Glacier Bay & Icy Strait Humpback Whale Population Monitoring: 2023 Update

National Park Service
U.S. Department of the Interior

Glacier Bay National Park & Preserve

A solitary whale (catalog ID #879) lunges to engulf a school of herring after producing a bubblenet near Pleasant Island in August 2023.

Background

Migratory humpback whales (*Megaptera novaeangliae*) use the waters in and around Glacier Bay National Park and Preserve (GBNPP) in southeastern Alaska (SEAK) as spring, summer, and fall feeding habitat. The majority spend the winter breeding season in Hawai'i but at least 10% migrate to Mexico. Commercial whaling decimated these populations until the mid-1970s. Most whales return to the same feeding areas where their mother brought them as a calf. This strong maternally directed site fidelity drove population growth until the unprecedented 2014-2016 NE Pacific marine heatwave (PMH) caused an abrupt crash in the SEAK population (Gabriele *et al.* 2022) and throughout the North Pacific (Cheeseman *et al.* 2024) and highlighted that climate change is a growing threat to this species.

This report summarizes results from 2023, the 39th consecutive year of GBNPP's humpback whale monitoring program in Glacier Bay and Icy Strait. The initial impetus for this program stemmed from concern in the 1970s that increased vessel traffic in Glacier Bay may have caused many whales to abandon the bay (Jurasz and Palmer 1981). Understanding the condition of the whale population is essential to making informed management decisions. GBNPP's decades long annual monitoring program is unique within Alaska and has produced one of the world's longest and most complete time-series of data on a baleen whale population.

Key Findings from 2023

- Over the past four years (2020-2023), whale abundance in Glacier Bay-Icy Strait (GB-IS) has been relatively consistent with numbers ~30% lower than before the 2014-2016 NE Pacific marine heatwave (PMH).
- Seven years since the PMH subsided, many whales that previously frequented GB-IS have not returned or been seen elsewhere and are presumed dead.
- We documented 11 mother/calf pairs and an increase in the crude birth rate (CBR) (6.4%) compared to 2022 (3.6%). Although calf production has increased since the sharp post-PMH decline, it remains below the pre-PMH mean CBR of 9.2%.
- We observed a lower rate of emaciation in 2023 (13%) which presumably reflects improved feeding conditions in GB-IS compared to when emaciation peaked in 2021 (27%). Seven mothers and three calves appeared to be "skinny".
- Male #159 returned to the study area and his 50-year sighting history (1974-2023) is the longest known span for any living whale in GB-IS.
- In May, adult male #1083 self-released from an entanglement in boat mooring gear near Gustavus.
- In October, whale #5490 became entangled in a tanner crab pot and was partially disentangled by a trained team, including NPS staff.

