



Humpback Whale Monitoring in Glacier Bay and Adjacent Waters 2016

Annual Progress Report

Natural Resource Report NPS/GLBA/NRR—2017/1503



ON THE COVER

Eighteen-year-old male humpback whale #1438 breaches in Glacier Bay, July 2016.
Image credit: NPS/Christine Gabriele

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Abstract

Migratory humpback whales (*Megaptera novaeangliae*) use southeastern Alaska as summer feeding habitat, including the waters in and around Glacier Bay National Park and Preserve (GBNPP). This report summarizes GBNPP's humpback whale monitoring program in Glacier Bay and Icy Strait (GB-IS) in 2016, the 32nd consecutive year of consistent data collection. In June-August, we documented 164 unique whales in GB-IS, our lowest count since 2008. Counts corrected for effort reveal an increasing trend following a dramatic decline in whale abundance in 2014. We found decreases in within-year and between-year site fidelity, with over one-third (35.6%) of our 'regularly sighted' whales missing in 2016. We identified only one mother/calf pair, resulting in the lowest crude birth rate (0.6%) since monitoring began in 1985, and there was also a notable absence of one and two-year-old whales. Many of the whales that we observed (13%) appeared to be abnormally thin. The 'core group' at Point Adolphus was not sighted and many of the whales typically associated with the group were not documented. In June, whale #441 was found dead marking the end of his 45-year sighting history (1972-2016), the world's longest for a humpback whale. There is mounting evidence that site fidelity, calving, and juvenile return rates in Glacier Bay-Icy Strait have declined substantially in recent years. Within Alaska, the long-term, consistent monitoring of humpback whales is limited to GB-IS, making it difficult to determine over what geographic scale these changes are occurring.

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Introduction

This report summarizes the findings of Glacier Bay National Park and Preserve's (GBNPP) humpback whale (*Megaptera novaeangliae*) monitoring program during the summer of 2016, the 32nd consecutive year of consistent data collection in Glacier Bay and Icy Strait, Alaska. The initial impetus for this program stemmed from concern in the late 1970s that increased vessel traffic in Glacier Bay may have caused a large proportion of the local whale population to abandon the bay (Jurasz and Palmer 1981). Beginning in 1973, humpback whales were listed as endangered under the U.S. Endangered Species Act [National Oceanic and Atmospheric Administration (NOAA) 2016], which afforded them increased federal protection and conservation concern. In addition, the National Park Service (NPS) is mandated to ensure that park management decisions do not negatively impact wildlife such as humpback whales [NPS Organic Act, 54 U.S. Code 100101(a)]. Therefore, each summer since 1985, Park biologists have documented the number of individual humpback whales in Glacier Bay and Icy Strait, as well as their residence times, spatial and temporal distribution, reproductive parameters, and feeding behavior. These data are used as an index to monitor long-term trends in the population's abundance, distribution, and reproduction (Gabriele *et al.* 2017). Long-term and consistent data collection in longitudinal studies is extremely rare and valuable in understanding the population parameters and recovery of an endangered species. The ongoing, systematic study of humpback whales in Glacier Bay/Icy Strait by GBNPP now constitutes one of the longest and most complete time-series of data on a living baleen whale population with documented individual humpback whale sighting histories of up to 45 years (Jurasz and Palmer 1981; Perry *et al.* 1990; Gabriele *et al.* 2017).

Photographic identification, life history, and genetic data from this study are shared with other researchers studying humpback whales (*e.g.*, Mizroch *et al.* 2004; Herman *et al.* 2009; Barlow *et al.* 2011; Hendrix *et al.* 2012; Baker *et al.* 2013; Pierszalowski *et al.* 2016). Beginning in 2011, Park biologists began collaborating with the National Marine Fisheries Service Alaska Region's Office of Protected Resources to produce whale sighting maps to provide timely updates to ship captains on shifting whale distribution in Glacier Bay and Icy Strait to help ship captains prevent whale-vessel collisions and disturbance. In addition, Park biologists use whale distribution data on a daily basis to make recommendations regarding when and where GBNPP 'whale waters' vessel course and speed restrictions should be implemented in Glacier Bay to reduce whale disturbance and collision risk.

Most humpback whales that feed in southeastern Alaska (SEAK) in the summer spend the winter breeding season in the Hawaiian Islands, although a small proportion (about 6%) winters in Mexico (Baker *et al.* 1986; Perry *et al.* 1990; Calambokidis *et al.* 1997; Baker *et al.* 2013; Wade *et al.* 2016). In September 2016, NOAA reclassified the humpback whale globally into 14 distinct population segments (DPSs). The Hawaii DPS was one of 10 DPSs worldwide removed from the U.S. Endangered Species List, while the Mexico DPS remains listed as 'threatened' (NOAA 2016). The most recent population estimate for SEAK was 1,585 humpback whales in 2008 (95% central probability interval: 1455, 1644) (Hendrix *et al.* 2012). This is considered the minimum population estimate for SEAK because no data were collected in southern SEAK. From 1985 through 2015, the number of unique whales documented annually in Glacier Bay and Icy Strait ranged from 41 to 240

whales, which closely matches population size estimates for this area through 2009 derived from capture-recapture models (Saracco *et al.* 2013). Humpback whales that summer in SEAK exhibit strong maternally-directed site fidelity that has driven population growth over time (Baker *et al.* 1990; Straley 1994; Baker *et al.* 2013; Pierszalowski *et al.* 2016). In the study area, the population increased annually by an estimated 5.1% (95% CI = -1.3%, 11.9%) from 1985-2014 and exhibited an accelerated rate of growth from 2002-2011 (11.1%/yr, 95% CI = 4.1%, 18.6%) (Gabriele *et al.* 2017). However, beginning in 2014 there was a marked decline in the number of whales in Glacier Bay and Icy Strait, driven in large part by declines in whale use of Icy Strait (Neilson and Gabriele 2016).

Humpback whale movement throughout SEAK is presumed to be linked with prey availability, which likely influences the number of whales in the study area (Baker *et al.* 1990; Krieger 1990; Straley 1994; Straley and Gabriele 1995). Whales in Glacier Bay and Icy Strait typically feed alone or in pairs (Gabriele *et al.* 2017), primarily on small schooling fishes such as capelin (*Mallotus villosus*), juvenile walleye pollock (*Gadus chalcogrammus*), Pacific sand lance (*Ammodytes personatus*), and Pacific herring (*Clupea pallasii*) (Wing and Krieger 1983; Krieger and Wing 1984, 1986; NPS unpublished data). A notable exception to these smaller group sizes is the large (*e.g.*, 10-12 or more whales), stable, coordinated ‘core group’ that commonly feeds at Point Adolphus in Icy Strait, although in recent years the group’s size and persistence during the summer have declined (Neilson *et al.* 2014, 2015; Neilson and Gabriele 2016). In addition, over the years less consistent large aggregations of whales have occasionally gathered to feed at various locations in Glacier Bay and Icy Strait (NPS unpublished data).

Methods

The methods used for this annual monitoring program have been described in previous reports and publications (e.g., Gabriele *et al.* 2017). The primary techniques have not changed significantly since 1985, allowing for comparison of data among years. The specific methods used in 2016 are outlined below. In addition, from August 1-14, 2016 we used these same methods to participate in a new collaborative study of humpback whales in northern SEAK called “Survey of Population Level Indices for Southeast Alaska Humpbacks” (SPLISH) (Moran *et al.* 2017).

Vessel Surveys

We conducted vessel surveys in Glacier Bay and Icy Strait from April 1 through October 10, 2016. One to two observers searched for, observed, and photographed humpback whales from the *Sand Lance*, a 5.8-meter motorboat based in Bartlett Cove and equipped with a four-stroke Mercury 150 HP outboard engine. In addition, we conducted two surveys from the *Boomer*, a 6.7-meter motorboat based in Bartlett Cove and equipped with a two-stroke Evinrude E-TEC 150 HP outboard engine. To minimize the potential impact that monitoring efforts might have on individual whales, we typically did not conduct surveys in the same area on consecutive days.

The study area (1668 sq. km) included most of Glacier Bay and Icy Strait (Fig. 1) with a primary survey area (770 sq. km) covering the main body of Glacier Bay (roughly defined by four corners: Point Gustavus, Point Carolus, Geikie Inlet, and Garforth Island) and central Icy Strait (roughly defined by four corners: Point Gustavus, Point Carolus, Pinta Cove, and Mud Bay). Between June 1 and August 31, we surveyed the primary survey area in Glacier Bay 3-4 days per week, focusing the day’s effort in a particular part of the study area. We surveyed the East Arm of Glacier Bay (generally only as far as the mouth of Adams Inlet) and the West Arm of Glacier Bay (generally only as far as Russell Island) infrequently. We did not conduct surveys in any Park designated non-motorized waters, although we receive occasional reports of whales in these areas. All indications are that the whales in non-motorized waters also use the motorized waters in Glacier Bay and are thus documented at least once at current levels of survey effort. We surveyed Icy Strait approximately once per week, with the greatest survey effort focused in the primary survey area. When whale numbers in Icy Strait were high and the weather allowed, we sometimes surveyed Icy Strait two or more times per week. Glacier Bay is the main area of NPS management concern with regard to whales, but descriptions of the whales’ use of Icy Strait provide essential context for the Glacier Bay results because whales frequently move between these areas and because Park waters include portions of Icy Strait.

The primary intent of the survey protocol is to photographically identify as many whales as possible in the study area between June 1 and August 31 in a manner that is comparable between years for monitoring humpback whale population trends. We use a mixed approach in which we target ‘hotspots’ where whale sightings have been reported or are very probable, while also surveying outlying areas where whales may or may not be present. We strive for five surveys per week that cover the entire primary survey area (Fig. 1). Survey effort is only systematic to the extent that we

