POPULATION CHARACTERISTICS OF HUMPBACK WHALES IN GLACIER BAY AND ADJACENT WATERS: 1998

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ABSTRACT

We photographically identified 92 individual humpback whales (*Megaptera novaeangliae*), including 8 calves, in Glacier Bay and Icy Strait between June 1 and August 31, 1998. This is the highest number of whales documented in the study area since the monitoring program began in 1985, contributing to a statistically significant increasing trend for the time period of 1985-1998. Thirty-two whales were 'resident' in Glacier Bay and 16 were 'resident' in Icy Strait for more than 20 days. We observed an unusually high number of incidences of bubblenet feeding (n=10) from single whales or pairs of whales in upper Glacier Bay. Bubblenet feeding was associated with prey patches extending 5-20 meters from the water's surface. Whale #1299, the 1997 calf of #161, returned as a yearling, bringing the 1974-1998 total number of returning offspring to 26. Whale #1031, born in 1988 to female #219, was identified with a calf for the first time, although we cannot determine whether the 1998 calf is her first, due to the lack of sighting data during 1992 and 1994. Several interactions between float planes and whales were observed in Bartlett Cove, as well as a reported whale entanglement in Icy Strait, which we could not confirm.

INTRODUCTION

This report summarizes the findings of the National Park Service's (NPS) annual humpback whale monitoring program during the late spring and summer of 1998, the fourteenth consecutive year of consistent data collection in Glacier Bay and Icy Strait. The initial impetus for this program stemmed from concern in the late 1970's that an increase in vessel traffic in Glacier Bay National Park (GBNP) may have caused a large proportion of the local whale population to abandon the bay (Jurasz and Palmer 1981a). Humpback whales are federally listed as an endangered species and the federal government is mandated to ensure that federal actions (including park management decisions) do not negatively impact endangered species.

In the early 1980's, research on whale prey distribution, underwater sound and whale behavior in the presence of vessels investigated whether changes in whale distribution were linked to vessel presence and/or natural variability in prey distribution. 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.

The current study began in 1985 when the NPS initiated an annual monitoring program to systematically characterize the humpback whale population in Glacier Bay and Icy Strait. The study area spans both Glacier Bay and Icy Strait because whales frequently move between these areas within and between years, effectively making them a single contiguous habitat. Each summer, GBNP biologists document the number of individual whales, as well as their residence times, spatial and temporal distribution, reproductive parameters and feeding behavior. These data are used to monitor long-term trends in the population's abundance, distribution, and reproductive rates. In addition, human-whale interactions including strandings, entanglements in fishing gear and disturbance by vessels and aircraft are documented opportunistically. Since 1993, biologists have recorded the water depth and temperature in areas used by humpback whales in order to characterize the abiotic features of their feeding habitat. Photographic identification data are shared with other researchers studying North Pacific humpback whales at a central data repository, in the National Marine Mammal Laboratory in Seattle, Washington. In addition, whale distribution data are used locally by park biologists to determine when and where special NPS whale protection regulations ("whale waters") should be implemented each summer in Glacier Bay.

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, with the majority of whales (70%) having been identified in two or more years in the Glacier Bay/Icy Strait region. The number of whales documented using Glacier Bay and Icy Strait from 1985 to 1997 ranged from 41 to 82 (Gabriele et al. 1997). In recent years there have been indications that whale counts were increasing in parts of the study area. Whale movement throughout southeastern Alaska is presumed to be linked with prey availability and likely influences the number of whales in the study area (Baker et al. 1990; Krieger 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*) (Wing and Krieger 1983; Krieger and Wing 1984, Krieger and Wing 1986). Most whales in the study area feed alone, with the exception of the large, stable "core group" that is commonly found at Point Adolphus, and the less consistent occurrence of large pods at Bartlett Cove and Pleasant Island Reef (Baker 1985; Perry et al. 1985; Gabriele 1997). Bubblenet, lunge and flick feeding occur infrequently compared with subsurface feeding (Jurasz and Jurasz 1979; Wing and Krieger 1983; Krieger and Wing 1984, 1986; Gabriele et al. 1997). This year's monitoring efforts add the fourteenth year of data to an increasingly valuable time series on humpback whale natural history and allow us to examine the continuity of the species' presence and behavior in the study area over time.

METHODS

The methods for this project have been described in previous reports. The primary techniques have not changed significantly since 1985, allowing for valid comparison of data between years. The specific methods used in 1998 are outlined below.

Vessel Surveys: We conducted surveys in Glacier Bay and Icy Strait from April 25 through October 11, 1998. We searched for, observed and photographed humpback whales from a 6 meter Boston Whaler powered with a 60 hp outboard engine. To minimize the potential impact that monitoring efforts might have on the whales, we typically 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 occasionally returned to the same area the following day.

We surveyed the main body of Glacier Bay (a rectangle defined by four corners: Bartlett Cove, Point Carolus, Geikie Inlet and Garforth Island) approximately 3 days per week (Fig. 1). We surveyed the West Arm of Glacier Bay (as far north as Russell Island) approximately bi-weekly. We surveyed the East Arm of Glacier Bay (as far north as Adams Inlet) when other vessels reported whale sightings in that area. We performed one to two Icy Strait surveys per week, with the greatest survey effort focused along the shoreline of Chichagof Island from Mud Bay to Pinta Cove (Fig. 1). Several surveys included Lemesurier Island, Burger Point and the north and west shorelines of Pleasant Island.

After we found whales, we recorded the latitude and longitude coordinates of their initial location, determined with either a Rockwell PLGR or a Trimble Pathfinder Global Positioning System (GPS) using the NAD27-Alaska or Alaska/Canada datum, respectively. We defined a pod of whales as one or more whales within 5 body lengths of each other, surfacing and diving in unison. We used datasheets to record all information pertaining to the pod, including the number of whales, their activity (feed, travel, surface active, rest, sleep, unknown), sketches of the markings on their tail flukes and dorsal fin, photographs taken, whale identity (if known), water depth, temperature and any prey patches observed on the echo-sounder, as well as details pertaining to feeding behavior. 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. We calibrated the temperature sensor with a scientific thermometer and determined that it was accurate within 0.1^{o} C. We rounded depth measurements 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 = 75%, chart speed = 9) to ensure that images observed on different sampling occasions would be comparable. We qualitatively described prey patches using the following five categories: '*Scattered*'- appeared like falling snow; a '*layer*'- a horizontal linear aggregation; a '*patch*' - a non-discrete, shapeless aggregation; a '*ball*' - a discrete, curvilinear form; and a '*mass*' - completely filled the echo-sounder screen, such that we could not determine the shape of the aggregation. We used field guides (Hart 1988; Kessler 1985; Paxton and Eschmeyer 1983) to taxonomically identify sample prey items that we opportunistically collected at the surface.

Individual Identification: Each whale's flukes have a distinct, stable black and white pigment pattern that allows for individual identification (Jurasz and Palmer 1981a; Katona et al. 1979). We took whale fluke photographs with Nikon cameras (models 8008 and N90S) equipped with motor drives, databacks and 300 millimeter lenses (Fig. 2). We photographed the ventral surface of the flukes of each whale with 1600 ASA black and white film. Photographs of the dorsal fin, which also allow for individual identification based on shape and scarification, 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 to other available catalogs (Darling 1991; Jurasz and Palmer 1981a; Perry et al. 1985; Perry et al. 1988; Sharpe unpubl. data; Straley and Gabriele 1997; Uchida and Higashi 1995; von Ziegesar 1992) to determine the identity and past sighting history of each whale. We referred to many whales 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 #950 coincide with those in the KBMML catalog, but those indentification numbers 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). We also referred to those whales first photo-identified by Jurasz and Palmer (1981) 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 GB98-13(18). We replaced temporary "filmcodes" with permanent identification numbers if we identified the whale on more than one day, or if it had been identified elsewhere or in previous years. We assigned calves an identification number if we obtained adequate photographs of the flukes, regardless of whether the calf was sighted on more than one day. We are able to identify an increasing number of whales by their dorsal fin alone, enabling us to augment the sighting histories of individuals whose dorsal fins we recognize from other observations accompanied by a fluke photograph. After we completed the photographic analysis, we added each whale's identity and the sighting data from the field notes to a Microsoft Access database containing Glacier Bay and Icy Strait whale sighting histories from 1977 to 1998. Finally, we printed and catalogued the best 1998 photograph of each individual.