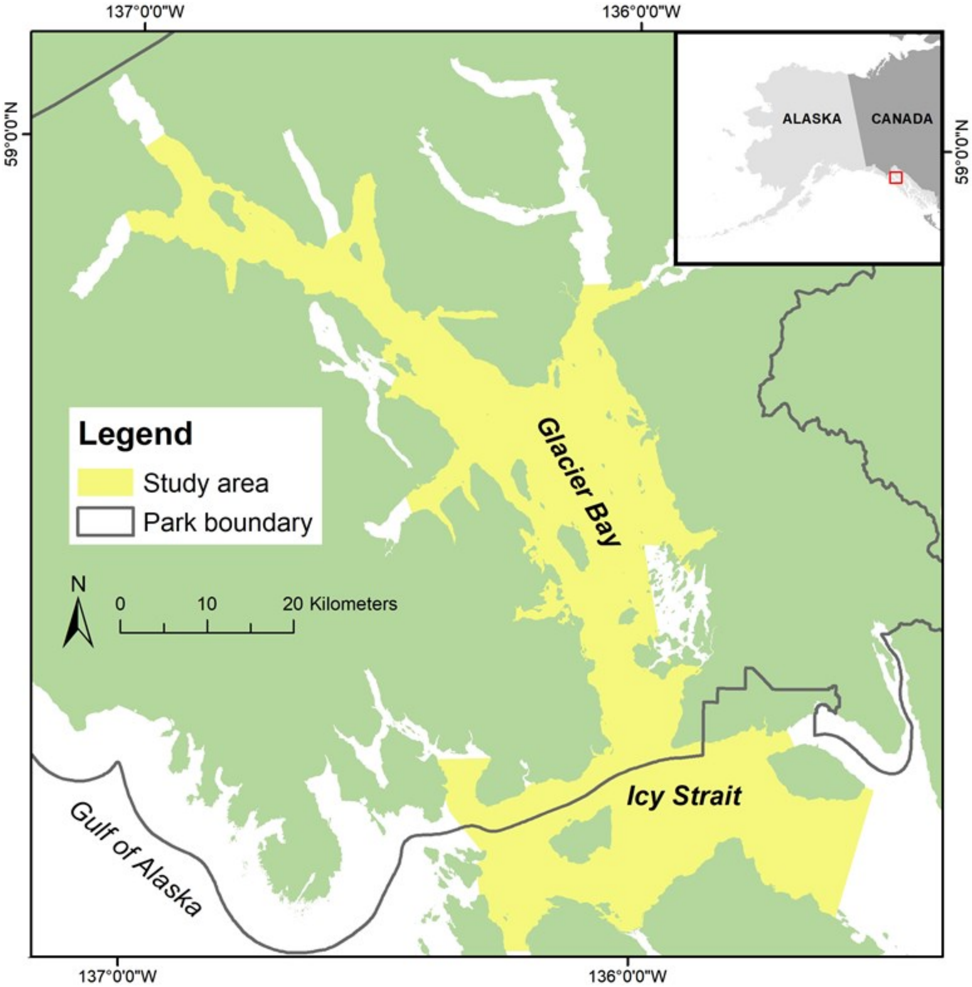

Figure 1. Study area in Glacier Bay and Icy Strait, Alaska.

Figure 2. The stable, distinct coloration and shape of a whale's flukes allow researchers to track individuals over time. Each whale receives a unique identification number. For example, the whale with black flukes is adult female #1834 (left) and the whale with white flukes is 29-year-old male #1293 (right).

Figure 3. R/V *Sand Lance* underway with research team. (Photo © UNESCO /Mark Kelley)

Where & How Do We Gather Data?

Every year since 1985, GBNPP biologists have conducted small boat-based photo-identification surveys in GB-IS (Figs. 1, 2) 4-5 days per week from June 1 - August 31 (core period) with less frequent surveys in the spring and fall (see Gabriele *et al.* 2017 and Neilson *et al.* 2018 for detailed methods). Our primary goal is to describe the distribution and abundance of humpback whales in a way that is comparable between years. We use a mixed approach in which we target 'hotspots' where whales have been reported or are known to frequent, while also surveying areas where whales may or may not be present.

Between April 18-November 1, 2023, we searched for and photographed humpback whales from the 5.8-m *R/V Sand Lance* (Fig. 3), the 6.7-m *Boomer*, and the 9.1-m *Capelin*. On September 11 we surveyed the upper East Arm due to consistent reports of whales there, which is not normally part of our study area.

We took photographs of each whale's flukes and dorsal fin with a Nikon D7200 digital camera equipped with a 80-400mm zoom lens.

We compared these photos to previous GBNPP photos to determine the identity and past sighting history of each whale. We used the Happywhale.com automatic matching system to identify whales that had not been sighted before in GB-IS. We entered sighting data, including group composition and behavior state, in a database shared with the University of Alaska Southeast in Sitka. We calculated the crude birth rate (CBR) as # calves/total # whales identified during the core monitoring period.

In 2023, we collected 18 water samples near feeding whales for a pilot study of forage fish eDNA. Other information that we collected opportunistically included: 1) sloughed whale skin for genetic analysis and 2) opportunistic observations of whales' body condition (*e.g.,* emaciation), body size (*e.g.,* small),

