on the new echo-sounder may have different sensitivity than the one used previously. Although we spot-calibrated the temperature sensor on a few occasions, this method would not measure the sensitivity of the sensor over a wide range of temperatures. In future work with temperature data we will attempt to improve our calibration methods and account for spatio-temporal distribution of whales when making between-year comparisons.

Prey Assessment: The prey patch depth figures obtained in 1997 appear to be as variable as the limited data collected in 1996 (Fig. 8), with a similar range from 1 to 91 m. Humpback whales feeding on euphausiids in Frederick Sound were found to feed exclusively in the upper 120 m of the water column, despite numerous observations of prey patches at 150 –200 m depth (Dolphin 1987). The whales in our study apparently fed at 90 m or shallower, as we did not observe prey patches extending below this depth. Unfortunately, our methods will not reveal whether the whales are feeding on the potential prey patches we see. Observations of obvious feeding behavior in the absence of any images on the echo-sounder screen indicated that we may have missed whale prey when they were present. Whales appear to prey upon patchy, fast-moving, ephemeral food sources that we may not detect during our observations.

This season whales were observed in association with both adult and juvenile stages of capelin. Based on our limited number of observations and the few fish sampled, capelin appeared to be an important whale prey species in Glacier Bay in 1997. All prey samples collected this year, both on video and in-hand, were identified as capelin smelt although in previous years we have documented Pacific herring, juvenile pollock and sand lance in areas near feeding humpbacks. Humpbacks in Glacier Bay appear to utilize the schools of capelin that assemble near shore during their spawning season from May to at least late June in Alaskan waters (Pahlke 1985). If capelin were super-abundant this year, the 1997 summer may have been a “boom” in the fluctuating abundance that is characteristic of capelin (Pahlke 1985). We speculate that when capelin booms occur, humpbacks may be present in increased numbers because capelin are a high-calorie prey item and may be preferred by humpbacks when available. The link between whale abundance and the abundance of preferred prey has been demonstrated in other studies (Payne et al. 1990).

Our attempts at identifying whale prey using an underwater video camera were successful in that we were able to video-record small schooling fish, however our success rate was low relative to the time expenditure. The primary problem was that deploying the gear and searching for the fast-moving schools of fish were time consuming and took away from whale search time (Andrews 1997). Adaptations to the equipment making it less cumbersome may increase our success in identifying whale prey in the future. If the underwater video method becomes a fruitful means of identifying prey, we could also conduct this aspect of the study from a separate boat so that whale survey time is not compromised.

Feeding Behavior: Whales were most commonly found alone, feeding below the sea surface, as observed in previous years. However, we observed a high degree of lunge feeding, which occurs sporadically but in some years is quite common (Baker 1985, Baker 1986, Gabriele 1995a, 1996, Straley 1989).

The "core group" was present in the Point Adolphus area from June through September. In other animals, cooperative hunting may based on foraging efficiency, relatedness among group members or social factors unrelated to feeding (Packer and Ruttan 1988). As we gather more information on the age, sex and relatedness of the group members, we may get a clearer view of how and why this particular group of humpback whales persists. Whale #1306 was sighted with the core group in 1997 and June 1996 but does not qualify as a 'core group member' according to the criteria discussed by Gabriele (1997). However, juvenile #1306's presence in the core group is interesting because he or she is the fourth offspring of a female with a loose affiliation to the core group to be sighted repeatedly with the group. The other three whales are female #353 and male #186 who meet the criteria as core group members, and whale #1075 who was born to whale #193 in 1986 and has been sighted in the core group on 8 occasions. None of the 8 returning offspring of any of the core group females (#155, #353, #573, #587, #539) has ever joined the group. Whale #1306's mother (#193) has been observed with the group 4 times and in the study area 8 of the 13 years since 1985. She was not observed in the group in 1992 when #1306 was a calf, but she was in the study area that year and may have affiliated with the group while we were not observing them.

Reproduction and Juvenile Survival: We obtained fluke photographs of a moderate proportion of 1997 calves, comparable to previous years (Fig. 9). The observation that 18% of this year's whale population were known-age returnees is somewhat higher than the 10.2% average figure over the course of the study. As we continue to obtain fluke photographs of calves and document their return to the area in later years, we expect

that these known-age whales will comprise an increasing proportion of the population. Many other whales in the study area were probably born to past and present females that first brought them here as calves. It is most likely that our knowledge of the study population that is changing, rather than the population composition.