Whale Counts: After we analyzed all of the photographs, we counted the number of distinct individual whales in the sample. We made separate counts of Glacier Bay and Icy Strait for the total monitoring period from 1 June to 31 August and for a 'standardized period' (after Perry et al. 1985) from 9 July to 16 August. Although the standardized period is substantially shorter than the current NPS June through August monitoring season, and the beginning and ending dates have no particular biological significance, 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. We defined a whale as resident if it was photographically identified in the study area over a span of 20 or more days (after 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. We used an alpha level of $p < 0.05$ to assess statistical significance.

RESULTS

Vessel Surveys: The total number of surveys (n=52) and their temporal distribution was typical of previous years (Table 1), although Glacier Bay received comparatively high effort and Icy Strait comparatively low effort in 1998 (Table 1, 2). The 1998 total effort of 52 surveys and 397 hours (Table 2) was higher than the 1985-1997 average of 54 surveys and 323 hours. To ensure that effort values for each year were comparable, we verified that 1994-1998 effort data included June, July and August surveys only, and re-calculated the effort statistics when necessary. The revised figures are shown in Table 2. Because the 1985-1993 effort data are not easily accessible, we are currently assuming that effort statistics prior to 1994 included June through August only. We found no statistically significant evidence for a trend toward changes in the amount of effort in Glacier Bay, Icy Strait or the combined area.

Whale Counts: Ninety-two individual humpback whales were photographically identified in Glacier Bay and Icy Strait between 1 June and 31 August 1998 (Table 3), exceeding the previous high count of 82 whales documented in 1997. During the standardized period, 44 whales were identified in Glacier Bay, 27 in Icy Strait and 69 in the combined Glacier Bay-Icy Strait area (Table 3, Appendix 1). The standardized count for Glacier Bay is the highest ever recorded during the 14 year monitoring program, while the Icy Strait standardized count is comparable to the 1985-1998 average of 28.7 whales (s.d.=6.8). We found statistically significant trends of increasing whale counts over the study period 1985-1998 in Glacier Bay, Icy Strait and the entire study area (Fig 3a, b, c). This increasing trend is substantiated by the finding that mean whale counts for 1985-1991 were significantly lower than mean whale counts for 1992-1998 in Glacier Bay, Icy Strait and the combined areas (Fig. 4).

Table 1. Humpback whale survey days per month in Glacier Bay and Icy Strait, 1985-1998

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	9	2	4	7	6	4
1998	10	20	23	12	5	4	3	6	4	2

Note: This table shows the number of survey days for May through September although our annual whale counts encompass June through August only.

Seasonal Distribution: Although we observed whales throughout Glacier Bay (Fig. 1), whale density was highest in Bartlett Cove, Beardslee Entrance, and around Flapjack Island. From mid-May to early June, we documented high concentrations of whales between Sandy Cove and the entrance to Adams Inlet. However, for the remainder of June the highest concentration of whales in Glacier Bay shifted to the area between Flapjack Island and Bartlett Cove. Whale use of Bartlett Cove remained high

Table 2. Search and encounter time in Glacier Bay and Icy Strait: June - August 1985-1998

Year	Glacier Bay hours	Icy Strait hours	Total hours	Total days
1985	234	92	326	45
1986	-	-	-	50
1987	-	-	-	48
1988	199	108	307	52
1989	231	123	354	66
1990	215	115	330	67
1991	256	100	356	61
1992	248	71	319	61
1993	192	62	254	41
1994	169	92	261	45
1995	167	90	258	44
1996	259	116	374	58
1997	327	90	417	57
1998	344	64	397	52

Note: Hours of effort for 1986 and 1987 are not available. Total # Days encompasses June, July and August only, and each figure is slightly lower than the sum of Table 2 values for Glacier Bay and Icy Strait because on some survey days, both areas were surveyed.

throughout June, July and August and then ended abruptly with no documented sightings in September. Whale use of the west side of the bay, particularly west Sitakaday Narrows and lower Whidbey Passage, peaked in July; whale use on the east side remained high during July. By September, the majority of whales were sighted on the east side of the bay between Flapjack Island and Beardslee Entrance with very few sightings on the west side. Throughout the summer, sightings in upper Whidbey Passage and Geikie Inlet were infrequent. Whale use of the West Arm peaked in June with most sightings between Hugh Miller Inlet and Scidmore Cut. Sightings in Blue Mouse Cove were infrequent. There were no documented sightings north of Scidmore Cut, but GBNP staff reported single whales (not shown in Fig. 1.) near Russell Island in late April and near Reid Inlet in early August (R. Salazar and A. Andrews, pers. comm.).

In Icy Strait, whales consistently concentrated around Point Adolphus in all months except September with a strong peak in July (Fig. 1). Whale use of the Gustavus Flats (the area between Point Gustavus and the Salmon River) was greatest in June and tapered off in July. Sightings in the middle of Icy Strait between Point Gustavus and Point Adolphus were fairly common throughout the summer. Nearly all of the whale sightings in or near Mud Bay occurred in August; there were no whales documented in Idaho

Inlet. However, for much of the summer poor sea conditions in western Icy Strait prevented regular surveys of these areas. GBNP staff reported one whale at the entrance to Idaho Inlet on 1 October (K. Boesser, pers. comm.).

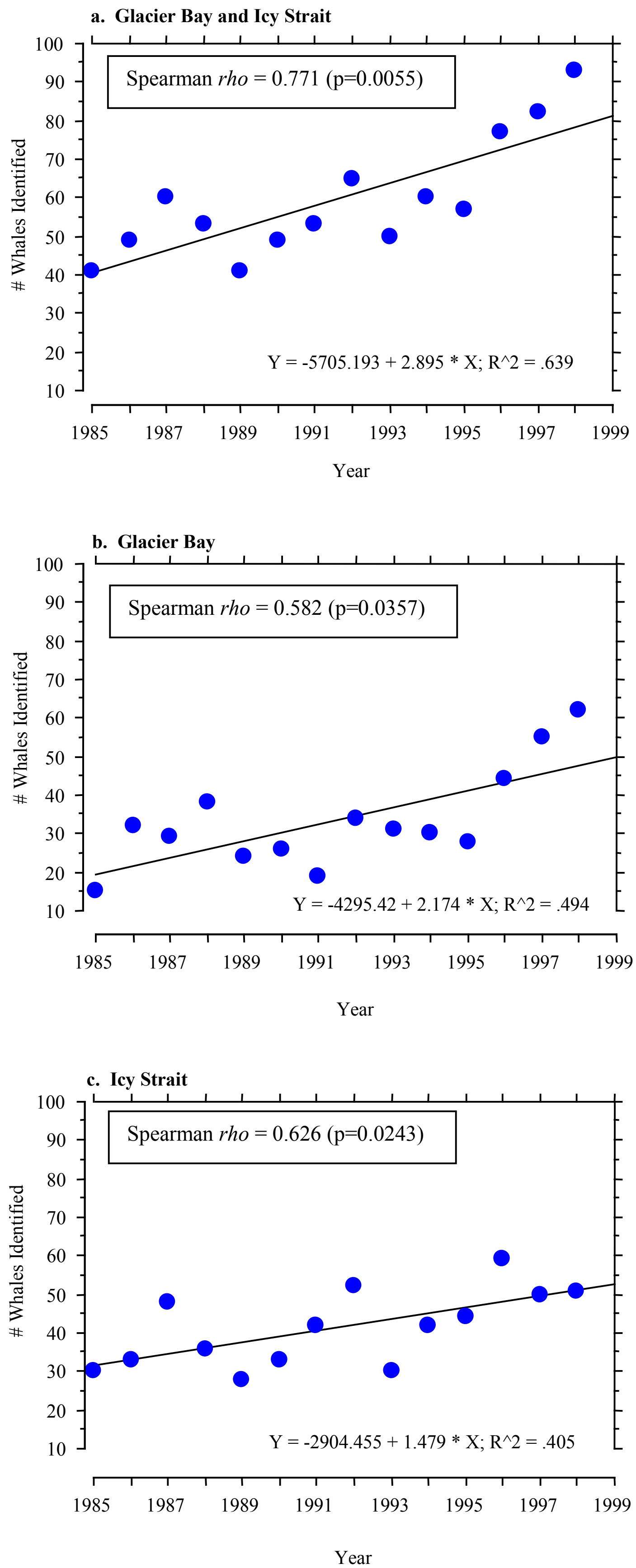
Table 3. Counts of humpback whales in Glacier Bay and Icy Strait, 1982-1998