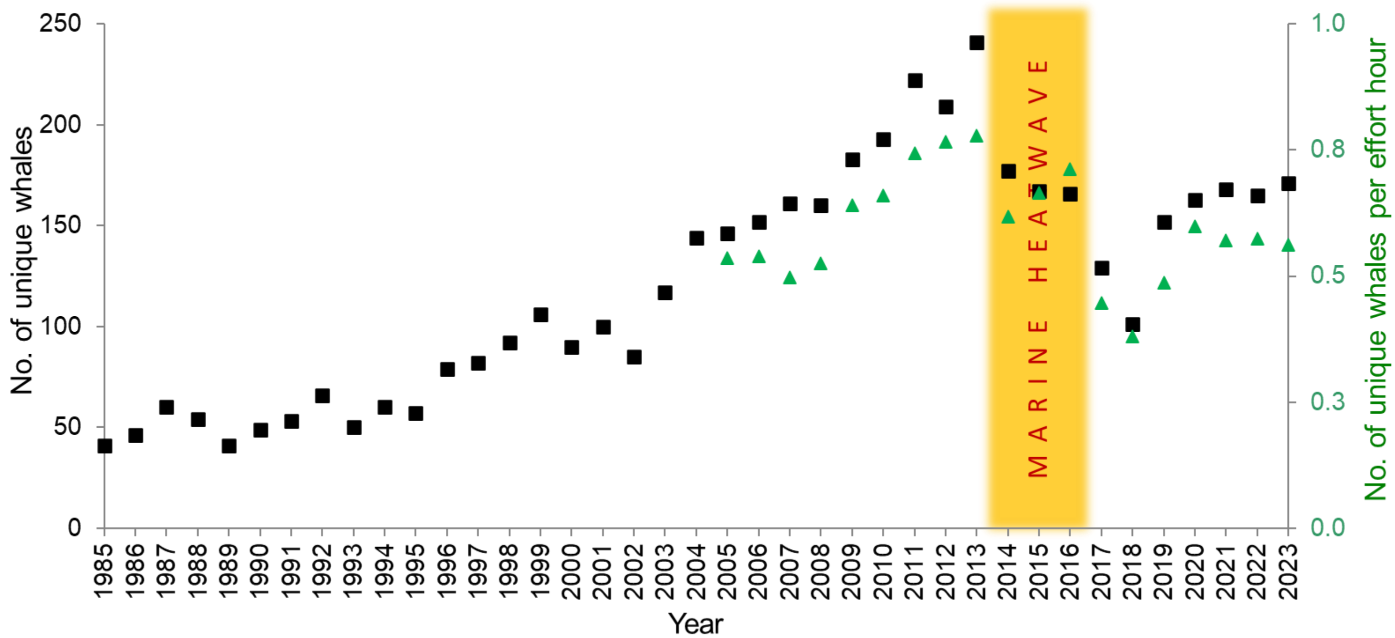

Figure 4. Relative abundance metrics for Glacier Bay & Icy Strait. Annual whale counts (black squares) and annual whale counts corrected for survey effort (green triangles) from June 1 – August 31, 1985-2023. A marine heatwave dominated the NE Pacific Ocean during the period highlighted in orange. Whales/effort hour is not available for 1985-2004.

and probable whale prey. We also recommended to the GBNPP superintendent where and when 'whale waters' vessel speed and/or course restrictions should be implemented to protect humpback whales from vessel collisions and disturbance.

What Did We Find in 2023?

Survey Effort

Our survey effort during the June 1 – August 31, 2023 core period (304 h) was above average compared to 2005-2022 (mean 285 h, SD = 22 h) but within the range for survey effort in these years (233-323 h). We strive to maintain consistent survey effort each year but it inevitably fluctuates as a result of factors such as weather, staff availability, and unexpected events (*e.g.,* mechanical issues and marine mammal strandings).

Whale Counts

Between June 1 and August 31, we documented 171 unique humpback whales (Fig. 4, black squares) in GB-IS. This raw count represents a 3.6% increase compared to 2022. However, correcting the count for survey effort reveals a 2.1% decline compared to 2022 (Fig. 4, green triangles). In Glacier Bay, abundance decreased compared to 2022, while in Icy Strait, abundance increased and these trends were consistent across the raw and effort-corrected counts. In Icy Strait, whale abundance was at its highest level in seven years but still far below pre-PMH levels.