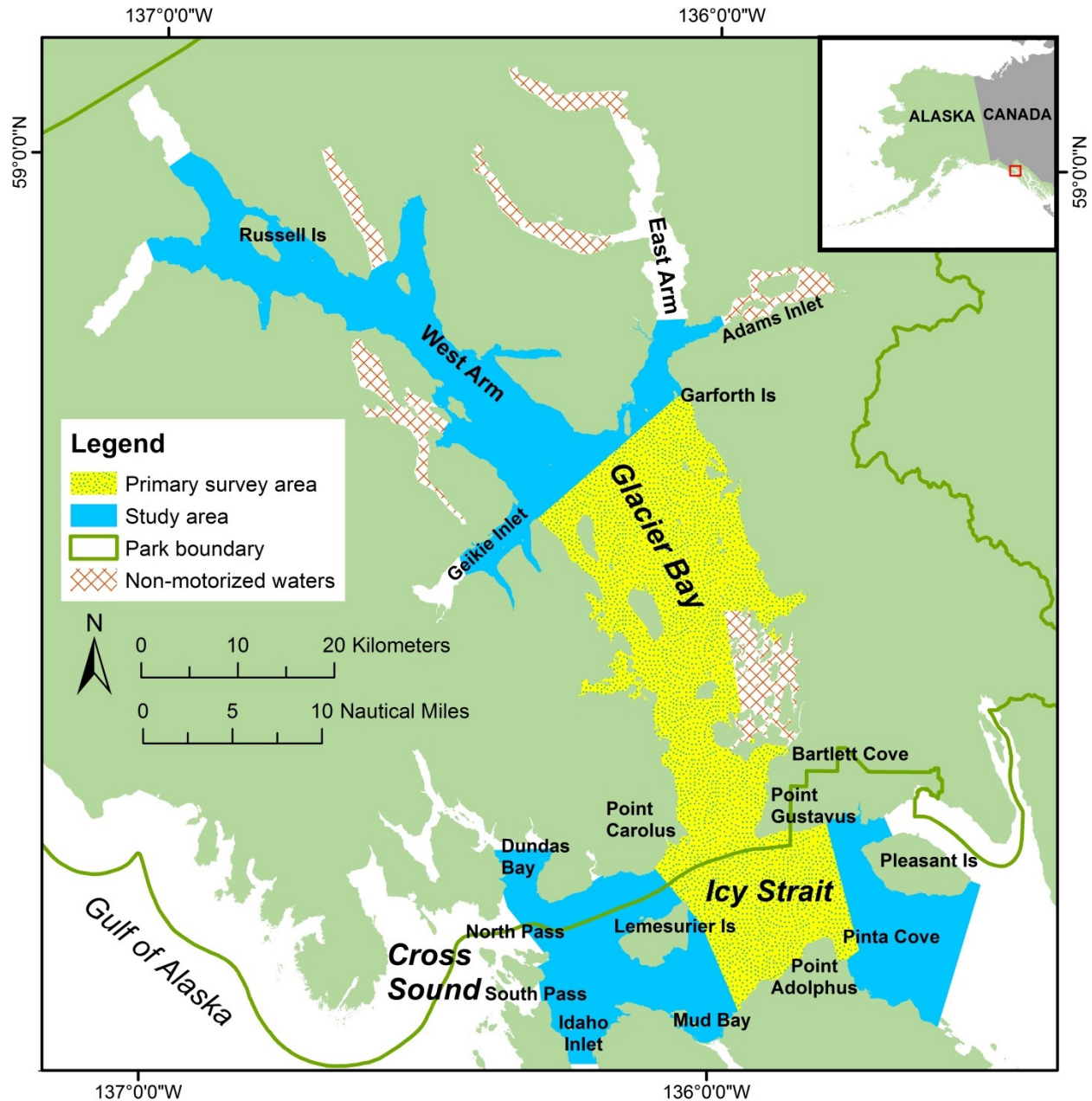


Figure 1. Study area in Glacier Bay and Icy Strait showing primary survey area and non-motorized waters.

aim to survey a particular portion of the study area on a given day and we generally do not survey the same area on consecutive days. However, where the whales are, and how many there are, dictates where the survey takes place and how much area we cover each day. Gathering life history data on individual whales is a secondary goal of the study, made possible by the whales' strong site-fidelity to the study area and the high level of effort with which we cover the study area. A third objective of the study is to inform park management about whale distribution in an effort to manage and mitigate vessel impacts to whales (*e.g.*, whale waters), thus our effort is somewhat biased towards areas where vessel management is a concern. We limit our observations to good to fair ocean and visibility

conditions [*e.g.*, in most cases, Beaufort ≤ 3 , seas < 0.6 m (2 ft) and visibility > 0.8 km (0.5 mi)] and we make periodic stops to scan with 10x40 binoculars and listen for blows to keep our detection rate of whales high. This survey approach, combined with a high level of effort, approximates a census that identifies most of the whales in the study area in a given summer. In a recent study, capture-recapture statistical techniques were applied to GBNPP humpback whale monitoring data collected from 1985-2009 and revealed that our annual whale counts equal about 90% of the non-calf whales estimated for the same study area (Saracco *et al.* 2013).

We defined ‘survey hours’ as the time we spent on the water in the study area each day (*i.e.*, from the time we departed the dock until the time we returned). This metric has been used since 1985. Beginning in 2005, we began recording ‘effort hours’ as the time we spent actively searching for whales each day (*i.e.*, not including transit time to/from the portion of the study area that was the day’s focus). We also re-defined a survey ‘day’ from any day with survey hours in Glacier Bay or Icy Strait (1985-2004) (*i.e.*, some Glacier Bay ‘days’ were solely transits to/from Icy Strait) to only those days with effort hours in Glacier Bay or Icy Strait (2005-present). We count days in which there was effort in both Glacier Bay and Icy Strait as one Glacier Bay day and one Icy Strait day.

We defined a pod of whales as one or more whales within 2-3 body lengths of each other, surfacing and diving in unison (Baker 1985; Clapham 1993). We defined a shoal as a group of whales composed of subgroups that were within 2-3 body lengths of each other that were not necessarily surfacing and diving in unison and in which associations between individuals were fluid and ephemeral. Upon locating a pod or a shoal, we recorded the latitude and longitude coordinates of their initial location. We used a GPS-enabled iPad with Tap Forms software version 4.0.7 (Tap Zapp Software, Inc., Calgary, Canada), combined with custom datasheets, to record field data pertaining to the pod or shoal, including the initial location, number of whales, their behavior (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, sea surface temperature, and any prey patches observed on the depth sounder. If the whales were feeding, we categorized their feeding behavior as subsurface, vertical lunge, lateral lunge, bubble net, other bubble, flick, or unknown (Jurasz and Jurasz 1979).

Individual Identification

The ventral surface of each whale's flukes has a distinct, stable black and white pigment pattern that allows for individual identification (Jurasz and Palmer 1981; Katona *et al.* 1979). For some whales, the shape and scarification of the dorsal fin also serve as unique identifiers (Blackmer *et al.* 2000). We took photographs of each whale’s flukes and dorsal fin with a Nikon D90 digital camera equipped with a 100-300 mm zoom lens. We compared fluke and dorsal fin photographs to previous NPS photographs and to photographs of other humpback whales from SEAK (University of Alaska Southeast, unpublished data) to determine the identity and past sighting history of each whale.

We referred to many whales by a permanent identification number common to the combined catalogs of GBNPP and University of Alaska Southeast researcher Jan Straley (<http://alaskahumpbacks.org/flukeIDcatalog.html>). We also referred to those whales first photo-identified by Jurasz and Palmer (1981) by their nicknames. We only assigned calves a permanent

identification number if we obtained at least one adequate photograph of the calf's flukes and the calf was sighted on more than one day. For calves that did not meet these criteria, we assigned a temporary unique identifier in the format "mother's identification number_calf_year" (e.g., 895_calf_2016). For non-calf whales that had not been previously identified in Glacier Bay and Icy Strait, we assigned temporary alphanumeric identification numbers. We replaced these temporary numbers with permanent identification numbers if we identified the whale on more than one day or if the whale was identified elsewhere by another researcher. Photographic and sighting data were added to a relational database containing Glacier Bay and Icy Strait whale sighting histories from 1977 to 2016. We also selected, printed, and catalogued the best 2016 identification photograph (flukes or dorsal fin) of each individual.

Whale Counts

We examined the 2016 season's photographs to determine the number of unique whales we observed. We counted the number of unique whales that we sighted in Glacier Bay, Icy Strait, and the combined GB-IS area for the dedicated monitoring period (June 1 - August 31). We used the "line drawn between Point Gustavus and Point Carolus" [Title 36 Code of Federal Regulations (CFR) Subpart N, 13.1102] to separate Glacier Bay and Icy Strait and assigned sightings north of the line to Glacier Bay and sightings south of the line to Icy Strait. This line may be biologically arbitrary but it is relevant for GBNPP regulatory purposes. We corrected our whale counts for effort by calculating whales/survey hour and whales/effort hour. We believe that whales/effort hour is the most appropriate metric to assess the population's trajectory because it includes only the time spent actively searching for whales.

Site Fidelity

We determined the number of whales that were 'resident' in the study area in 2016. We designated a whale as resident if it was photographically identified more than once in Glacier Bay and/or Icy Strait over a span of 20 or more days between June 1 - August 31 (after Baker 1986). Sighting data indicate that many whales remain in the study area (e.g., see Appendix in Neilson *et al.* 2014) but in some cases, an individual could leave Glacier Bay or Icy Strait in the interval between our sightings, then return, and be counted as a resident in the study area as long as 20 or more days had elapsed between two or more GB-IS sightings.

After noticing that many of the individual whales that regularly return to the study area annually were not sighted in 2016, new this year, we assessed long-term site fidelity by determining how many of the whales we regularly sight in GB-IS were identified each year (all dates 1985-2016). We defined 'regularly sighted' whales as those individuals that had been documented in GB-IS before 2000, seen in GB-IS at least through 2010, and had been sighted in GB-IS at least once in more than 15 different years.

To examine changes in site fidelity over time, we calculated how many of these regularly sighted whales were seen each year for the period 2002-2016, and referred to this metric as the 'annual fidelity index'. We did this for each year by dividing the number of regularly sighted whales seen in that year by the total number of regularly sighted whales from 2002-2016. The total number of whales was adjusted if a whale was known to have died. We chose this date range because several of

the regularly sighted whales were calves as late as 1999. The mean age at which calves return to the study area is 3.2 years (Gabriele *et al.* 2017), therefore we considered years prior to 2002 to be biased against sighting some whales.

Reproduction and Juvenile Survival

We defined the following age classes for whales whose birth year was known based on photo-identification records: calves (less than one year old), juveniles (age 1-4 years, as determined by prior sighting history), and adults (age ≥ 5 years) (Chittleborough 1959). We monitor the reproductive histories of individual females and document the return and recruitment of their offspring into the population. We calculated crude birth rate as an index of reproduction by dividing the number of calves by the total whale count from June 1 - August 31.

Tissue Samples

We opportunistically collected sloughed skin on the sea surface with a small dip net when whales breached or performed other ‘surface active’ behavior (*e.g.*, breaches, tail slaps, etc.). We stored these sloughed skin samples in plastic vials filled with dry table salt (NaCl). We archived one-third of each skin sample at GBNPP (in dry salt) and sent one-third to be archived (frozen at -80° F) at the National Marine Fisheries Service Southwest Fisheries Science Center where they are available on request to other scientists studying a variety of topics. The remaining one-third of the sample was provided to the Cetacean Conservation and Genomics Laboratory at Oregon State University for use in our long-term collaboration examining humpback whale population structure in southeastern Alaska.

Feeding Behavior and Prey Identification

We opportunistically noted when individual whales appeared to be abnormally thin (*e.g.*, scapulae protruding and/or noticeable postcranial depression; after Bradford *et al.* 2012). We also opportunistically documented any unusual humpback whale feeding behavior (*i.e.*, different from typical subsurface, vertical lunge, lateral lunge, bubble net, other bubble, or flick) that we observed in the study area.

We recorded instances when we observed probable whale prey such as small schooling fish in the vicinity of whales. In addition, we opportunistically collected anecdotal reports of whale prey in the study area. We used field guides (Smith and Johnson 1977; Pearse *et al.* 1987; Hart 1988; Mecklenburg *et al.* 2002; Johnson *et al.* 2015) and/or provided high resolution photographs to fish identification experts to taxonomically identify sample prey items that we collected opportunistically using a dip net. We also consulted results of long-term systematic surveys in Icy Strait [the Southeast Coastal Monitoring (SECM) project] in attempt to provide context for our whale observations. Since 1997, the SECM project has annually collected and analyzed stomach contents from larger pelagic fish (primarily salmon) in Icy Strait (along a transect that roughly follows the eastern boundary of our study area) to identify the number and species of fish and zooplankton consumed.