	Glacier Bay		Icy Strait		Glacier Bay & Icy Strait	
Year	**Standardized Count**	**Total Count**	**Standardized Count**	**Total Count**	**Standardized Count**	**Total Count**
1985	7	15	19	30	24	41
1986	26	32	24	33	39	49
1987	18	29	33	48	40	60
1988	17	38	29	36	40	53
1989	20	24	20	28	32	41
1990	16	26	24	33	32	49
1991	17	19	33	42	44	53
1992	27	34	38	52	48	65
1993	24	31	24	30	40	50
1994	17	30	29	42	44	60
1995	18	28	26	44	37	57
1996	37	44	43	59	65	77
1997	41	55	33	50	66	82
1998	45	62	28	51	69	92
1999	36	60	40	66	69	104

Note: Total counts refer to the number of whales (adults and calves) identified during the entire monitoring season (1 June – 31 August). 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.

Local Movement and Residency: Twenty-two of the 92 total whales (24%) were sighted in both Glacier Bay and Icy Strait in 1998. Thirty-one whales, including 3 cow/calf pairs, were sighted exclusively in Icy Strait and 42, including 4 cow/calf pairs, were observed exclusively in Glacier Bay. Thirteen individuals (14%), made one or more round trips between areas (Appendix 1). No cow/calf pairs were documented moving between Glacier Bay and Icy Strait. In June, female #154 was sighted in the study area for the first time since 1982. Her most recent southeastern Alaska sightings occurred in 1985 and 1986, when she was sighted in Frederick Sound and Seymour Canal. Interestingly, whale #587 was sighted on 18 May in Adams Inlet, but on all six of her subsequent sightings (Appendix 1) she was sighted at Point Adolphus, more than 60 kilometers to the south.

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



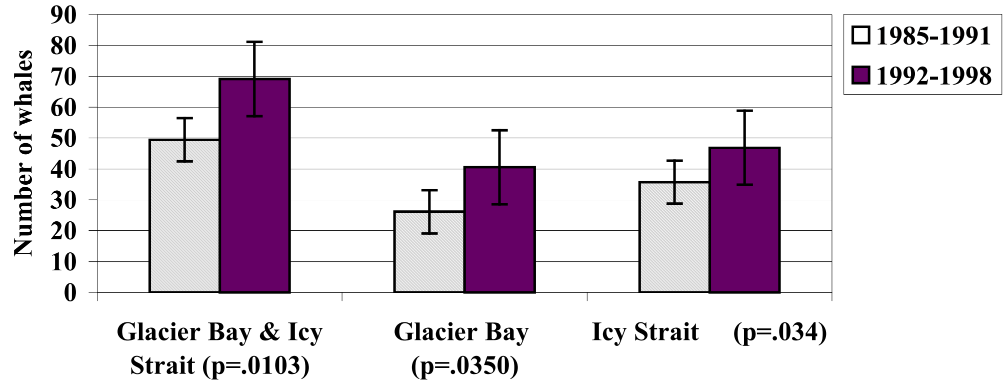


Figure 4. Total number of whales identified:
June-August 1985-1991 vs. 1992-1998

Thirty-two (52%) of the 62 whales that entered Glacier Bay between June 1 and August 31 remained 20 or more days, long enough to be considered resident (after Baker et al. 1983). Fifteen (30%) of the 50 Icy Strait whales were considered resident in that area during the study and 59 (63%) of the 92 whales in Glacier Bay/Icy Strait were resident in the combined Glacier Bay/Icy Strait area. Twenty (23%) of the whales that entered the study area between June 1 and August 31 were identified on just one day: 10 in Glacier Bay and 10 in Icy Strait. Aside from one whale identified at Eagle Point, in Icy Strait, all of these individuals were sighted in areas that are part of our regular survey areas, most notably Point Adolphus (n=6). 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).

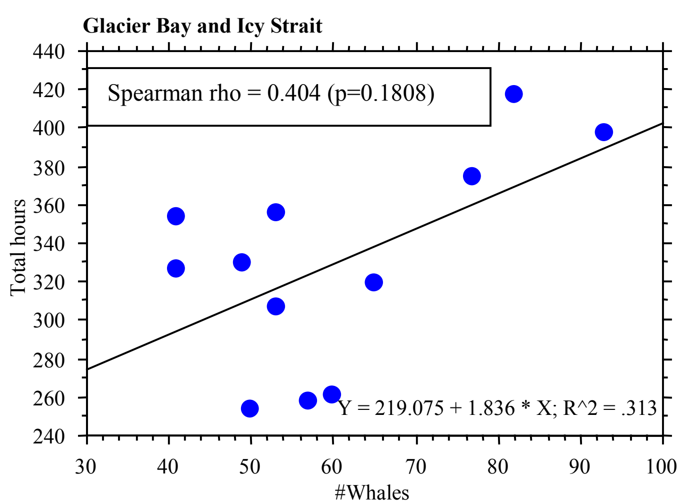


Figure 5. Hours of effort versus number of whales identified: 1985-1998

Habitat Characteristics: We measured sea surface temperature during 396 whale observation sessions in 1998. The average sea surface temperature was 9.6 ^{o}C (s.d. =1.47, range =6.2-14.9, Fig. 6). 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 398 whale observations. Groups of whales were found in a wide range of water depths ranging from 5 to 430 meters (Fig. 7). The majority of whales (70%) were in water 60 meters or less in depth.

Prey Assessment: We used 162 qualitative descriptions of echo-sounder traces to determine that the vertical extent of prey patches ranged from 1-50 meters. In most cases (n=137, 84%) the upper edge of the prey patch was within 20 meters of the surface, and in 34 of those cases (20%) it was at or near the surface. Forty-eight percent (n=79) of the lower edges of prey patches averaged were also within 20 meters of the surface (range 4-80). There were no detectable trends for systematic changes in these prey patch attributes over the course of the season. We could not determine whether whales were feeding on the potential prey patches that we observed with the echo-sounder. In 33% (n=107) of 324 observations of humpback whale groups, we saw nothing on the echo-sounder screen. During 14 of these cases we observed the whales vertical or lateral lunge feeding, but in the remaining cases we saw no visible feeding behavior. In 28% (n=73) of our 264 prey shape observations, the prey patch was classified as ball shaped. The other predominant prey patch shape was linear horizontal layers (n=64, 24%).

We determined the potential whale prey type on five occasions. We observed herring jumping near whales at Point Adolphus in July and August. We collected a dead juvenile pollock near a single whale at the entrance to Berg Bay and used a dipnet to sample capelin in the vicinity of a lunge feeding whale at Point Gustavus in August. In mid-July, a member of the Park's coastal mapping team on a personal kayak trip discovered a 5-8 centimeters deep, 20 meter by 90 meter patch of fish eggs on a sandy beach on Young Island, along with a small fish that we later identified as a sand lance (B. Eichenlaub, pers. comm.). Three or more whales were observed to be feeding adjacent to the beach at the time, including two whales that we photographically identified.