Overall, whale abundance in GB-IS over the past four years (2020-2023) has been relatively consistent, but total counts remain approximately 30% lower than their peak prior to the 2014-2016 Northeast Pacific marine heatwave (PMH), which caused widespread and prolonged ecological disruption (Arimitsu *et al.* 2021, Suryan *et al.* 2021). A recent estimate revealed a significant decline in the North Pacific humpback whale population of ~7,000 whales (Cheeseman *et al.* 2024). In Glacier Bay, effort-corrected abundance peaked before the PMH in 2012 (0.87 whales/effort hr) and our 2023 counts (0.51 whales/effort hr) represent a 41.5% decline since 2012. In Icy Strait, effort-corrected abundance peaked before the PMH in 2013 (2.01 whales/effort hr) and our 2023 counts (1.26 whales/effort hr) represent a 37.4% decline since 2013.

Outside of the core monitoring period, we documented eight more whales (six in IS in Sept/Oct and two in GB in May/Sept) for a grand total of 179 unique whales in 2023. Across all dates and not

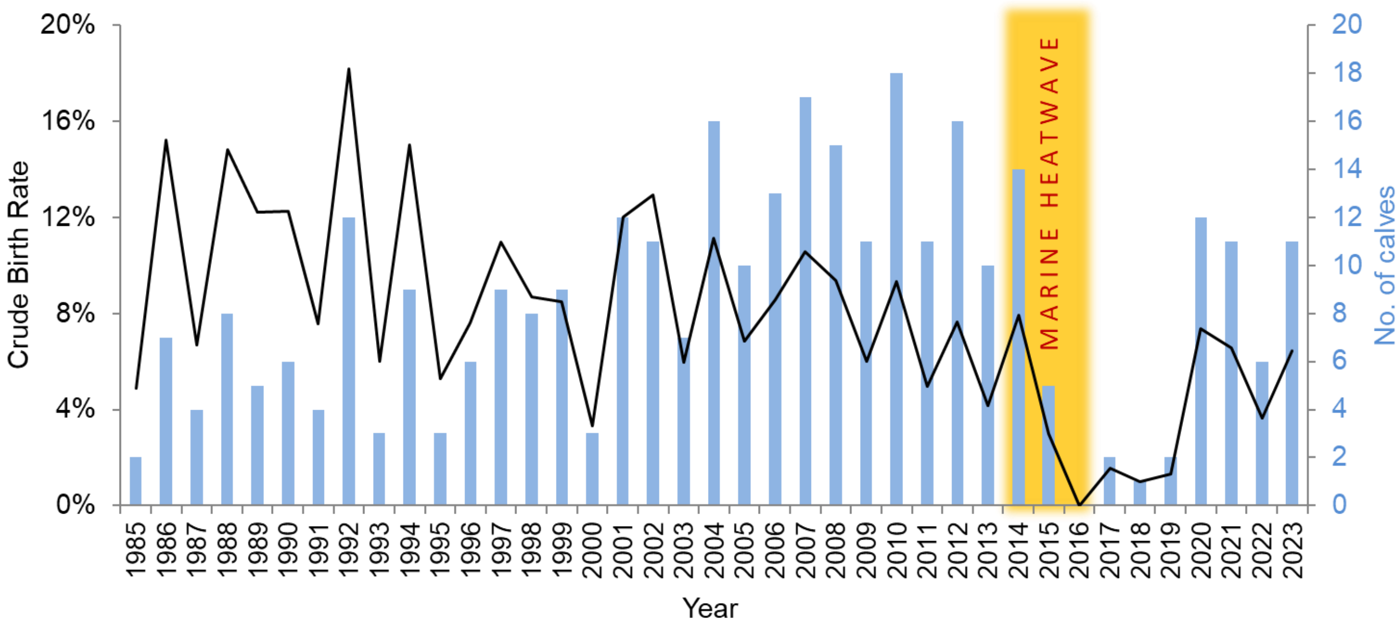

Figure 5. Crude birth rate (black line; # calves/total # whales) and annual number of calves (blue bars) in GB-IS from 1985-2023.

including calves, seven whales were new to the study (one in GB, five in IS, one in both areas).

Reproduction & Juvenile Survival

We documented 11 mother/calf pairs and a crude birth rate (CBR) of 6.4% (Fig. 5, Fig. 6). Calf production increased compared to 2022 (CBR 3.6%) but remains below the mean CBR prior to the PMH (9.2%, 1985-2013). An increase in the 2023 birth rate was also documented elsewhere in northern SEAK (Alaska Whale Foundation 2024).