Whale/Human Interactions

‘Whale waters’ are defined by NPS regulation as “any portion of Glacier Bay, designated by the superintendent, having a high probability of whale occupancy, based upon recent sighting and/or past

patterns of occurrence” (Title 36 CFR Subpart N, 13.1102). The whale observations from this study are used to make recommendations to the GBNPP superintendent on where and when whale waters should be implemented. Vessel course and speed restrictions have long been used to reduce whale disturbance and collision risk in Glacier Bay whale waters (Title 36 CFR Subpart N, 13.1174). Course restrictions require transiting vessels over 5.5 m (18 ft) to remain at least 1.9 km (1 nautical mile) from shore, or mid-channel in areas too narrow to maintain this course, to avoid the near shore areas most often used by feeding whales. Speed and course restrictions are both important aspects of whale protection because whales’ unpredictable distribution means that whales are often present mid-channel as well as near shore.

We summarized whale/human interactions (including strandings, vessel collisions, and entanglements) in the study area and elsewhere in Alaska in 2016, based on our observations and those of other NPS staff, stranding data compiled by the NOAA Alaska Region Office of Protected Resources, the media, and via anecdotal observations from the public. In addition, we opportunistically documented disturbance of whales by vessels and aircraft in the study area. While our reporting is likely not comprehensive because under-reporting is known to occur, we attempted to characterize the number and types of whale/human interactions using the best available information.

Results and Discussion

Vessel Surveys

Between June 1 and August 31, survey hours in the combined Glacier Bay/Icy Strait study area totaled 308 h and effort hours totaled 233 h (Table 1). Effort in both Glacier Bay (157 h) and Icy Strait (76 h) was below average compared to 2005-2015 (189.5 h and 99.5 h, respectively). Overall, 67% of our survey hours were in Glacier Bay and 33% were in Icy Strait, which is comparable to the average for 2005-2015 (66% and 34%, respectively). From 2005-2013, anomalously high numbers of whales around Point Carolus in Icy Strait likely inflated our Icy Strait effort, however this area ceased being a whale hotspot in 2014 (Neilson *et al.* 2015). Although we strive to maintain a comparable level of survey effort each year (Table 1, Table 2), it inevitably fluctuates as a result of inter-annual variability in factors beyond our control such as weather, availability of staff, and the frequency of unexpected events that detract from our ability to conduct surveys (*e.g.*, mechanical difficulties and marine mammal strandings). In 2016, various factors caused us to have below average effort, including responding to whale #441's stranding (see below, Dead Whales), mechanical issues, and frequent wind, fog, and heavy rain.

Whale Counts

Between June 1 and August 31, 2016, we documented 164 humpback whales in Glacier Bay and Icy Strait (Table 3, Fig. 2, Fig. 3) which is similar to 2015 ($n = 166$) and our lowest annual whale count since 2008. Outside of the regular June through August monitoring period, we documented an additional 14 whales in the study area, for a grand total of 178 unique whales in 2016. All of these additional whales were observed just once and all these observations occurred during the spring (April, $n = 1$; May, $n = 13$). This is notable for two reasons: 1) None of the whales were documented on multiple days, which indicates that these 14 individuals were likely transiting through the study area and 2) We did not document any additional unique whales in the fall (*e.g.*, after August 31), even though the number of fall surveys that we opportunistically conducted ($n = 7$) was typical compared to recent years (2010-2015 range = 6-9) and we usually document additional unique whales in the fall (2010-2015 range = 3-14).

Nine whales (May, $n = 4$; June 1 - August 31, $n = 5$) were considered 'new' because we had not sighted them previously in the study area. All appeared to be adults based on their body size and most ($n = 7$) were sighted in Icy Strait. Three of the whales that were new to the study area had been documented previously in SEAK but six had no prior recorded sightings. Interestingly, two whales new to the study area (#2219 and #2425) that were documented together in Icy Strait on May 16 were also documented together in a large shoal during their previous sighting on November 15, 2009 in Seymour Canal (National Marine Fisheries Service, unpublished data).

Correcting our counts for effort reveals an increasing abundance of whales in 2016 compared to 2015 in Glacier Bay, Icy Strait, and the study area as a whole (Fig. 3, Fig. 4, Fig. 5). After a marked decline in abundance in 2014, which ended a pattern of long-term growth in the GB-IS whale population over the past 30 years, the number of whales in the study area appears to be rebounding.

Table 1. Annual number of survey hours and effort hours in Glacier Bay, Icy Strait, and the combined area, June 1 - August 31, 1985-2016. The dashed line highlights a change in the way survey effort was calculated beginning in 2005 (see Neilson and Gabriele 2007). Survey hours are not available for 1986 or 1987. For 2005-2016, survey hours are only available for the combined area (Glacier Bay-Icy Strait). Effort hours are not available prior to 2005.

Year	No. survey hours			No. effort hours		
	GB	IS	GB-IS	GB	IS	GB-IS
1985	234	92	326	-	-	-
1986	-	-	-	-	-	-
1987	-	-	-	-	-	-
1988	199	108	307	-	-	-
1989	231	123	354	-	-	-
1990	215	115	330	-	-	-
1991	256	100	356	-	-	-
1992	248	71	319	-	-	-
1993	192	62	254	-	-	-
1994	169	92	261	-	-	-
1995	167	90	258	-	-	-
1996	259	116	374	-	-	-
1997	327	90	417	-	-	-
1998	344	64	408	-	-	-
1999	318	64	382	-	-	-
2000	321	84	405	-	-	-
2001	236	76	312	-	-	-
2002	297	68	365	-	-	-
2003	283	101	384	-	-	-
2004	373	74	447	-	-	-
2005	-	-	357	216	56	272
2006	-	-	356	197	85	282
2007	-	-	393	206	117	323
2008	-	-	367	187	117	304
2009	-	-	357	179	107	286
2010	-	-	364	194	99	293
2011	-	-	379	189	110	299
2012	-	-	343	144	129	273
2013	-	-	401	208	102	309
2014	-	-	352	177	110	287
2015	-	-	332	188	63	251
2016	-	-	308	157	76	233
2005-2015 average:				189.5	99.5	289.0

Table 2. Monthly and annual number of survey days in Glacier Bay and Icy Strait, 1985-2016. The dedicated annual monitoring period (June 1 - August 31) is shaded. The dashed line highlights a change in the way survey effort was calculated beginning in 2005 (see Neilson and Gabriele 2007).

Year	May		June		July		August		September		Jun 1 – Aug 31	
	GB	IS	GB	IS	GB	IS	GB	IS	GB	IS	GB	IS
1985	0	0	10	7	11	4	10	3	0	1	31	14
1986	0	0	13	5	17	3	6	6	0	2	36	14
1987	3	2	12	5	12	7	5	7	1	2	29	19
1988	0	0	11	5	12	7	12	5	7	3	35	17
1989	3	1	17	6	14	6	16	7	1	4	47	19
1990	6	4	16	5	18	6	14	8	0	0	48	19
1991	7	3	14	7	17	6	13	4	6	3	44	17
1992	3	2	19	4	17	5	12	4	7	1	48	13
1993	2	1	10	3	13	3	7	5	1	1	30	11
1994	1	0	9	5	10	4	13	8	1	1	32	17
1995	3	2	10	4	11	4	10	7	2	2	31	15
1996	4	2	11	5	17	10	16	3	3	1	44	18
1997	5	2	17	4	21	7	19	6	9	4	57	17
1998	10	4	20	3	23	6	12	4	5	2	55	13
1999	4	1	16	4	18	6	18	3	5	1	52	13
2000	1	0	21	8	21	5	23	6	5	1	65	19
2001	3	1	17	6	14	5	20	5	6	2	51	16
2002	3	1	19	6	19	4	18	2	4	2	56	12
2003	5	0	20	7	19	5	16	5	3	1	55	17
2004	6	2	21	3	19	5	21	5	8	2	61	13
2005	1	0	16	5	17	3	12	3	4	3	45	11
2006	2	2	14	6	15	7	16	7	5	1	45	20
2007	4	2	15	10	14	7	14	6	5	2	43	23
2008	4	1	16	10	14	8	12	9	3	1	42	27
2009	6	5	12	10	16	9	10	5	5	4	38	24
2010	5	3	14	9	11	11	17	8	3	5	42	28
2011	3	1	13	10	14	6	13	7	5	3	40	23
2012	5	2	11	8	12	9	12	10	4	2	35	27
2013	7	4	13	7	16	12	19	7	5	1	48	26
2014	5	6	11	9	14	8	15	4	4	1	40	21
2015	5	2	16	4	15	6	14	5	5	1	45	15
2016	5	2	11	5	13	6	11	5	5	3	35	16
2005-2015 average:			13.7	8.0	14.4	7.8	14.0	6.5				

Table 3. Annual whale counts not corrected for effort (June 1 - August 31), 1985-2016.

Year	Glacier Bay	Icy Strait	Glacier Bay & Icy Strait
1985	15	30	41
1986	32	29	46
1987	30	48	60
1988	41	36	54
1989	26	28	41
1990	25	33	49
1991	19	42	53
1992	34	51	66
1993	30	30	50
1994	29	42	60
1995	28	44	57
1996	44	60	78
1997	55	50	82
1998	63	50	92
1999	63	65	106
2000	59	58	90
2001	45	85	100
2002	44	61	85
2003	83	77	117
2004	112	64	139
2005	102	90	146
2006	84	123	152
2007	91	129	161
2008	86	139	160
2009	108	162	182
2010	131	145	193
2011	152	157	222
2012	125	177	209
2013	161	205	240
2014	99	125	175
2015	125	76	166
2016	116	100	164