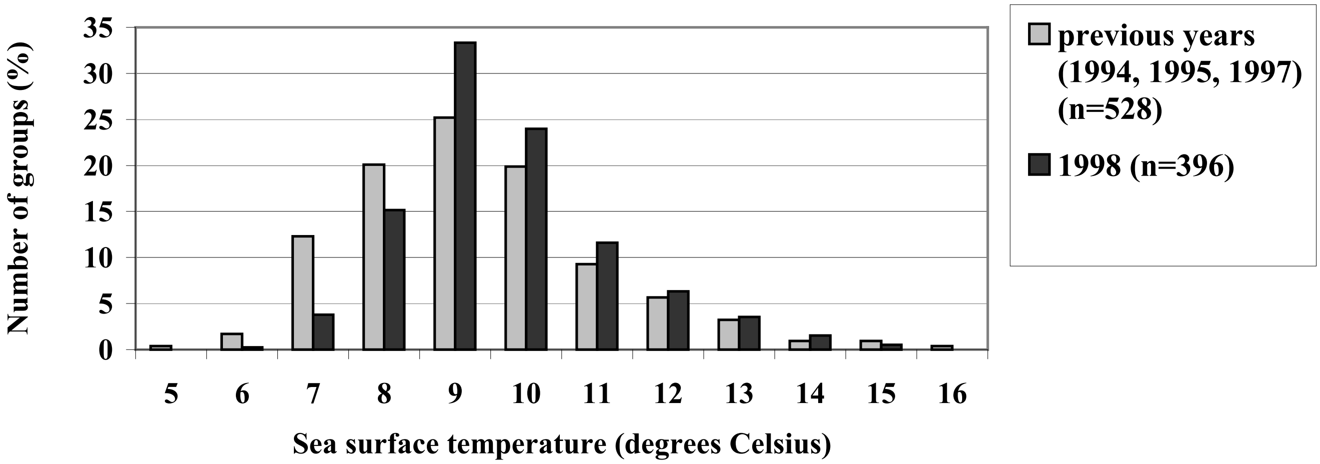


Figure 6 . Sea surface temperature near humpback whale groups in 1998 versus previous years (1994, 1995, 1997). Data for 1996 were not available.

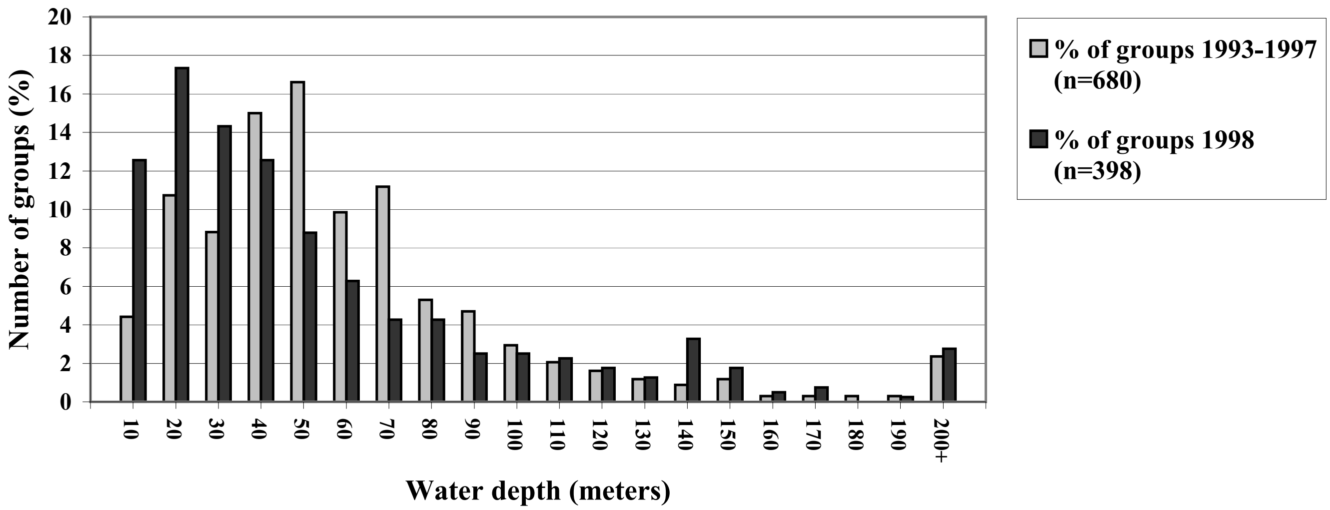


***Figure 7*.** Water depth at humpback whale groups in 1993-1997 vs. 1998 Each value on the depth axis represents a 10 meter range of depths centered around the value (i.e., 20 meters represents 16-25 meters, 30 meters represents 26-35 meters, etc.)

Feeding Behavior: We documented the feeding behavior of 142 different groups of whales in 1998, but in an additional 190 observation sessions other attributes of their behavior made us uncertain whether the whales were feeding. Of the 142 cases in which we believed the whales were feeding, 60 were categorized as subsurface, and we observed vertical or lateral lunge-feeding on 66 occasions. Whales produced bubbles during feeding on 18 occasions , including 10 incidences of bubblenet-feeding (as defined by Jurasz and Jurasz 1979). On 6 of these encounters, the whales used bubblenet feeding in combination with subsurface feeding or produced other bubble structures. Most bubblenet feeding was done by single whales (n=7) but 2 pairs of whales also produced bubblenets. Seven different whales were involved in these encounters, although 3 individuals were observed bubblenet feeding on two different days. Bubblenet feeding was observed in a variety of locations, primarily in upper Glacier Bay (Blue Mouse Cove, Hugh Miller Inlet, Geikie Inlet, Whidbey Passage, Gilbert Peninsula and Sturgess Island). For 6 of the 10 occurrences of bubblenet feeding, the associated prey patch was a horizontal layer with a vertical extent of 5 to 20 meters.

The 'core group' (after Perry et al. 1985) fed together from late June to late August in the vicinity of Point Adolphus. The group was sighted regularly. For the second consecutive year, typical core group members male #577, male #166 and female #236 were observed several times (independently) in Glacier Bay and Icy Strait in May, June and July, but were never sighted with the core group (Appendix 1). Core group female #155 was accompanied by a calf this summer. The calf of #397 (#1471) was identified in the core group and alone in the vicinity of the group on 7 different occasions on 4 days in July and August. We were unsure who was the mother of #1471, (because the calf was often left unattended while #397 was feeding with the group), until a sighting of this pair alone in August eventually allowed us to link them as mother and calf.

Reproduction and Juvenile Survival: We documented 8 cow/calf pairs in the study area in 1998, all of which were sighted in either Glacier Bay or Icy Strait, but not both areas (Table 4). We obtained fluke identification photographs of 7 of the cows and 7 of the calves. The crude birth rate of the study population for 1998, computed by dividing the number of calves by the total number of whales, is 8.7%. A number of the 1998 calves (most notably #1471, #1437, and #1438) were very independent, spending long periods of time away from their mothers. Calf #1471 was photographed on 4 days, but only on the final encounter was the calf observed swimming closely with its mother, #397. During this encounter we obtained high quality dorsal fin photographs of the mother and later determined her identity. We were unable to obtain fluke identification photographs of #235's calf, but we did obtain one high quality dorsal fin photograph.

Table 4. Cows Identified with a Calf in Glacier Bay and Icy Strait 1998.

Cow ID#	Calf ID#	# of days sighted in Glacier Bay	# of days sighted in Icy Strait
1. 155	1438	0	7
2. 235	-	3	0
3. 535	1437	8	0
4. 581	1440	0	2
5. 883	1439	1	0
6. 1031	1475	0	1
7. 1460	1470	2	0
8. 397	1471	0	4

Note: Only calves whose flukes were photographed received an identification number.

Table 5. Crude birth rate of humpback whales in Glacier Bay and Icy Strait, 1982-1998.

Year	#Whales	#Calves	Crude Birth Rate (%)	#Calves Photographically Identified
1985	41	2	4.9	1
1986	49	8	16.3	5
1987	60	4	6.7	3
1988	53	8	15.1	5
1989	41	5	12.2	3
1990	49	6	12.2	6
1991	53	4	7.5	4
1992	65	12	18.5	11
1993	50	3	6.0	3
1994	60	9	15.0	5
1995	57	3	5.3	3
1996	77	7	9.1	2
1997	82	9	11.0	7
1998	92	8	8.7	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.

Since the study began, a total of 26 whales that were first identified in the study area as calves have also been sighted in subsequent years. Eighteen percent of whales identified in 1998 (n=17) were whales first identified as calves. Between 1982 and 1997, 3% to 19% of the annual population count was comprised of known-age whales.