Whale /Human Interactions: We received several reports of a single whale with a 1.2 m by 6 m flap of skin hanging off of its body in July and August in Peril Strait and Chatham Strait (K. Brix, pers. comm., B. Spellman, pers. comm.). It seems likely this was the same wounded whale we observed in Icy Strait in September, although we do not have identification photographs to verify this. The whale's behavior and odor in Icy Strait in September suggest that the whale's condition deteriorated over time. We believe that the odor may have been the whale's breath, perhaps indicating infection and disease. The origin of the whale's injury is unknown, but it is difficult to imagine such a large laceration being inflicted by anything other than a collision with a large ship.

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Appendix 1

	Whale ID#		5/21/97	5/22/97	5/29/97	6/10/97	6/11/97	6/16/97	6/17/97	6/19/97	6/23/97	6/24/97	6/25/97	6/26/97	6/27/97	6/30/97	6/5/97	6/6/97	6/9/97	7/10/97	7/14/97	7/15/97	7/16/97	7/17/97
1	157	M.D.	I											I					I	I				
2	161	B.W.M.	I		I					I					G								G	
3	1299	calf of 161	I		I					I					G								G	
4	1018			G					G												G	G		
5	196				I																			
6	160				I					G														
7	1425				I																			
8	937				I				G		G						G							
9	236	Leigh			I					I					G				I					
10	577	Scoper			I					I														
11	1298				I																			
12	1296					G		G				G					G						G	
13	159					G			G		G		G			G	G							
14	1304						G	G										G					G	
15	1012						G		G			G												
16	235	Spot						G			G												G	
17	1014							G				G												
18	237	Dike							G															
19	1079								G								G					G		
20	351								G								G							
21	352									I													G	
22	219									I				I					I					I
23	1295									I										I				I
24	584									I													G	
25	221										G					G							G	
26	1046											G									G	G		
27	1293											G						G						
28	1426											G												
29	117	White Eyes											G			G								
30	1244														I								G	
31	1306													I						I				
32	155	Freckle Fluke												I						I				I
33	616	Lesser												I						I				
34	1297														I									
35	1063																G							
36	587	Gertrude													G				I	I				I
37	1421	calf of 587													G				I	I				I
38	387														I									I
39	1428	calf of 387													I									I
40	1246															G								
41	1412															G								
42	564	Round-up Taylor														G	G							
43	GB97-22(25)															G								
44	1292																G							
45	633																	G						
46	166	Frenchie																	I					
47	186																		I	I				I
48	941																		I				G	
49	118	Chop Suey																	I				G	
50	573																			I				
51	1423	calf of 573																		I				I
52	581																			I				
53	1019																			I				
54	1042																			I				I
55	GB97-31(12)																			I				
56	GB97-32(34)																				G			
57	225																					G		
58	516	Garfunkle																						I
59	201(22)																							
60	875																							
61	250																							
62	353																							
63	GB97-44(12)																							
64	1424	calf of 353																						
65	513																							
66	GB97-45(34)	dorsal fin photo only																						
67		calf of GB97-45(34)																						
68	283																							
69	539	Max																						
70	1422	calf of 539																						
71	801																							
72	535	Quits																						
73	1179																							
74	833																							
75	1031																							
76	1233																							
77	1427	calf of 225																						

	Whale ID#		7/18/97	7/2/97	7/22/97	7/23/97	7/24/97	7/25/97	7/28/97	7/29/97	7/3/97	7/30/97	7/31/97	7/7/97	7/8/97	7/9/97	8/1/97	8/11/97	8/14/97	8/16/97	8/17/97	8/18/97	8/20/97	8/21/97
1	157	M.D.	G	I				G						G	G		G				G			
2	161	B.W.M.			G						G				G									
3	1299	calf of 161			G						G				G									
4	1018																							
5	196																							
6	160			I												G								
7	1425																							
8	937													G	G									
9	236	Leigh												G						G				
10	577	Scoper			G						G				G									
11	1298								I										G					
12	1296															G								
13	159							G			G	G		G	G									
14	1304														G			G						
15	1012															G				G				
16	235	Spot																		G				
17	1014										G						G							
18	237	Dike																						
19	1079																G	G						
20	351																					I		G
21	352			I									G											
22	219			I																				
23	1295																							
24	584							G					G											
25	221									I				G										
26	1046										G					G	G							
27	1293				G											G		G						
28	1426																							
29	117	White Eyes															G							
30	1244				I						G				G			G		G				
31	1306																							
32	155	Freckle Fluke		I	G				I	I														
33	616	Lesser																						
34	1297																							
35	1063																G							
36	587	Gertrude							I	I														
37	1421	calf of 587							I															
38	387																							
39	1428	calf of 387																						
40	1246				G		I																	
41	1412																							
42	564	Round-up Taylor				G							G				G						G	
43	GB97-22(25)																G			G				
44	1292																							
45	633				G																			
46	166	Frenchie								I				G								I		
47	186								I													I		
48	941		G									G												
49	118	Chop Suey						G										G						
50	573								I															
51	1423	calf of 573							I	I														
52	581			I					I															
53	1019						I																	
54	1042			I																				
55	GB97-31(12)		G										G											
56	GB97-32(34)																							
57	225																						G	
58	516	Garfunkle															G		G					
59	201(22)			I																				
60	875					G					G			G									G	
61	250												G											
62	353								I	I												I		
63	GB97-44(12)								I															
64	1424	calf of 353							I	I												I		
65	513								I															
66	GB97-45(34)	dorsal fin photo only								I														
67		calf of GB97-45(34)								I														
68	283										G												G	
69	539	Max										G		G		G		G					G	
70	1422	calf of 539										G		G		G		G					G	
71	801											G												
72	535	Quits												G										
73	1179																							
74	833																G							
75	1031																					I		
76	1233																						G	G
77	1427	calf of 225																					G	