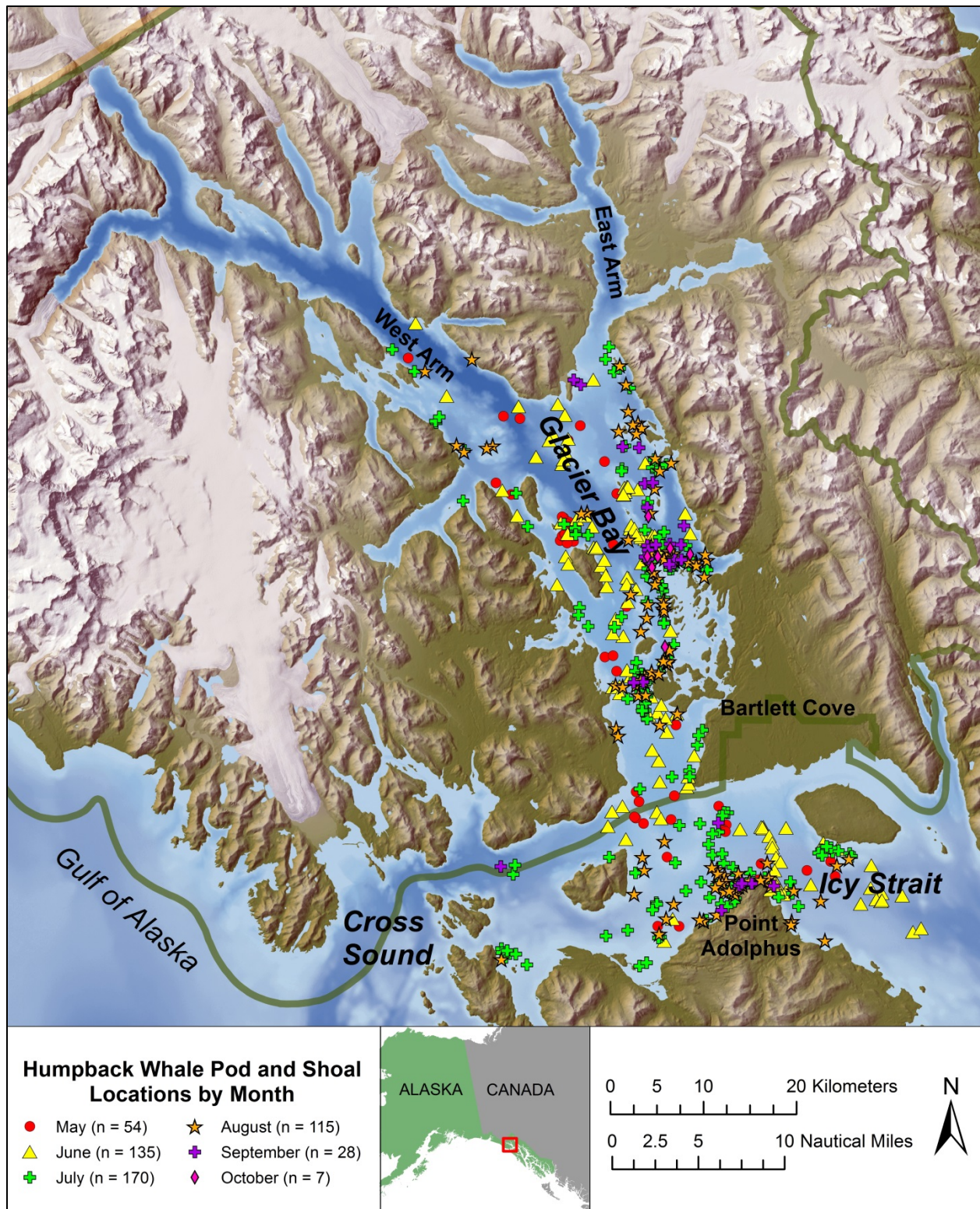


Figure 2. Study area in Glacier Bay and Icy Strait showing distribution of humpback whale pods and shoals in 2016. Each symbol represents a pod or shoal containing one or more whales.

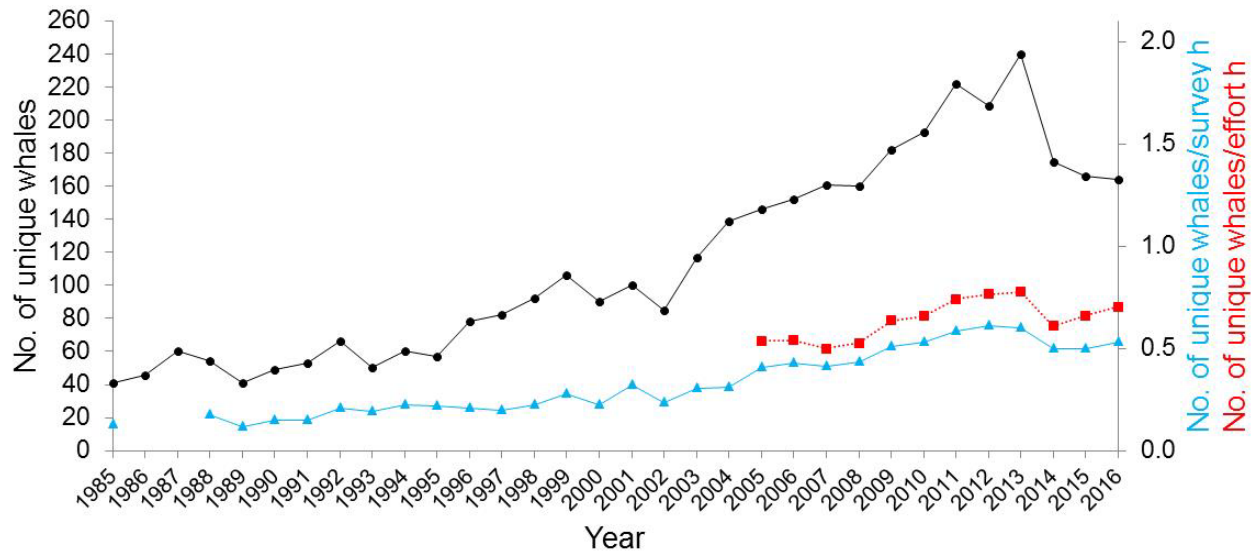


Figure 3. Annual whale counts (black), whales/survey h (blue), and whales/effort h (red) in Glacier Bay and Icy Strait from June 1 - August 31, 1985-2016. Whales/survey h is not available for 1986-1987. Whales/effort h is not available for 1985-2004 because in these years we only recorded survey hours (see Neilson and Gabriele 2007).

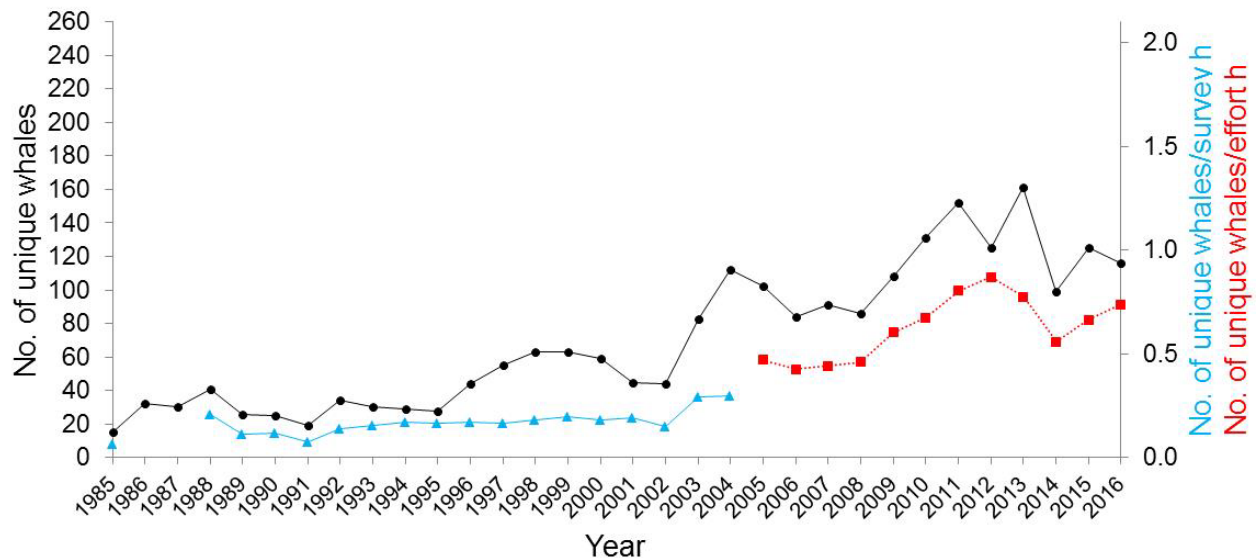


Figure 4. Annual whale counts (black), whales/survey h (blue), and whales/effort h (red) in Glacier Bay from June 1 - August 31, 1985-2016. Whales/survey h is not available for 1986-1987. Whales/effort h is not available for 1985-2004 because in these years we only recorded survey hours (see Neilson and Gabriele 2007).

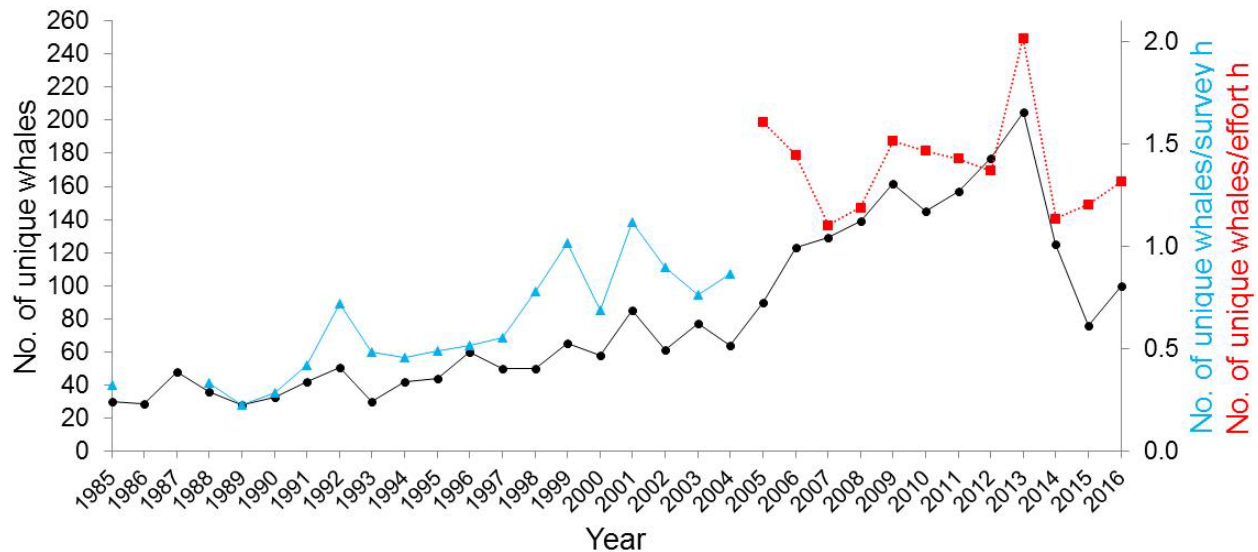


Figure 5. Annual whale counts (black), whales/survey h (blue), and whales/effort h (red) in Icy Strait from June 1 - August 31, 1985-2016. Whales/survey h is not available for 1986-1987. Whales/effort h is not available for 1985-2004 because in these years we only recorded survey hours (see Neilson and Gabriele 2007).

These positive trends are encouraging, yet by all metrics whale numbers in the study area remain lower than in 2011-2013, when abundance peaked at 0.78 whales/effort h in the overall study area (Fig. 3), 0.87 whales/effort h in Glacier Bay (Fig. 4), and 2.02 whales/effort h in Icy Strait (Fig. 5).

We presume that prey availability is the primary driver of whale movement in SE Alaska, thus the relatively lower number of whales in the study area in recent years (2014-2016) compared to the prior 3-5 years is likely the result of changes in prey availability (see Neilson and Gabriele 2016 for additional discussion on this topic). There is no systematic monitoring of forage fish in the study area but Alaska Department of Fish and Game surveys that monitor herring biomass at nine spawning areas in SEAK (the closest to the study area being Tenakee Inlet, approximately 75 km from the study area by water) show a period of high regional productivity from about 2005-2011, followed by a declining trend for herring in SEAK through 2015 (Hebert and Dressel 2016). Our and others' anecdotal observations of a decrease in herring in Icy Strait beginning in 2014, especially around Point Adolphus (see below, Prey Identification; Neilson *et al.* 2015; Neilson and Gabriele 2016), are consistent with declines in whales/effort h in Icy Strait in 2014-2016 compared to higher levels in 2009-2013 (Fig. 5).