The typical age at first return to the study area is 3 years (Fig. 8). Whale #1299 returned as a yearling and was sighted in Glacier Bay near Flapjack Island (n=2), Beardslee Entrance (n=2) and in the middle of Icy Strait (n=1). In all but one of these encounters #1299 was sighted alone. On the single occasion when #1299 was identified with another whale (six year old whale #1298) we noted that it was a loose affiliation, meaning that the whales were not closely associated although they met the criteria to be considered a pod.

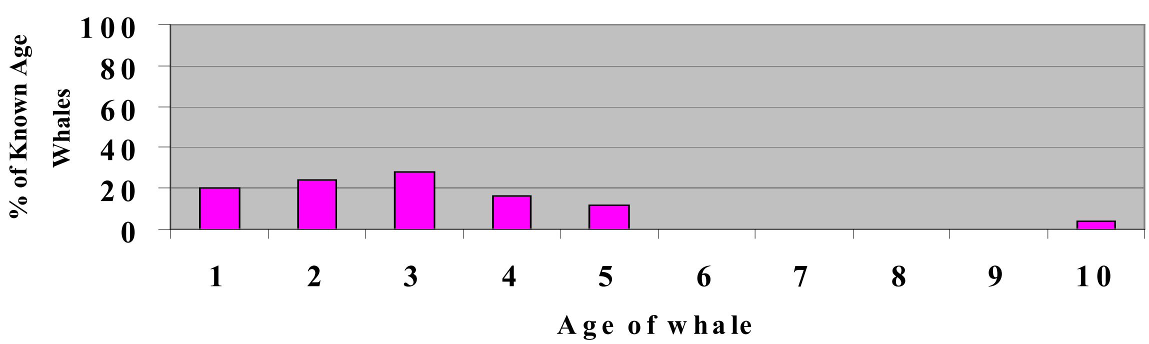


Figure 8. Known Age Whales (n=26): Age at First Return to Glacier Bay Area: 1974-1998

Whale #1031, born in 1988, was identified with a calf in Mud Bay on August 19. Prior to this sighting, #1031's sex was unknown. She was identified in the study area in 1991, 1993, 1995, 1996 and 1997 without a calf. However, the absence of sighting data from 1992 and 1994 when she was 4 and 6 years old, respectively (i.e., potentially reproductively mature) means that we cannot assume that the 1998 calf is her first. Whale #219, mother of #1031, is now the second documented grandmother in the study population. She is a prolific female who has been observed with calves in 1988, 1990, 1992 and 1996. Whale #1031 is the only one of these 4 offspring who has been resighted in southeastern Alaska.

Whale/Human Interactions: We opportunistically documented three interactions involving humpback whales and float planes in Glacier Bay in 1998. The first incident occurred on July 6 during a whale survey that included the area between Bartlett Cove and Point Gustavus. As we maneuvered toward a single whale that was feeding close to shore along a kelp bed, a float plane began circling the whale (and our vessel) at an altitude of approximately 60-90 meters. The plane continued to circle for six minutes, during which time the whale dove. Eleven minutes later the whale was sighted approximately 1 kilometer offshore traveling north. We attempted to photograph the whale but found the whale very difficult to approach (when we got close the whale dove or diverted its path to avoid being close to the boat.) After 14 minutes of unsuccessful attempts to photographically identify the whale, we ended the encounter.

On July 22, we observed the same float plane (identified by its physical description and registration numbers) circling two whales at the entrance to Bartlett Cove. We were not conducting a survey at the time, so we do not have detailed observations of the whales involved. However, from our vantage point approximately 500 meters to the south, we estimated that the plane was at an altitude of approximately 90-120 meters as it circled the whales once and then departed. Afterward, we observed one whale traveling rapidly to the northwest while the second whale remained close to shore where it had been prior to the plane's approach. Our last observation involving whales and float planes occurred on July 27 near the entrance to Bartlett Cove. As a float plane passed over a single whale at an altitude of approximately 45 meters, the whale suddenly slapped its tailstock on the water.

In two observations in Glacier Bay in 1998, whale #1018 reacted to a cruise ship wake breaking on the shoreline in the West Arm. On June 3, this female was sighted very close to shore on the Gilbert Peninsula and began tail-slapping and trumpet-blowing when a large wake from a cruise ship broke against the shore. After the waves subsided, she ceased surface activity. On August 12, she was sleeping within 100 meters of shore and apparently ignored a cruise ship that motored by at a distance of over 1800 meters, but awoke with a start several minutes later when the ship's wake audibly hit the beach.

On July 11, charter vessel *Argus* reported seeing a small humpback whale at Point Adolphus that appeared lethargic. The crew of the *Argus* were concerned because they observed the whale for approximately two hours and only saw it dive once in that time. We attempted to find this whale in the Point Adolphus area on July 13 but we did not observe any whales matching its description, despite excellent sighting conditions until mid-afternoon. We contacted the operator of another charter vessel who had been at Point Adolphus on July 12 whale-watching. He did not observe any sluggish whales or abnormal behavior (G. Nelson, pers. comm.). There were no further reports of the lethargic whale.

One entangled whale was reported in Glacier Bay and Icy Strait. On September 5, the dispatcher at the Visitor Information Station (VIS) at GBNP overheard the operator of a private vessel reporting a humpback whale entangled in "crab pot gear" near Sisters Island in Icy Strait to the Coast Guard on the VHF radio (J. Challoner-Wood, pers. comm.). We contacted the National Marine Fisheries Service (NMFS) and were prepared to assist in a disentanglement but did not attempt to travel to Sisters' Island, which is outside our typical range. Over the next two days, the tour vessels *Auk Nu* and *Wilderness Explorer* reported (to the VIS and to NPS naturalists onboard) a humpback whale trailing approximately about 15 ft of line and one large, round orange buoy in Icy Strait and Glacier Bay (K. Schot, pers. comm; F. Bauer-Young, pers. comm.). However, we did not learn about the subsequent Glacier Bay and Icy Strait sightings until September 9. On that date, we surveyed Icy Strait under excellent sighting conditions but did not locate the entangled whale. Inclement weather prevented additional surveys until September 14 and we received no further reports of the entangled whale.

DISCUSSION

Whale Counts: Keen observers will note that many of the whale counts (Table 3) are slightly adjusted from the values presented in previous reports. These adjustments are attributable to a data verification process that we completed just prior to finalizing this report. First, because the dates of the total study period have varied slightly among years, we decided that in order for annual counts to be strictly comparable, the total count should only include whales sighted from June 1 to August 31, long recognized as our "main" season. Second, each year, several of the whales with a temporary "filmcode" identification number are listed in each year's annual report are matched to known whales with permanent identification numbers. These matches sometimes result in the discovery that two of the whales on an annual whale list are the same. Both of these factors have been apparent throughout the study, but modifying Table 3 each year to document these minor variations in whale counts seemed likely to generate more confusion than was worthwhile. However, this year we made a major effort to verify and adjust the 1985-1998 whale counts reported in Table 3 because numerous minor whale count changes have accumulated over time. Changes to the whale counts occurred in all of the study years and appeared to affect Glacier Bay and Icy Strait counts equivalently. Regardless of slight increases and decreases in individual whale counts, we continued to see an increasing population trend throughout the study area.

The 1998 count of 92 represents the largest number of whales ever identified in the study area in a single season. The standardized and total counts of whales in Glacier Bay were also the highest ever, while Icy Strait whale numbers were slightly below average (Table 3, Fig. 3). It appears that high whale counts in Glacier Bay contributed substantially to the overall positive population trend in the study area as a whole. Since 1996, Glacier Bay whale numbers have been higher than usual, but this year for the first time we were able to detect a statistically significant increasing population trend in Glacier Bay (Fig. 3, 4). For the study area as a whole, whale counts in the past 3 years have been 30-55% higher than the 1985-1998 average of 59 whales. We believe that the increasing trend is due to increased whale abundance in the study area, although we evaluated the potential effects of inter-observer differences, varying levels of effort, and the increasing use of dorsal fin photographs.