Some calves were unusually independent of their mothers, especially #2710 (calf of #1246) and #2716 (calf of #2456). The most extreme example occurred on July 17, when we observed #2710 >3 mi from #1246 before they reunited. These observations highlight how easy it is to misidentify mother/calf associations without repeated encounters over different days to confirm relationships and age classes.

Potential factors in this continued reduced CBR are covered elsewhere (Gabriele *et al.* 2023). Some adult females are exhibiting unusually long calving intervals or have not successfully resumed calving since the PMH. There may also have been an increase in the female age at first calving following the PMH (Gabriele *et al.* 2023). Four of this year's mothers were documented with their first known calves at ages 16-18+, in contrast to the pre-PMH mean age at first calving at age 12 (Gabriele *et al.* 2017). Female #2033 (age 16) has a complete sighting history (except at age 5), therefore this was likely her first calf at age 16. The other three females (#2456, age 16; #2455, age 18; and #2220, minimum age 18), have incomplete sighting histories and could have had a calf in previous years.

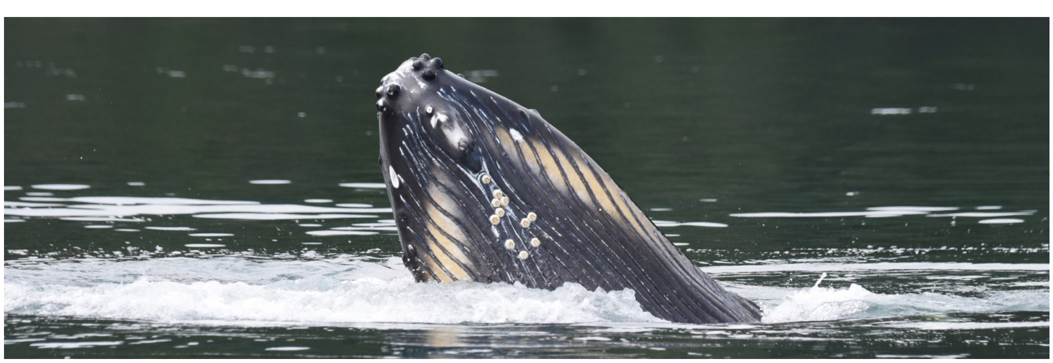

Figure 6. Calf #2711, shown here, is the sixth known calf of #1428, a female we have been tracking since she was a calf in 1997.

On August 13, a charter fishing captain reported that killer whales successfully separated an unidentified humpback whale mother from her calf and attempted to drown the calf near Pleasant Island in Icy Strait (J. Parker, pers. comm.). The mother was seen fleeing the area but it was not clear if the calf was with her. We are unaware of any successful killer whale predation attempts on humpback whales in SE Alaska and observations of attempted predation are extremely rare, therefore it is notable that in 2023 we received two more reports of killer whales harassing and/or attacking humpback whales within a few weeks of this report. These other reports did not involve calves: 1) On July 28, park visitors filmed a group of killer whales as they appeared to harass a single humpback whale that appeared to be an adult near Russell Island (L. Williams, pers. comm.). We were unable to individually identify the humpback whale to confirm its age class or fate; 2) On August 3, we received a report that a group of killer whales attacked a single unidentified humpback whale in Middle Pass near the Inian Islands in western Icy Strait, however the fate of this whale is unknown (K. O'Brien, pers. comm.)

We suspect that the presence of an unusually large group of marine mammal-eating killer whales in our area may have been related to the three reports of killer whales attacking/harassing humpbacks. On July 27, the day before the first report, we documented an exceptionally large pod of Bigg's killer whales (40+ individuals) traveling up Glacier Bay. Bigg's killer whales feed on marine mammals (*vs.* resident killer whales, which feed on fish).

Resightings of juveniles continued to trend upwards after calf survival dropped from 40% to 3% during and after the PMH (Gabriele *et al.* 2022). Only 11 out of 58 (19%) of the GB-IS calves born during or after the PMH (2014-2022) are known to have survived past their calf year. However, since 2019, juvenile survival appears to be increasing after an abrupt decline during and after the PMH.