Examining the diets of larger pelagic fish which prey on forage fish in the study area may offer some insights into recent forage fish trends. Between 2013 and 2016, SECM surveys in Icy Strait documented a substantial decline in the proportion of capelin comprising fish stomach contents from 31.7% in 2013 ($n = 315$ stomachs analyzed) to 0% in 2016 ($n = 45$ stomachs analyzed). During this same period, herring comprised a variable but low proportion of fish diets (0.2%-5.3%), while walleye pollock increased from 5.3%-23.7% (NOAA unpublished data). These apparent changes in forage fish availability in Icy Strait are important to a myriad of predators, including humpback

whales, because capelin are one of the highest lipid forage fishes (averaging ~18-24% lipid), while walleye pollock are a low-lipid fish (~7% lipid) (Anthony *et al.* 2000).

We suspect that at least part of the sudden decline in whale abundance that we documented in the study area in 2014 is attributable to a powerful earthquake near Glacier Bay in July that year. This seismic activity generated one or more submarine landslides that greatly increased turbidity locally in the water column, likely leading to decreased whale foraging success in lower Glacier Bay and Icy Strait (Neilson *et al.* 2015). The short- and long-term effects of these submarine landslides on forage fish abundance, distribution, and survival are unknown.

Summer 2014 was also the first year that unusually high sea surface temperatures occurred in the northeastern Pacific Ocean (a phenomenon nicknamed “The Blob”). This warm water anomaly, which persisted through summer 2016 (Miller 2016a), combined with a strong El Niño in 2015, generated the largest marine heatwave ever recorded (Di Lorenzo and Mantua 2016). The effects of this unprecedented oceanographic phenomenon on humpback whales and their prey in the northeastern Pacific are unknown, but unusually warm waters were implicated in a wide variety of cascading effects on the marine ecosystem (Bond *et al.* 2015; Miller 2016b; Rosen 2017) and it seems likely that some of the changes we have documented in recent years are related to large-scale changes in ocean temperature.

Preliminary analysis of oceanographic data collected by the NPS in Glacier Bay (20 stations) and Icy Strait (two stations) indicates that on average, waters were significantly warmer (up to ~1.5 deg C above average) and less saline in 2015-2016 compared to 2011-2014 (NPS unpublished data). As we have previously noted (Neilson and Gabriele 2016), Glacier Bay’s surface waters are affected by the cooling and freshening influence of meltwater from warming tidewater glaciers, which may buffer Glacier Bay from regional ocean warming trends (S. Danielson, pers. comm.), however the observed changes in temperature and salinity in 2015-16 occurred throughout the water column. Anomalously warm waters (~0.5 deg C above average compared to 1997-2015) were also detected by the SECM project during summer 2015 along their Icy Strait transect (Fergusson and Orsi 2016). The effects of these changes in temperature and salinity (as well as other oceanographic factors, such as stratification) on humpback whale prey abundance and distribution in the study are unknown. However, the above-average water temperatures in Icy Strait in summer 2015 coincided with anomalously low zooplankton densities (with the exception of gastropods) (Fergusson and Orsi 2016), indicating that forage fish in the area may have been food-limited in 2015.

The long-term, consistent monitoring of humpback whales in GB-IS is unique within Alaska, making it difficult to determine over what geographic scale the recent changes we have observed may have occurred. However there is evidence that humpback whale abundance and distribution may have been similarly atypical on a regional scale in recent years. Cetacean surveys conducted in offshore areas of the central and western Gulf of Alaska in 2015 documented significantly fewer humpback whales in 2015 compared to 2013 (Rone *et al.* 2017) and researchers from NOAA’s Marine Mammal Laboratory who have conducted long-term cetacean surveys in SEAK (*e.g.*, Dahlheim *et al.* 2009) reported relatively low numbers of cetaceans in the inland waters of SEAK in 2015 and 2016 compared to previous years [including humpback whales, killer whales (*Orcinus orca*), and Dall’s

porpoise (*Phocoenoides dalli*) (M. Dahlheim, pers. comm.). In addition, during the winter of 2015/2016, researchers in Hawaii and Mexico reported anomalously low numbers of humpback whales (including calves) on the breeding grounds, with many whales arriving late and leaving early (Loomis 2016).

In July and August 2016, cruise ship bridge teams reported relatively high numbers of humpback whales in upper Clarence Strait, however it appeared that whale numbers may have been below average southeast of Admiralty Island, where very high numbers of whales have historically congregated at this time of summer (NOAA unpublished data). Beginning in late August and early September, above-average numbers of whales gathered to feed on herring in Sitka Sound (J. Straley, pers. comm.). In November and December 2016, a time of year when humpback whales have historically gathered in very high numbers in Seymour Canal to feed on krill (*e.g.*, >130 individuals in 2015; D. Rogers, pers. comm.), deer hunters in the area reported seeing few to no whales or krill. In Sitka, whale numbers dropped over the winter but in early February 2017 (the peak of the breeding season when we would expect most humpback whales to be in Hawaii or Mexico), unusually high numbers of whales (40-60) were present in Sitka Sound. Notably, many appeared to be in poor body condition (abnormally thin, infested with external parasites (*Cyamus* sp.), etc.) (University of Alaska Southeast, unpublished data.). It is unknown whether these humpback whales over-wintered in Alaska. Alternatively, they may have migrated but returned early from the breeding grounds or delayed their migration south and not yet departed. In the North Atlantic, humpback whales were found to shift their migratory timing to and from a feeding ground in an apparent response to rising sea surface temperatures, however these changes took place gradually over three decades (Ramp *et al.* 2015) and we have not attempted an analogous study to quantify potential shifts in the phenology of humpback whales in SEAK.

Site Fidelity

Within-year residence times and year-to-year return to the study area are valuable reflections of habitat use. The historically high rate of within-season residency in the study area highlights the importance of the Glacier Bay-Icy Strait region as a summer feeding ground for many humpback whales. At a finer scale, monitoring results over many years have shown that while some whales are exclusive residents to either Glacier Bay or Icy Strait, many whales move frequently between the two areas, demonstrating that the Glacier Bay-Icy Strait ecosystem functions as a single contiguous habitat (*e.g.*, Neilson *et al.* 2012). In 2016, 91 of the 164 whales (55%) that we documented in the study area between June 1 and August 31 were resighted 20 or more days apart, meeting our definition of resident. This proportion is lower than average historic values (1985-2015 mean = 62%, SD = 8%) but higher than in 2014, when the residency rate dropped to 49% (Neilson *et al.* 2015).

In contrast to residents, 43 (26%) of the whales that we documented between June 1 and August 31 were transitory; *i.e.*, identified on just one day (14 in Glacier Bay and 29 in Icy Strait). The proportion of transitory whales varies widely each year (1985-2015 range = 17%-42%, mean = 26%, SD = 7%). In 2016, the majority of these whales (70%, *n* = 30) were documented in the first half of the season (*i.e.*, on or before July 15) and over one-third (35%) were sighted in either the middle of

Icy Strait ($n = 9$) or near Pleasant Island ($n = 6$); otherwise, the sightings occurred over a broad range of locations.

We examined between-year site fidelity using our newly created criteria for ‘regularly sighted’ whales. Seventy-four whales met these criteria (Appendix A). Six of these whales (four males and two females) exhibited strong long-term site fidelity to GB-IS with sightings in the study area every year from 1985 through 2016. Eight additional whales (six males, two females) were sighted in GB-IS in 30-31 years out of the 32-year study period. Out of 11 whales documented in GB-IS every year from 1985-2014 (Gabriele *et al.* 2017), four were not sighted in northern SEAK in 2015 and/or 2016 and one whale (#516) was missing from GB-IS in 2016 but seen elsewhere in SEAK (K. Barlow, pers. comm.), ending a long-term pattern of unbroken annual sightings for these five whales in the study area. The lack of sightings of some whales in earlier years may indicate that they were born around the time of their first sighting.

From 2002-2013, the annual fidelity index for the GB-IS study area was consistently high (range = 86.5%-98.6%, mean = 94.0%, SD = 3.4%) (Fig. 6). These values may be positively biased because the timespan includes two years of above-average survey effort levels throughout northern SEAK in 2004-2005 during the Structure of Populations, Levels of Abundance and Status of Humpbacks (SPLASH) study (Barlow *et al.* 2011). However beginning in 2014, numerous whales with a long-term history of site fidelity to the study area appeared to be missing, initiating a declining pattern in the annual fidelity index in 2014 (79.7%), 2015 (76.7%), and 2016 (64.4%) (Fig. 6).

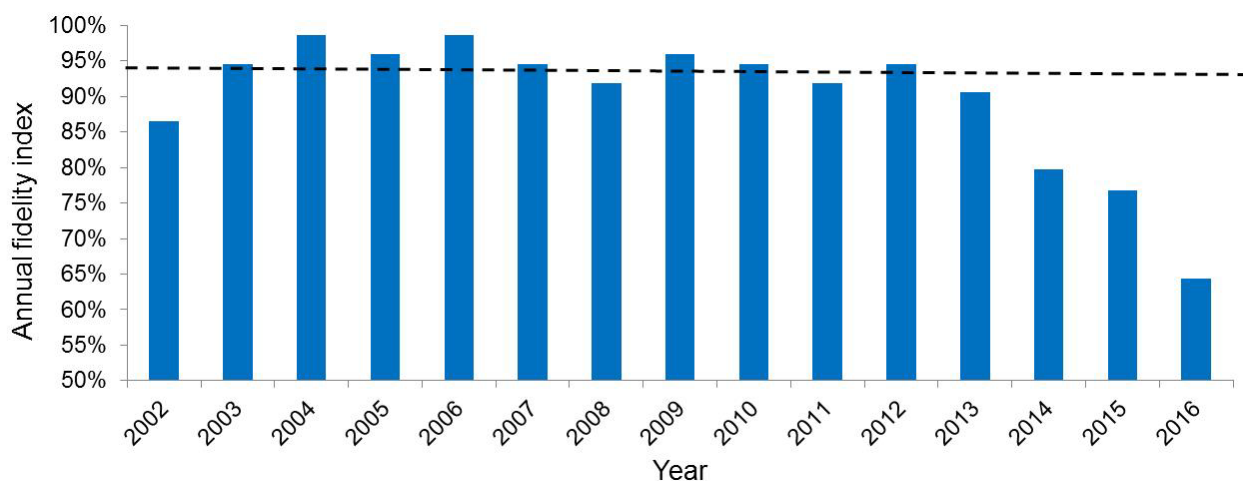


Figure 6. Annual fidelity index for the Glacier Bay-Icy Strait study area, 2002-2016. The dashed line indicates the mean annual fidelity index from 2002-2013 (94.0%).

In 2016, over one-third (35.6%, $n = 26$) of the regularly sighted whales from GB-IS ($n = 73$) appeared to be missing (Fig. 6, Appendix A). Four individuals were documented in other areas in northern SEAK (Appendix A), however the whereabouts and/or fate of the remaining 22 whales is unknown. While the recent absences of some whales could indicate natural mortality related to old age that may have accelerated due to challenging ecological conditions, the regularly sighted whales

represent a broad age range including relatively young whales (with some as young as 24 years old - e.g., whale #1295, whale #1304). At least two regularly sighted whales, 27-year-old female #1014 and adult male #441 (the latter based on necropsy in June; see below, Dead Whales), were abnormally thin in 2016 with a heavy infestation of external parasites (*Cyamus* sp.). Whale #1014 was sighted intermittently throughout the summer in GB-IS but appeared to be in very poor health and her fate is unknown (Fig. 7) (NPS unpublished data; J. Francis, T. Sebens, and C. Sergeant, pers. comm.). We presume that some of the regularly sighted whales' absences in recent years represent a shift in feeding away from GB-IS (and other areas with sporadic photo-ID coverage) as opposed to mortality, although their fates remain unknown, contingent on future sightings.