Since 1985, a total of only three principal investigators has led the research, lending strong continuity to the data collection methods over the past 14 years. However, in recent years the number of biologists conducting whale surveys has departed from the 1985 to 1995 norm, when one biologist collected and analyzed all data for the study. In 1996 and 1998, one biological technician and in 1997 two technicians assisted with data collection, but the principal investigator maintained primary responsibility for analyzing and interpreting the data. We do not believe that the number of different observers collecting data in a particular year would tend to increase the number of whales photographically identified. Conversely, one might expect new observers' inexperience to decrease the number of whales successfully approached and photographed. Overall, we do not believe that inter-observer differences have systematically affected our whale counts. However, we acknowledge that maintaining consistent staff and duties would minimize the potential for inter-observer differences and benefit the monitoring program.

In 1998, a comparatively high number of hours of survey effort (particularly in Glacier Bay), coincided with the highest whale count. Indeed, the past 3 years have shown the highest hours of effort and the highest whale counts (Table 2, 3). Attempts to correlate the number of whales identified and the number of hours of survey time (Fig.5) approached statistical significance by parametric (r^2=0.313, p=0.0585) but not by non-parametric statistical methods (Spearman *rho* = 0.404, p =0.1808), leading us to suspect that the appearance of a correlation is driven largely by the high whale counts and high hours of effort in the 1996-1998 data, rather than an overall trend. Additionally, it appears likely that the number of whales in an area affects the amount of time required to survey that area, because it takes the observer much longer to identify whales that have been found than it does to transit through the area with few or no whales present. The interdependence of these two parameters makes it difficult to determine the extent to which greater effort might account for higher whale counts.

Another potential source of increased whale counts could be our increasing ability to identify whales by their dorsal fin even if they do not show their flukes. For the most part, the use of dorsal fin identifications allows us to add within-season sightings to the histories of whales whose flukes have already been photographed that year. However, in 1998, one whale, #1473, was identified strictly on the basis of its very distinctive dorsal fin. In other years, for example 1995 when whale #1244 was identified on the basis of its highly distinctive dorsal fin only, one or two whales are sometimes included in the yearly whale count despite the lack of a fluke photograph. These cases add an individual to the whale count despite the lack of a fluke photograph in a particular year. However, the magnitude of the 1985-1998 increasing trend in whale counts appears to be too great to be attributable to the use of dorsal fin photographs.

All of the factors mentioned above may have some small effect on whale counts, but we believe that the rising whale counts are attributable to an increase in the number of whales in the study area. There are several factors probably involved in the increase. First, there are indications that the southeastern Alaska whale population may be increasing. However, we cannot confidently attribute increasing whale counts in the Glacier Bay area to a population increase in southeastern Alaska because the most recent population estimate only includes data up to 1992 (Straley 1994). However, it is notable that the approximately 800 different fluke identifications in the recent southeastern Alaska humpback whale catalog (Straley and Gabriele 1997), far exceeds the 350-458 whale 95% confidence limits of the 1979-1992 population estimate. Additionally, in the context of the increasing population estimate for the North Pacific humpback whale population (Calambokidis et al. 1997), increases in regional feeding herds make sense. An up to date humpback whale population estimate for the southeastern Alaska feeding herd is badly needed.

On the local level, the size and yearly variability in the crude birth rate (Table 5) suggests that increased calf production is not a major factor in the increase in Glacier Bay area whale counts. However, the return of whales first sighted as calves in the study area appears to be contributing to the population's growth, with these "known age" individuals accounting for nearly 20% of annual whale counts in recent years (Gabriele et al. 1997). It is reasonable to suggest that many of these individuals will continue to inhabit the Glacier Bay area in future years. Nearly half of each year's whale roster typically consists of individuals who reliably return to the area year after year. An additional one-third of the population is comprised of whales that are not frequently identified in our study area but have been sighted elsewhere in southeastern Alaska, including a small proportion of whales that have never been identified before. We presume that prey availability influences these infrequent visitors to come into the Glacier Bay area in a particular season, but have no way of knowing whether their presence in a given year indicates that prey availability was particularly high in the Glacier Bay area, or comparatively low in their typical feeding range. Krieger (1990) asserts that whale distribution in southeastern Alaska is directly related to the distribution of euphausiids, although whales in the Glacier Bay area feed primarily on small schooling fish (Krieger and Wing 1984, 1986; Wing and Krieger 1983). This implies that perhaps the infrequent appearance of some whales in the study area is related to the availability of euphausiids elsewhere in southeastern Alaska. Moreover, the ultimate causes of changing prey distribution and abundance, including El Nino-Southern Oscillation (ENSO) ocean temperature cycles, will remain difficult to determine.

Seasonal Distribution: Whale distribution in Glacier Bay was similar to that observed in previous summers. However, we documented fewer whales in the upper reaches of the West Arm, Blue Mouse Cove, Geikie Inlet, and upper Whidbey Passage than in 1997. Whale distribution in the mid-lower bay was similar to that observed in previous years with Bartlett Cove and Flapjack Island continuing to be important habitat for whales throughout the season. The high concentration of whales observed early in the season between Adams Inlet and Sandy Cove has not been observed since the summers of 1985-1987, when this area experienced concentrated whale activity. The entrance to the East Arm was designated as 'whale waters' in the Vessel Management Plan due to perennial use of this area by whales (NPS 1995). Regular surveys of this area in the late spring and early summer should be conducted each year to continue to document its relative importance as feeding habitat.

In eastern Icy Strait, whales were distributed comparably to past summers with the majority of whales concentrated around Point Adolphus. Distribution in western Icy Strait, particularly in Idaho Inlet and on the west side of Lemesurier Island, should not be compared with past years' data because of the minimal survey effort in this region in 1998.

Local Movement and Residency: Overall patterns of whale movement in 1998 were similar to previous years. All cow/calf pairs in 1998 were specific to either Glacier Bay or Icy Strait, in contrast to observations in past years. The number of whales who made one or more roundtrips between areas is comparable to the number documented in 1997, but higher than that documented in previous years. The proportion of 20-day 'resident' whales in the study area (52%) is similar to past years.

The identification of whale #587 at the entrance to Adams Inlet in May was unexpected based on her recent sighting history, but interesting in light of her long-term history. Between 1977 and 1997, #587 has been identified 186 times. Only 10% (n=18) of these sightings were in Glacier Bay, while the remainder were in Icy Strait (primarily at Point Adolphus). Most of the Glacier Bay sightings were in the lower bay (i.e., Bartlett Cove and Sitakaday Narrows), with the notable exception of the summers of 1977 and 1984, when she was regularly sighted near the entrance to the East Arm (Perry et al. 1985, Jurasz and Palmer 1981b). Whale #587's return to the East Arm in 1998 coincided with a large influx of whales feeding between Adams Inlet and Sandy Cove. Our observation of #587 in this area is intriguing because it implies that whales use long-term prior experience to find and exploit seasonal and very localized prey aggregations.

Habitat Characteristics: Whales were observed in predominantly shallow waters, as in previous years (Fig 7). The distribution of the 1998 data shows numerous pods in 10-30 meter water depth, but does not depart substantially from the 1993-1997 data. The whales' use of the range of water depths in their habitat undoubtedly reflects the distribution of their prey, but until we gain a better understanding of small schooling fish distribution we are not likely to advance our understanding of whale habit use.

The sea surface temperatures observed in 1998 were comparable to data collected in 1997 (mean = 9.7 ^{o}C, *s.d.* = 1.56) and approximately 2 ^{o}C higher than the averages in both 1994 (mean = 7.6, *s.d.* = 4.87) and 1995 (mean = 7.5, *s.d.* = 2.33). It is possible that our temperature observations reflect the temporary ocean temperature cycles trend resulting from the 1997-1998 ENSO event (Suplee 1999).

Prey Assessment: The prey patch depths obtained in 1998 appear to be similar to those observed in 1996 and 1997 (Gabriele et al. 1997). The variety of prey species identified in 1998 is consistent with previous studies that documented Pacific herring, juvenile pollock and sand lance in areas near feeding humpbacks (Krieger 1990).