	Whale ID#		8/22/97	8/24/97	8/25/97	8/26/97	8/27/97	8/28/97	8/4/97	8/5/97	8/6/97	8/7/97	8/8/97	9/11/97	9/15/97	9/16/97	9/22/97	9/25/97	9/3/97	9/4/97	9/8/97	9/9/97	10/4/97
1	157	M.D.				G					G					I						I	
2	161	B.W.M.																					
3	1299	calf of 161																					
4	1018						G																
5	196																						
6	160																						
7	1425																						
8	937					G								G									
9	236	Leigh				G					G				G				G				G
10	577	Scoper														I						I	
11	1298																		G				
12	1296																		G				
13	159									G	G									G			
14	1304																						
15	1012				G		G			G				G									
16	235	Spot			G												G			G			
17	1014																						
18	237	Dike													G			G		G			
19	1079									G													
20	351				I										G								
21	352															I					I		
22	219															I						I	
23	1295		G														G						
24	584																						
25	221											I											
26	1046										G				G								
27	1293																						G
28	1426																						
29	117	White Eyes												G					G				
30	1244				I					G										G			
31	1306																						
32	155	Freckle Fluke										I				I					I	I	
33	616	Lesser																					
34	1297																						
35	1063										G												
36	587	Gertrude										I				I					I	I	
37	1421	calf of 587										I				I					I		
38	387																						
39	1428	calf of 387																					
40	1246							G					I										
41	1412																						
42	564	Round-up Taylor	G																	G			
43	GB97-22(25)																						
44	1292																						
45	633																						
46	166	Frenchie													G								
47	186				I											I		I			I	I	
48	941																						
49	118	Chop Suey																G					
50	573											I											
51	1423	calf of 573										I											
52	581				I																		
53	1019				I								I										
54	1042				I																		
55	GB97-31(12)						G				G												
56	GB97-32(34)																						
57	225						G	I															
58	516	Garfunkle				G			G									I				I	
59	201(22)																						
60	875						G																
61	250					G																	
62	353				I							I				I					I	I	
63	GB97-44(12)																						
64	1424	calf of 353			I							I				I					I	I	
65	513																						
66	GB97-45(34)	dorsal fin photo only																					
67		calf of GB97-45(34)																					
68	283																			G			
69	539	Max			G		G																
70	1422	calf of 539			G																		
71	801																						
72	535	Quits				G																	
73	1179				I																		
74	833																						
75	1031												I										
76	1233					G														G			
77	1427	calf of 225						I															

Appendix 1

	Whale ID#	5/21/97	5/22/97	5/29/97	6/10/97	6/11/97	6/16/97	6/17/97	6/19/97	6/23/97	6/24/97	6/25/97	6/26/97	6/27/97	6/30/97	6/5/97	6/6/97	6/9/97	7/10/97	7/14/97	7/15/97	7/16/97	7/17/97	7/18/97	7/2/97	7/22/97	7/23/97	7/24/97	7/25/97	7/28/97	7/29/97	7/3/97	7/30/97	7/31/97	7/7/97	7/8/97	7/9/97	8/1/97	8/11/97	8/14/97	8/16/97	8/17/97	8/18/97	8/20/97	8/21/97	8/22/97	8/24/97	8/25/97	8/26/97	8/27/97	8/28/97	8/4/97	8/5/97	8/6/97	8/7/97	8/8/97	9/11/97	9/15/97	9/16/97	9/22/97	9/25/97	9/3/97	9/4/97	9/8/97	9/9/97	10/4/97
78	GB97-64(31)																																											G																															
79	GB97-65(4)																																												G																															
80	1241																																																																											
81	calf of 1241																																																																											
82	397																																																																											
83	946																																																																											
84	1372																																																																											
85	GB97-56(21)																																																																											