Figure 7. 27-year-old female whale #1014 appearing abnormally thin with a heavy infestation of external parasites (*Cyamus* sp.), likely indicating an extended period of poor health and/or injury (Osmond and Kaufman 1998; Pettis *et al.* 2004). The propeller scar on her right flank is not thought to be related to her current condition, as it was first documented in 2002. Photo courtesy of T. Sebens.

Available records indicate that the number of dead humpback whales found in SEAK in recent years has not been unusually high, however there is an ongoing large whale Unusual Mortality Event (May 2015 – present) in the Gulf of Alaska that includes humpback whales (see below, Dead Whales; NOAA unpublished data). It is notable that at the start of the winter 2016/2017 breeding season, a record high number of dead humpback whales ($n = 6$, including several adult-sized whales) were reported around Hawaii (D. Schofield, pers. comm.). All of the carcasses were in a state of decomposition that precluded individually identifying the animals or determining their cause(s) of death (NOAA Pacific Islands Region unpublished data). The number of adult whales that die during the whales' annual migration between Hawaii/Mexico and SEAK is unknown, but historically, adult survival rates for SEAK humpback whales have been high (1979-1996 = 0.957, 95% CI: 0.943-0.995; Mizroch *et al.* 2004).

Reproduction and Juvenile Survival

We identified only one mother/calf pair in 2016, which led to the lowest crude birth rate (0.6%) since monitoring began in 1985 (Fig. 8). Preliminary analysis from SPLISH reveals that in August 2016, calf numbers were also low in other areas of northern SEAK, with only nine calves identified out of over 500 whales observed (Moran *et al.* 2017). The lone mother in our study area (whale #895) is a whale that we had not documented in Glacier Bay or Icy Strait since 1999. We observed #895 and her calf on only one day (May 24) near Willoughby Island in Glacier Bay. Both whales appeared to be abnormally thin, especially #895 who has also had a very bumpy skin condition of unknown origin since at least 1999.

We received very few reports from other observers of calves in the study area in 2016. Humpback whale researchers based at a field camp on Strawberry Island from June 22 through August 9 reported seeing one mother/calf pair on June 22 and a possible mother/calf pair on July 17 (M. Fournet and D. Culp, pers. comm.). We also received anecdotal reports of possible mother/calf pairs on March 13 (Hugh Miller Inlet), May 11 (near Gloomy Knob), May 26 (near Hugh Miller Rocks), and June 30 (near Garforth Island) (T. Bruno, K. Lee and B. Weitzman, pers. comm.) but we were unable to confirm these reports or to determine if they were whale #895 and her calf or another pair.

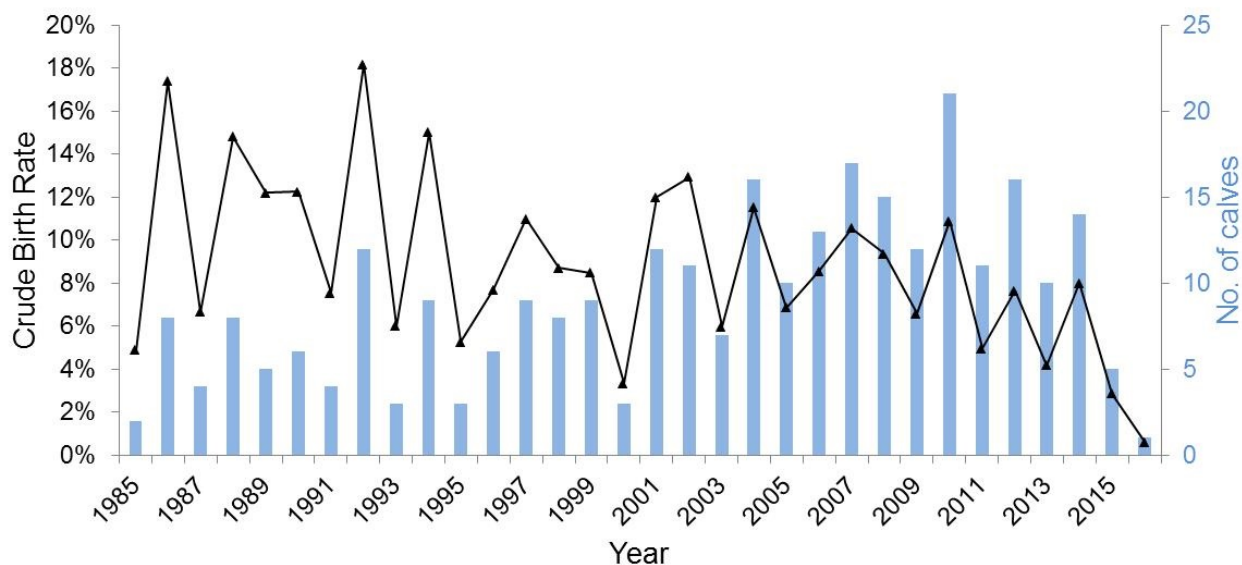


Figure 8. Crude birth rate (black line) and annual number of calves (blue bars) in Glacier Bay from 1985-2016.

We did not document any one or two-year-old whales in 2016. Out of 29 calves that we documented in the study area from 2013-2015, only two individuals (7%) are known to have survived to be juveniles in the GB-IS population (both were calves from 2013). While the mean age at which calves return to the study area is 3.2 years (Gabriele *et al.* 2017) and juvenile whales can be difficult to track and photo-identify based on their small size and often erratic behavior, it is notable that before 2016, the last time we documented no one- or two-year-old whales in the study area was 2003 (Fig. 9).

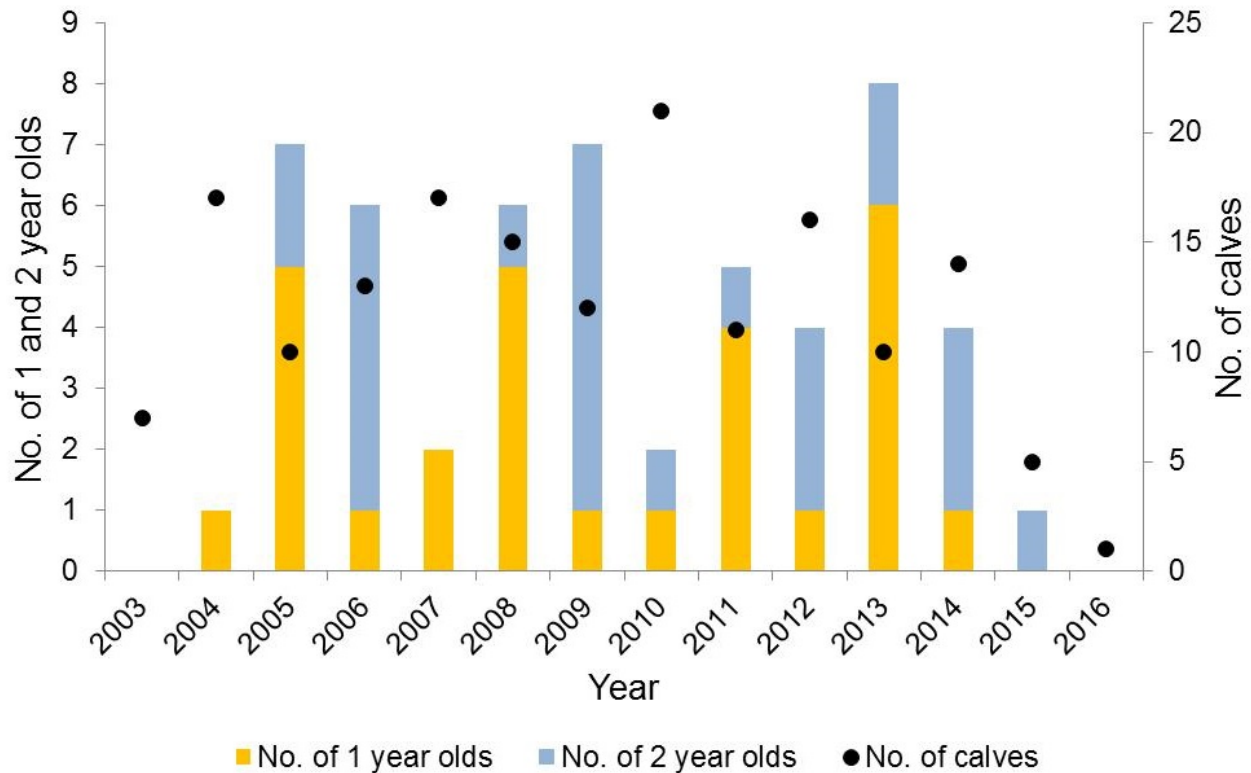


Figure 9. Number of calves, one- and two-year-old whales documented annually in Glacier Bay-Icy Strait, 2003-2016.

To summarize, there is mounting evidence that calving and juvenile return rates in Glacier Bay-Icy Strait have declined substantially in recent years. In 2014, an unprecedented number of calves ($n = 5$) went missing between early August and late October (Neilson *et al.* 2015). We have resighted none of the remaining nine calves from 2014 in subsequent years. In 2015, we documented relatively few calves ($n = 5$) and we resighted none in 2016. In 2016, we documented only one mother/calf pair and both appeared to be abnormally thin. Whether or not calving and juvenile return rates have declined in other areas in SEAK and/or the entire Hawaii DPS is unknown.

We hypothesize that these changes in calving and juvenile return rates may be related to recent changes in prey availability and/or quality (possibly linked to recent oceanographic changes such as “The Blob”, see above), which may in turn be negatively affecting whale body condition and therefore female reproductive success and/or overall juvenile survival (see below, Feeding Behavior and Prey Identification) (Bradford *et al.* 2012; Fuentes *et al.* 2016; Seyboth *et al.* 2016). Recruitment from local populations (vs. immigration from outside populations) is a key driver of population growth over the past 30 years in the study area (Pierszalowski *et al.* 2016), therefore sustained declines in calving and/or recruitment will have long-term effects in the GB-IS whale population.

Tissue Samples

In 2016 we collected 12 sloughed skin samples, all from unique whales. Since 1996, we have collected 326 sloughed skin samples in the study area. Genetic analysis of these samples allows sex

determination, definition of mitochondrial DNA haplotype, and nuclear DNA genotyping and these results have contributed to several humpback whale genetic studies (*e.g.*, Baker *et al.* 2013, Pierszalowski *et al.* 2016).

Feeding Behavior and Prey Identification

Many of the whales that we observed in 2016 (23 out of 178 unique individuals = 13%) appeared to be abnormally thin, including the sole calf that we documented. We presume this was caused by a lack of food but it could also indicate illness or disease. Each year we typically observe a few “skinny” whales, especially in the spring when whales return from fasting during their annual migration to the breeding grounds. However, 2016 was unusual because: 1) Although we do not systematically assess body condition, our impression was that we encountered more skinny whales in 2016 compared to past years and 2) We continued to document new thin individuals throughout the summer, even as late as August 19 (April, n = 1; May, n = 5; June, n = 10; July n = 5; August, n = 2). In addition, an adult male humpback whale found dead in Icy Strait on June 26 and an adult female humpback whale found dead near Sitka on July 4 appeared to be emaciated (see below, Dead Whales). Preliminary analysis of SPLISH data revealed that many skinny whales were also observed in other areas in northern SEAK in the first half of August (Moran *et al.* 2017).