Our July observation of fish eggs laid on coarse sand and a dead sand lance suggests the occurrence of sand lance spawning in Glacier Bay. However, we interpret these results with caution because as study in the Gulf of Alaska documented the species' spawning season to be late September through November (Robards et al. 1999). Sand lance are also known to prey upon other fish species' eggs (M. Robards, pers. comm.). Taxonomic identification of the eggs themselves will determine whether they are sand lance eggs. We are interested in increasing our ability to document small schooling fish spawning events because of their potential importance as a food resource for whales and other animals. We queried the Park's coastal resource inventory and mapping database to determine the substrate type and grain size at the beach where the fish eggs were found and determined that it was classified as "granules, pebbles and coarse sand" (Sharman et al. 1999). Using this information we again queried the coastal database to generate a map of all beaches with that type of substrate, and identified several potential spawning beaches. Future studies may attempt to document spawning events and correlate them with the occurrence of potential predators including whales.

Feeding Behavior: Whales typically fed below the sea surface, although we also observed numerous bouts of lunge feeding and an unusually high number (n=10) of occurrences of bubblenet feeding. However, we cannot quantify the relative likelihood of various types of feeding behavior because we are unable to determine for sure whether a whale is subsurface feeding. Although we documented many instances of surface feeding, we saw no indications of surface-swarming euphausiids as were reportedly common prior to the 1980's (Jurasz and Palmer 1981, Krieger 1990). As our habitat characteristics database grows we may be able to make generalizations about the types of prey aggregations associated with particular types of feeding behavior.

Reproduction and Juvenile Survival: The documentation of three generations of whales (#219, #1031, #1475) in Icy Strait is the second in the history of this study and highlights the value of long-term studies to the understanding of reproduction and life history in humpback whales. The average female age at first reproduction in the North Pacific humpback population is not known, with the only southeastern Alaska known age female having been observed in this study (Gabriele 1992) with her first calf at age 8. In addition to this year's sighting of #1031, two other southeastern Alaska whales of known age have been observed with a calf (J. Straley, pers. comm.), but we cannot determine whether these calves were their first, because neither whale has a complete sighting history. Age at first reproduction is an important parameter determining long-term population growth that will necessitate continued data collection.

Whale/Human Interactions: The observed approach and disturbance of whales by float planes, whether intentional or not, is cause for concern, especially in Bartlett Cove where the concentrations of whales and planes generate a higher probability of interactions. It appears that much of the problem stems from the fact that float planes take off and land regularly in Bartlett Cove, creating a situation where whales are often exposed to planes flying at very low altitudes. Further investigation into the frequency and effects of these interactions may be warranted to ensure that whales are not being disrupted from feeding in Bartlett Cove. An increased effort to educate float plane pilots about whales is also advisable.

It was unusual to observe a whale reacting to sounds produced indirectly by a vessel (i.e. its wake breaking on shore), because in most studies of whale/vessel interaction, the sound of the engine and propellers are identified as factors that produce a response (Baker and Herman 1989; Malme et al. 1982, Miles and Malme 1983). It is also interesting that both of these disturbances involved the same whale, and invites speculation about whether she is particularly sensitive. We do not fully understand the varying acoustic environments of Glacier Bay, but it is possible that the steep fjord walls in #1018's typical West Arm feeding range cause wake splash reverberations to be particularly loud. Underwater acoustic research planned to begin in the year 2000 may improve our understanding of sound propagation in Glacier Bay.

Each year in southeastern Alaska, at least one whale is reported to be entangled in fishing gear (K. Brix, pers. comm.) although they are rarely sighted in Glacier Bay or Icy Strait. Although in the September 1998 entanglement, lack of communication and inclement weather prevented us from finding the whale, it is important to document these occurrences and to be prepared to take action. Three Park staff participated in a whale disentanglement workshop sponsored by the NMFS in Sitka in November 1998. Since 1985, Park biologists have disentangled whales from fishing gear on two occasions. As local whale abundance increases, the potential for all types of whale interactions with humans can be expected to rise, especially given the apparently increasing human presence in whale habitat in the form of kayakers, motorized boaters, sport and commercial fisherman, and aircraft pilots. In light of this trend, managers must be prepared to meet the challenges of maintaining adequate protection for whales both inside and outside of Park waters.

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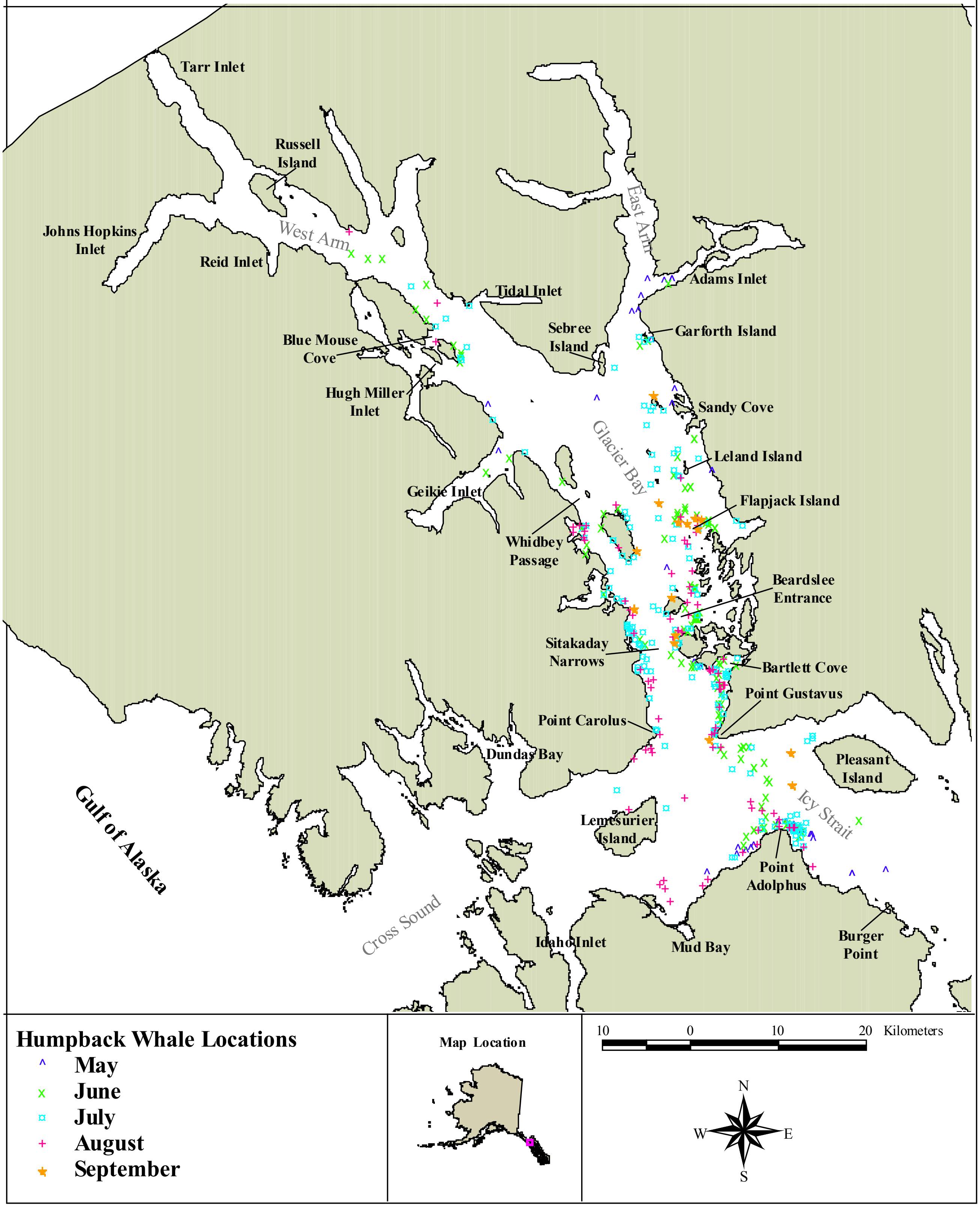
Figure 1. Humpback Whales in Glacier Bay and Icy Strait 1998



Appendix 1: Sighting Histories of Individually Identified Whales

	Whale ID#		4/25/98	4/26/98	5/5/98	5/8/98	5/13/98	5/14/98	5/18/98	5/28/98	5/29/98	6/2/98	6/3/98	6/4/98	6/5/98	6/8/98	6/10/98	6/11/98	6/15/98	6/16/98	6/17/98	6/18/98	6/19/98	6/22/98	6/23/98	6/24/98	6/25/98	6/26/98	6/29/98	6/30/98	7/1/98	7/2/98	7/6/98	7/7/98	7/8/98
1	801				G																	G						G				G			
2	1018				G				G				G									G					G	G							
3	G98-1(19)				G																														
4	539	Max				I		I																											
5	1293					I						G						G							G										
6	1431					I		I														G													
7	G98-1(25)					I																													
8	351						G			G																					G	G			
9	118	Chop Suey						I			I															I									I
10	157	M.D.						I			I																								
11	160							I						G									G			I									
12	516	Garfunkle						I			I																								I
13	587	Gertrude							G																	I									I
14	1012								G					G																G	G				
15	1014								G	G				G	G		G	G	G		G	G									G	G			
16	117	White Eyes								G																									
17	221									G				G						I				G					G						
18	937									G				G	G		G	G	G				G	G									G		
19	1065									G				G							G				G										
20	1244									G		G			G																				G
21	1476									G					G																				
22	1477									G				G																	G				
23	1481									G				G	G																				
24	166	Frenchie									I									I															I
25	219										I															I									
26	352										I																						G	G	I
27	1042										I									I						I									I
28	564	Roundup Taylor											G		G							G											G	G	
29	159													G				G											G		G				
30	161	B.W.M.												G	G					I			G										G +		
31	535	Quits												G	G				G								G		G						
32	1437	calf of 535												G	G				G								G		G						G
33	1079													G				G					G				G								
34	1246													G																					
35	1479														G																G				
36	1242															I		G		I															
37	1046																	G	G					G								G			
38	1299																	G																	
39	283																		G						G										I
40	154	Freckles																		I						I									
41	155	Freckle Fluke																		I						I									I
42	1438	calf of 155																		I						I									I
43	577	Scoper																		I			G	G									G +		
44	933																			I															I
45	1292																			I															
46	1298																			I															
47	1345																			I						I									
48	1478																			I															
49	193																			I															
50	513																				G														
51	1426																				G														
52	350	Lace																				G			G										
53	236	Leigh																					G	G									G +		
54	225	Vagn																							G										I
55	235	Spot																							G										
56		calf of 235																							G										
57	1460																								G										

	Whale ID#	7/9/98	7/13/98	7/15/98	7/16/98	7/17/98	7/20/98	7/22/98	7/23/98	7/27/98	7/28/98	7/29/98	7/30/98	7/31/98	8/3/98	8/4/98	8/6/98	8/10/98	8/11/98	8/12/98	8/13/98	8/18/98	8/19/98	8/20/98	8/21/98	8/25/98	9/9/98	9/14/98	9/22/98	9/28/98	10/11/1998
1	801								G			G																			
2	1018	G						G											G	G									G		
3	G98-1(19)																														
4	539																														
5	1293			G														G			G	G									
6	1431																						I								I
7	G98-1(25)																														
8	351																	G											G		
9	118		I					G		I				G	G		I							I					G		
10	157											I													G						I
11	160			G																							I				
12	516		I																												
13	587		I							I							I							I							
14	1012	G		G								G						G								G					
15	1014			G																						G					
16	117						G				G																				
17	221			G			G						G															G			
18	937						G				G		G																		
19	1065												G		G				G						G		G				
20	1244						G						G																		
21	1476																														
22	1477								G																	G		G	G		
23	1481																I														
24	166											I						G													
25	219											I																			
26	352											G			G		I					G	G								I
27	1042									I																					
28	564						G				G		G		G				G		G				G						
29	159											G	G			G					G	G					G				
30	161			G																											
31	535			G				G																							
32	1437			G				G																							
33	1079										G															G		G			
34	1246																														I
35	1479																														
36	1242																														
37	1046				G							G							G												
38	1299					G		G		I				G																	
39	283												G								G										
40	154																														
41	155		I							I							I							I							
42	1438		I							I							I							I							
43	577			G										G	G																
44	933									I							I							I							
45	1292						G										I								G			G			I
46	1298			G		G		G					G																		
47	1345		I							I							I							I							
48	1478																														
49	193									I																					
50	513																														
51	1426																														
52	350	G			G				G		G	G																			
53	236			G														G													
54	225					G																							G		
55	235													G							G										
56														G							G										
57	1460				G																										

Note: Shading shows Total (June 1 - August 31) and Standardized (July 9 -August 16) whale counting periods.

Appendix 1: Sighting Histories of Individually Identified Whales

	Whale ID#		4/25/98	4/26/98	5/5/98	5/8/98	5/13/98	5/14/98	5/18/98	5/28/98	5/29/98	6/2/98	6/3/98	6/4/98	6/5/98	6/8/98	6/10/98	6/11/98	6/15/98	6/16/98	6/17/98	6/18/98	6/19/98	6/22/98
58	1470	calf of 1460																						
59	1473																							
60	186																							
61	187																							
62	353																							
63	512																							
64	573																							
65	817																							
66	941																							
67	1306																							
68	237	Dike																						
69	883																							
70	1439	calf of 883																						
71	1233																		G					
72	250																							
73	1063																							
74	1083																							
75	1082																							
76	1295																							
77	584																							
78	196																							
79	397																							
82	1471	calf of 397																						
80	541																							
81	1061																							
83	581																							
84	1440	calf of 581																						
85	1461																							
86	1996 calf of																							
87	1049																							
88	1302																							
89	465																							
90	1432																							
91	1474																							
92	1031																							
93	1475	calf of 1031																						
94	875																							
95	G98-75(20)																							
96	G98-83(9)																							

	Whale ID#		6/23/98	6/24/98	6/25/98	6/26/98	6/29/98	6/30/98	7/1/98	7/2/98	7/6/98	7/7/98	7/8/98	7/9/98	7/13/98	7/15/98	7/16/98	7/17/98	7/20/98	7/22/98	7/23/98	7/27/98	7/28/98
58	1470	calf of 1460	G														G						
59	1473		G							G													
60	186			I											I							I	
61	187			I																			
62	353			I									I		I							I	
63	512			I			G																
64	573			I									I		I							I	
65	817			I																			
66	941			I							I												
67	1306			I																			
68	237	Dike				G		G						G						G			
69	883					G																	
70	1439	calf of 883				G																	
71	1233						G												G				
72	250								G														
73	1063								G							G							G
74	1083								G								G	G	G				
75	1082									G										G	G		
76	1295										I									G	G		
77	584												G										
78	196												I										
79	397												I									I	
82	1471	calf of 397											I		I							I	
80	541												I										
81	1061												I									I	
83	581														I							I	
84	1440	calf of 581													I							I	
85	1461															G							
86	1996 calf of																G						
87	1049																		G				
88	1302						G													G			
89	465																						
90	1432																						
91	1474																						
92	1031																						
93	1475	calf of 1031																					
94	875																						
95	G98-75(20)																						
96	G98-83(9)																						

	Whale ID#		7/29/98	7/30/98	7/31/98	8/3/98	8/4/98	8/6/98	8/10/98	8/11/98	8/12/98	8/13/98	8/18/98	8/19/98	8/20/98	8/21/98	8/25/98	9/9/98	9/14/98	9/22/98	9/28/98	10/11/1998
58	1470	calf of 1460																				
59	1473		G																			
60	186																					
61	187																					
62	353							I														
63	512																					
64	573														I							
65	817																					
66	941		I					I						G								
67	1306																					
68	237	Dike														G						
69	883																					
70	1439	calf of 883																				
71	1233			G																		I
72	250																					
73	1063																					
74	1083																					
75	1082									G											I	
76	1295							G														
77	584																					
78	196																					
79	397							I														
82	1471	calf of 397						I														
80	541																					
81	1061																					
83	581																					
84	1440	calf of 581																				
85	1461				G	G																
86	1996 calf of			G		G																
87	1049		G																			
88	1302		G																			
89	465		I																			
90	1432					I																
91	1474					I								I						G		
92	1031													I								
93	1475	calf of 1031												I								
94	875														I							
95	G98-75(20)														I							
96	G98-83(9)																				I	

Note: Shading shows Total (June 1 - August 31) and Standardized (July 9 -August 16) whale counting periods.