On August 16, we observed 12-year-old whale #1836 feeding very close to shore just outside Bartlett Cove and a photograph of a fish near the whale’s head was positively identified as sand lance (M. Arimitsu, pers. comm.). The whale’s feeding behavior was unusual because it involved repeated tight turns and twisting at the surface, followed by the whale pumping its flukes rapidly up and down, lifting its head slightly, and then engulfing prey just below the surface (Fig. 10).

In 2016, this was our only confirmed detection of sand lance near feeding whales, however it is possible that some of the unidentified forage fish that we observed near feeding whales were sand lance. On July 18, we received a report from a local charter vessel captain who had been observing sand lance around Flapjack Island, both on his vessel’s sonar and in the stomachs of harvested fish (J. Kearns, pers. comm.). In addition, on August 10, we observed numerous seabirds feeding on forage fish in Sitakaday Narrows and a photograph of several fish being carried by a gull was positively identified as young-of-the-year sand lance (M. Arimitsu, pers. comm.), however there were no humpback whales nearby.

In 2016, we opportunistically detected capelin near feeding humpback whales less often than in past years, especially in Glacier Bay. The only confirmed detections of capelin in 2016 were two samples that we collected with a dip net near whales feeding in the middle of Icy Strait on July 20 and August 1. On August 5 we observed a school of fish that resembled capelin in size and color near a whale feeding at the mouth of the West Arm but we were unable to confirm the species.



Figure 10. Whale #1836 feeding on sand lance on August 16, 2016. The whale turned and twisted at the surface (top), then pumped its flukes rapidly while lifting its head slightly and engulfing the fish near the surface (bottom).

Capelin have a distinctive cucumber-like smell (Johnson *et al.* 2015) that in the past we have frequently detected near feeding whales (*e.g.*, 2015, $n = 9$), however in 2016 there were only two occasions when we noted a cucumber smell in the air. One instance occurred on July 15 between Bartlett Cove and Point Gustavus when we observed seabirds feeding on a school of forage fish that looked and smelled like capelin. No whales were nearby but this observation is notable because it was our only olfactory detection of capelin in Glacier Bay in 2016. A second instance, in Icy Strait, was near a feeding whale at Point Adolphus on July 29 when we saw and smelled a school of forage fish near the surface that appeared to be capelin.

We detected herring twice in Icy Strait and possibly up to four times in Glacier Bay in 2016. In Icy Strait, both detections (mature herring on July 6 and young-of-the-year herring scales on August 11) were near whales feeding at the mouth of Idaho Inlet (M. Arimitsu, pers. comm.). In Glacier Bay, we observed the same whale (four-year-old whale #2602) on two separate occasions (July 14 and August 2) feeding on forage fish near Garforth Island. In both cases, the fish appeared similar and a photograph from the August encounter was identified as possibly young-of-the-year herring (M. Arimitsu, pers. comm.). On July 21, we photographed a gull carrying a fish that was positively identified as a herring (M. Arimitsu, pers. comm.) in Bartlett Cove, although there were no whales

nearby. In addition, on September 2 we photographed a seabird eating a forage fish near a feeding whale at Flapjack Island that appeared to be either a herring or a juvenile salmon (M. Arimitsu, pers. comm.). In 2015, we detected herring near feeding whales in Glacier Bay for the first time (Neilson *et al.* 2016) so these additional observations from 2016 are notable because they may indicate that herring are becoming more common in Glacier Bay. While previous studies have documented herring in Glacier Bay, they were in relatively lower overall abundance than other forage fish such as capelin, walleye pollock, and sand lance (Arimitsu *et al.* 2007; Renner 2012).

Until 2014, it was not uncommon for us to document herring near whales feeding around Point Adolphus but in recent years these observations have become rare. In 2015 we had only one possible observation of herring at Point Adolphus (based on a sonar image near a group of feeding whales) and in 2016 we observed no herring in this area. A local charter vessel operator who frequents Point Adolphus noted that he saw no herring there in 2016. In addition, he reported that in past summers he regularly saw 20-50 bald eagles (*Haliaeetus leucocephalus*) congregate at Point Adolphus (presumably feeding on herring), but in 2016 he observed very few eagles (K. Thompson, pers. comm.). From 1985-2012, Point Adolphus was a consistent hot spot for high numbers of humpback whales, including a large, stable ‘core group’ that appeared to target herring as their primary prey. However 2016 was the fourth year in a row that we have documented relatively low numbers of whales around Point Adolphus. To our knowledge, 2013 was the first year since monitoring began in 1985 that the ‘core group’ did not form, although we documented many of the whales commonly associated with the group scattered around the study area (Neilson *et al.* 2014). In 2014 and 2015, we documented a relatively small version of the core group, containing fewer than 10 individuals (Neilson *et al.* 2015; Neilson and Gabriele 2016). In 2016, similar to 2013, it appeared that the core group never formed, however this time, many of the whales typically associated with the group were not documented elsewhere in the study area (nor elsewhere in northern SEAK; NOAA, University of Alaska Southeast, and Alaska Whale Foundation, unpublished data).

On five occasions, we observed forage fish near feeding whales that we were unable to identify. In one case, forage fish several inches long were boiling at the surface near a feeding whale at Flapjack Island but when we attempted to dipnet a sample, we only caught several mysids that were swarming in the same location.

In late May, when whale activity increased in the middle of Glacier Bay, a local charter vessel captain reported many “clouds” of feed visible on his vessel’s sonar at approximately 30 m (100 ft) depth between Willoughby and Boulder Islands. When he caught a northern ronquil (*Ronquilus jordani*) at this location, it was “spitting up lots of krill”. He observed approximately 10 humpback whales in the area and reported lots of underwater whale vocalizations when he listened with an onboard hydrophone (J. Kearns, pers. comm.). This report was notable because in general, humpback whales in the study area appear to feed primarily on forage fish, although euphausiids (krill) are important prey in other parts of SEAK (Krieger and Wing 1986; NPS unpublished data).

On June 14, the same captain observed a humpback whale feeding near Strawberry Island and found several dead forage fish floating at the surface in the same general area that were positively identified as juvenile walleye pollock (J. Kearns and C. Murdoch, pers. comm.). On August 23, we observed

many gulls feeding in a tiderip outside Beardslee Entrance on fish that were identified as young-of-the-year gadids (likely walleye pollock) (M. Arimitsu, pers. comm.).

A local charter fishing vessel captain reported that juvenile walleye pollock and small squid [and to a lesser degree, northern lampfish (*Stenobrachius leucopsarus*)] dominated halibut stomach contents in Icy Strait during summer 2016 (M. Halbert, pers. comm.). Young of the year walleye pollock, one of the most abundant components of the Glacier Bay forage fish community (Arimitsu *et al.* 2016), also dominated forage fish catches in other nearshore areas of coastal Alaska during summer 2016 (Arimitsu *et al.* 2017; M. Arimitsu, pers. comm.).

In our experience, sand lance and walleye pollock are more difficult to detect visually than either herring or capelin. The latter two species are relatively large, seem to have a greater tendency to boil at the sea surface in very tight schools, and (in the case of capelin) have a distinctive smell that aids in detection.

While our whale prey observations are opportunistic and may be biased towards easier to detect species (*e.g.*, capelin, herring), in a long-term study of three puffin species, Sydeman *et al.* (2017) concluded that long-term studies of predator food habits are useful for elucidating changes in the spatial and temporal availability of prey species in marine ecosystems. Although long-term oceanographic data lend explanatory power to our observations, a dedicated long-term forage fish monitoring program in Glacier Bay and Icy Strait is needed to more fully understand and interpret observed changes in the abundance, distribution, and health of humpback whales and other marine predators over time in the study area.

Whale/Human Interactions

On August 12 we documented a raw injury on whale #2534's back (Fig. 11) that was not there during our previous encounter on July 12, 2016. This whale (age and sex unknown) was first documented in 2012 and frequents Icy Strait. The origin of the wound is unknown but it appears to be anthropogenic such as from a vessel collision or possibly an entanglement in line.

Whale Waters

In late May, high numbers of whales were present in the lower West Arm, prompting temporary whale waters in this area for five days, but by early June this activity had subsided. Around the same time, we documented a growing concentration of whales in the middle of Glacier Bay, where temporary whale waters were designated from June 2-28. Whale activity next shifted to lower Glacier Bay (primarily around Beardslee Entrance), where a 13-knot vessel speed limit was implemented for 55 days (June 29-August 22). In recent years longer duration whale waters in lower



Figure 11. Whale #2534 with a raw injury across its back on August 12, 2016.

Glacier Bay have been typical (2007-2015 range = 75-143 days, mean = 113 days) but in 2016 the relatively late onset of whale activity, coupled with a tapering off of whale use of the area by mid to late August, led to a shorter duration whale waters period.

Vessel Collisions

No humpback whale-vessel collisions were reported in the study area in 2016. However, there were several near misses in Glacier Bay in which one or more whales surfaced within 300 m of the bow of transiting cruise ships (NPS unpublished data). In nearly all cases in Glacier Bay to date, the identity of the whale(s) involved in near misses is unknown. However, on August 12 a fluke photograph from a cruise ship passenger revealed that nine-year-old male whale #2029 dove approximately 100 m ahead of the ship as it transited at 16 knots in the lower West Arm. We did not resight this whale after August 12, however we presume that the whale successfully evaded the ship based on the report from the onboard NPS marine mammal observer (NPS unpublished data).

Elsewhere in SEAK, no humpback whale-vessel collisions were reported in 2016. However, a subadult female found dead in Stephens Passage on May 23 and an adult male (estimated to be 62 years old based on earplug growth layer groups) found dead in Sitka Sound on September 11 were suspected to have died from vessel collisions based on their injuries (NOAA Alaska Region unpublished data) (see below, Dead Whales). In July, two whale-vessel collisions were reported in Resurrection Bay, but otherwise no collisions with live whales were reported in Alaska in 2016 (NOAA Alaska Region unpublished data). One of these incidents involved a whale that struck and significantly damaged a drifting 6.8 m (22 ft) private vessel in Resurrection Bay (NOAA Alaska Region unpublished data). The overall lack of collision reports from vessel operators in 2016 was unexpectedly low (*e.g.*, for comparison, six collisions with humpback whales were reported by vessel operators in Alaska in 2014 and five were reported in 2015; NOAA Alaska Region unpublished data) and is inconsistent with past findings of a significant increase in collision reports over time (1978-2011) in Alaska (Neilson *et al.* 2012).

Dead Whales

On June 26, a charter vessel operator reported a dead humpback whale floating in park waters west of Point Carolus in Icy Strait (P. Johnson, pers. comm.). Park staff located the carcass and towed it to

a nearby beach for examination (Fig. 12). Based on a post-mortem fluke identification photograph, we identified the whale as #441 (nicknamed “Festus”), an adult male first documented in 1972 in Lynn Canal by Charles Jurasz (SeaSearch, unpublished data). This whale was satellite-tagged in February 1999 in Hawaii and subsequently had an area of chronic inflammation near the tag site, that was first visibly noted during photo-ID surveys in 2000 (Gabriele and Hart 2000). On June 28, veterinary pathologist Stephen Raverty worked with GBNPP staff and local volunteers to conduct a detailed necropsy to determine the age and cause of death of the whale. The last documented live sighting of whale #441 was in June 2015 in Glacier Bay (NPS unpublished data). With a 45-year sighting history (1972-2016), this individual has the longest sighting history yet recorded for a humpback whale in the world.



Figure 12. NPS vessels tow whale #441's carcass to shore west of Point Carolus on June 26, 2016. Response authorized under NOAA Marine Mammal Health and Stranding permit #18786.

Based on counts of the growth layer groups in the whale's earplug collected during the necropsy, #441 is estimated to have been 66 years old (C. Lockyer and NPS unpublished data). Humpback whale earplug age estimates from twentieth-century commercial whaling indicate that most humpback whale lifespans were shorter than this (Gabriele *et al.* 2010) although whale #539, who was killed by ship strike in summer 2014, is estimated to have been at least 70 years old at the time of her death (Gabriele *et al.* 2017). Overall, #441 appeared to be in poor physical condition, with diminished fat stores in the blubber (*i.e.*, abnormally thin) and a heavy infestation of external parasites (“whale lice”, *Cyamus* sp.). Cyamids are common on humpback whale skin, but elevated numbers are often associated with extended periods of poor health and/or injury (Osmond and Kaufman 1998; Pettis *et al.* 2004). Lymph nodes at the back of the throat were enlarged and consistent with a secondary bacterial infection that has been identified as *Edwardsiella* sp., as well as an unidentified fungal or yeast infection (K. Burek, pers. comm.). The whale's urine sample tested positive for domoic acid, an algal toxin known to be harmful to baleen whales (see below regarding the Gulf of Alaska Unusual Mortality Event), however the levels were so low that they were likely insignificant (K. Burek, pers. comm.; Lefebvre *et al.* 2016). Upon examining the remains of the

carcass in late August, more of the whale's skeleton was exposed and we noticed that many of the lumbar and caudal vertebrae were severely deformed with large bony lesions of unknown etiology that resembled osteomyelitis (infection of the bone) (Fig. 13) (K. Burek, pers. comm.). Laboratory analyses of tissue and bone samples that will help reveal the cause(s) of #441's death are still underway.



Figure 13. One of whale #441's vertebrae showing erosion of the epiphysis and large bony growths of unknown origin. Photograph taken on November 11, 2016.

On August 24, we received a second-hand report of a possible whale carcass floating near the mouth of Idaho Inlet on about August 19th. The carcass, which was sighted briefly in dense fog, was reported to have birds pecking at it but no photographs were taken and the species was not confirmed, given the circumstances (J. Gitkov, pers. comm.).

Elsewhere in SEAK, four additional dead humpbacks were reported in 2016 (NOAA Alaska Region unpublished data). Two of the carcasses bore evidence of ship strikes (see above, Vessel Collisions) but the cause of death in the other two whales is unknown. On July 4, an adult female humpback was found dead near Sitka. A necropsy revealed that she was in poor body condition (somewhat emaciated with possible muscular atrophy) and had heavy loads of internal (*Crassicauda* sp.) and external (*Cyamus* sp.) parasites, however the cause of death was undetermined. On July 30, a subadult male humpback was reported floating near Noyes Island (west of Prince of Wales Island) but no necropsy was conducted (NOAA Alaska Region unpublished data).

The Unusual Mortality Event (UME) that NOAA declared in August 2015 for large whales in the western Gulf of Alaska remained open and under investigation in 2016. During 2016, a total of at least 27 dead humpbacks were reported in Alaska (Gulf of Alaska, $n = 16$; SEAK, $n = 5$; south

central Alaska, n = 4; Bering Sea, n = 2) (NOAA Alaska Region unpublished data). Samples from several whales were collected, including samples used in testing for harmful algal bloom toxins (*e.g.*, domoic acid, saxitoxin) which may have contributed to the UME (Brashear 2016).

Entangled Whales

On May 16, an entangled whale was reported in the study area in Icy Strait traveling from Pleasant Island towards Port Frederick. The whale was reported to be trailing a light green bullet buoy and may have had line across its body (NOAA Alaska Region unpublished data). No further sightings were reported and the fate of this animal is unknown. Reports of entangled whales in the study area are rare and generally do not exceed one per year (NPS unpublished data).

Elsewhere in SEAK, 11 humpback whales were reported entangled, although some of these reports may have been re-sights of the same individuals. One case involved an adult humpback whale that became entangled in an anchor line (and possibly a Danforth anchor) on June 1 in Seymour Canal. After the entanglement was assessed to be potentially life threatening, trained responders attached a satellite telemetry tag to track the whale. In 16 days, the whale traveled at least 1250 km (675 nautical miles), circumnavigating Admiralty Island. During this time, several disentanglement attempts were made but when the whale was last sighted on June 17, the tag was accidentally removed but the whale remained entangled in line that appeared to originate from its mouth.

Elsewhere in Alaska, five more humpback whales were reported entangled, including two whales that self-released from gear and one whale that was found dead near Dutch Harbor (NOAA Alaska Region unpublished data).

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Appendix A

Annual sighting histories of individual humpback whales ‘regularly sighted’ in Glacier Bay-Icy Strait (1985-2016) are shown in Table A-1 below. Years when a whale was sighted in the GB-IS study area are indicated with an “X”. Years when a whale was not documented in the GB-IS study area are indicated with a yellow “O”. Years when a whale is known to have died are indicated with an orange “D”. Years when a whale is known to have been a calf are indicated with a “C”. All calf sightings were in GB-IS except whale #1295, who was documented as a calf in Sitka Sound (J. Straley Investigations, unpublished data).

Years when a whale was not seen in the GB-IS study area but was documented elsewhere in northern SEAK are indicated with gray cells and the area where they were sighted is represented by a two-letter code (see key below table). Unless otherwise noted, all sightings from elsewhere in northern SEAK are from the University of Alaska Southeast (UAS) Sitka and/or J. Straley Investigations (JSI). Sightings gleaned from other external sources are noted in the Comments field (AWF = Alaska Whale Foundation, UAS Juneau = University of Alaska Southeast Juneau, or photographer’s name if not associated with a research group).

Table A-1. Annual sighting histories of individual humpback whales 'regularly sighted' in Glacier Bay-Icy Strait (1985-2016). "X" = whale was sighted, "O" = whale was not documented, "D" = whale is known to have died, and "C" = calf. See key below for other codes that represent sighting locations outside Glacier Bay/Icy Strait.

ID#	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Comments
117	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
118	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
155	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
157	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
159	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
161	X	X	X	X	X	FS	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X	
166	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	O	
186	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	
193	X	X	X	X	X	FS	X	X	X	O	O	O	X	X	X	SP	X	O	X	FS	X	X	X	X	X	X	X	X	X	X	O	X	O
219	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	O	
221	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
232	X	O	O	X	O	X	O	O	O	O	O	O	O	O	O	X	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	
235	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	FS	2016 = AWF
237	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	SP	X	X	X	X	X	X	X	O	X	O	O	O	O	O	O	2001 = D. Matkin
250	O	FS	FS	O	X	O	X	O	O	O	X	X	X	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	O	X	
283	O	FS	X	X	SC	O	O	O	O	X	O	O	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X	X	X	X	X	X	
351	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
352	O	O	X	X	X	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
353	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X	X	X	X	X	X	X	O	O	O	O	O	O	
397	O	FS	FS	O	O	O	CS	X	O	SS	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X	O	
441	O	X	X	O	X	O	X	O	O	X	X	X	O	O	O	X	X	X	X	LC	X	LC	LC	O	X	O	X	X	X	X	X	D	Dead 6/26/16 in IS
465	O	O	O	O	O	O	O	O	O	X	O	O	O	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
516	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	LC	2016 = K. Barlow
535	O	X	O	X	O	X	X	X	X	FS	O	SP	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	O	
539	O	FS	X	O	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	O	D		Dead 7/1/14 in CS	
564	X	X	X	X	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	SC	X	O	X	X	O	O	O	
573	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	
577	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	O	O	O	
581	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	O	O	
584	X	X	X	X	O	X	X	X	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	O	O	O	
587	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		

ID#	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Comments
616	X	X	O	X	O	X	X	O	O	X	O	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	1996 = D. Matkin
801	X	O	X	O	O	X	X	X	X	X	X	X	X	X	X	O	X	X	X	X	X	X	X	O	X	X	X	X	X	X	X	X	
875	SC	FS	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	1996 = S. King
937	O	X	X	O	O	X	SB	X	CS	X	FS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
941	O	X	O	X	O	X	X	X	SS	X	X	X	X	X	O	O	X	X	X	X	X	X	X	X	X	O	O	X	X	O	O	O	
944	X	X	X	SS	SS	O	SB	FS	O	SS	O	X	SS	O	O	SS	X	SS	X	X	X	O	X	O	X	X	X	X	O	X	X	X	
1012	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1018	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	
1061	O	O	O	O	O	O	X	X	X	X	O	X	FS	X	X	X	X	X	X	O	X	X	X	X	O	X	X	X	O	O	LC	2016 = UAS Juneau	
1063	O	O	O	O	O	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1082	O	O	O	O	O	O	FS	O	X	X	FS	O	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1244	O	O	O	O	O	O	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1246	O	O	O	O	O	O	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	
1432	O	O	O	O	O	O	O	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1461	O	O	O	O	O	O	LI	O	O	O	O	SS	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1479	O	O	O	O	O	O	O	O	O	FS	O	SS	O	X	X	X	X	SS	X	X	X	X	X	O	X	X	X	X	X	X	X	X	
1489	O	O	O	O	O	O	O	O	O	O	O	O	O	O	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
933	C	O	FS	O	O	O	SP	O	O	FS	X	CS	X	X	X	X	X	X	X	X	X	CS	X	X	O	X	X	X	CS	O	O		
1233	C	O	O	O	O	O	FS	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1042	C	O	O	X	X	X	O	X	FS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	
1046	C	O	O	X	O	O	X	X	FS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1019	C	O	O	O	O	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1031	C	O	O	X	O	X	O	X	X	X	X	X	X	X	X	X	SS	X	X	X	X	X	X	X	X	X	O	X	X	X	O		
1014	C	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1049	C	O	O	X	O	X	O	SS	X	X	X	X	O	X	X	X	X	X	X	X	O	X	O	X	O	X	O	X	O	X	O		
1083	C	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1057	C	X	O	FS	FS	X	X	FS	X	O	X	TI	X	X	TI	X	X	X	X	X	X	X	X	X	X	X	X	X	O	O	PF	2016 = E. Simonson	
1065	C	O	O	FS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1295	C	O	SB	X	X	X	X	X	X	SS	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	O	
1298	C	X	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1302	C	O	X	X	X	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1304	C	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	O	X	X	X	X	X	X	X	X	X	X	X	X	O	
1306	C	O	O	FS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	O	X	X		
1088	C	O	O	O	SS	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X													

ID#	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Comments	
1293										C	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
1313										C	O	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1299													C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1474													C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1438														C	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	2004 = UAS Sitka
1439														C	X	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1659														C	O	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1485															C	X	X	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
1486															C	O	O	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

Key to sighting locations outside Glacier Bay/Icy Strait (if sighted in >1 area, only one area is listed in the table due to space limitations):

CS = Chatham Strait

FS = Frederick Sound

LC = Lynn Canal

LI = Lisianski Inlet

PF = Port Frederick

SB = Salisbury Sound

SC = Seymour Canal

SP = Stephens Passage

SS = Sitka Sound

TI = Tenakee Inlet

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 132/139884, August 2017

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