Although we documented no former GB-IS calves at ages 1-3 in the study area this year, the survival of five former GB-IS calves was discovered through Happywhale matches (Table 1). The resighting of #2772* at age 10 in Mexico is notable because #2772 is the only one of the 23 GB-IS calves born in 2014-2016 (*i.e.,* during the PMH) that is known to have survived past its calf year.

Table 1. Glacier Bay/Icy Strait calf survivals discovered through Happywhale matches made since Neilson *et al.* 2023.

SEAK ID	Born	Date & location of first sighting post-calf
2611	2013	06/27/2016, Glacier Bay, AK
2772*	2014	01/31/2024, Mexico[1]
2663	2020	09/21/2023, Prince William Sound, AK[2]
2703	2022	09/19/2023, Prince William Sound, AK[2]
2704	2022	01/15/2023, Hawai'i[3]

The discovery that #2611 was an internal match in our catalog that matched a GB-IS calf born in 2013 (formerly known as #2556), highlights the remarkable accuracy of the Happywhale matching algorithm, even when fluke pigmentation patterns change significantly after the calf year (Fig. 7).

Figure 7. The color of whale #2611's flukes changed dramatically as it grew from a calf (left) into an adult (right). The Happywhale.com automated fluke matching system detected that these were the same whale and we confirmed the match by comparing photographs of the trailing edge of the flukes and dorsal fin. By combining these whale's records, we now know that #2611 returned to GB-IS in 2016 at age 3. Since then, we have seen this whale many times, most recently in summer 2022.

Site Fidelity

Between June 1 and August 31, 67% (n = 114) of whales were resighted over a span of ≥20 days (range 21-92 days) and 19% (n = 33) were considered 'transient' (sighted one day only). During and after the PMH, we documented a general trend of low residency (2014-2018: mean = 51%) and high transience (2014-2018: mean = 33%). However, since 2019 the residency and transience rates have been more similar to before the PMH (2005-2013: mean residency = 68%; mean transience = 21%). The resumption of a pattern of high residency and low transience presumably reflects the return of favorable feeding conditions in GB-IS since the PMH. Three of the 33 transients were new to the study area.

Since the onset of the PMH, many humpback whales that previously frequented GB-IS have not returned. Many of these whales exhibited a long-term pattern of site fidelity to GB-IS before the PMH caused widespread and abrupt marine ecosystem impacts. Preliminary results of an ongoing analysis of all available sightings (including Happywhale.com) of 266 whales with ≥5 year sighting histories in GB-IS indicate a marked increase in the number of whales missing since the PMH (Neilson *et al.* 2024). Since 2013, three GB-IS whales are known to have died (#539, #441, #235) and 58 whales are presumed dead due to a lack of sightings anywhere in the past ≥5 years, including on the winter breeding grounds. In light of the documented decline in GB-IS non-calf survival from 0.982 pre-PMH to 0.899 post-PMH (Gabriele *et al.* 2022), it appears increasingly likely that many of these whales are dead, rather than relocated to other feeding areas.

In contrast, 2023 marked the 37th consecutive summer that male #159 (age unknown) returned to GB-IS, giving him the longest unbroken sighting record for any whale in this study. Furthermore, #159's earliest known sighting was in GB in 1974 (Sea Search Ltd., unpublished data) and his 50-year sighting history (1974-2023) is the longest known span for any living whale in GB-IS.

Tissue Samples

We collected 16 sloughed skin samples from 16 unique individuals, including six calves. Since 1996, we have collected 400 sloughed skin samples which are analyzed by the Cetacean Conservation and Genomics Lab at Oregon State University for sex determination, mitochondrial DNA haplotype, and nuclear DNA genotyping.

Physical Condition

Twenty-three (13%) of the 171 whales we observed during the core monitoring period appeared to be "skinny" based on physical indicators such as visible scapulae, an overall "angular" appearance, and/or the presence of a post-cranial depression. Beginning in 2016 we started to notice whales in continued poor body condition in the summer and emaciation rates peaked at 27% in 2021 (Fig. 8). While this year's result represents a continued downward trend in emaciation rate (down from 16% in 2022), three calves in 2023 appeared "skinny" and the high proportion of mothers who appeared thin (64%; 7 of 11) represents an increase compared to the rate of emaciation in mothers in 2022 (50%; 3 of 6).

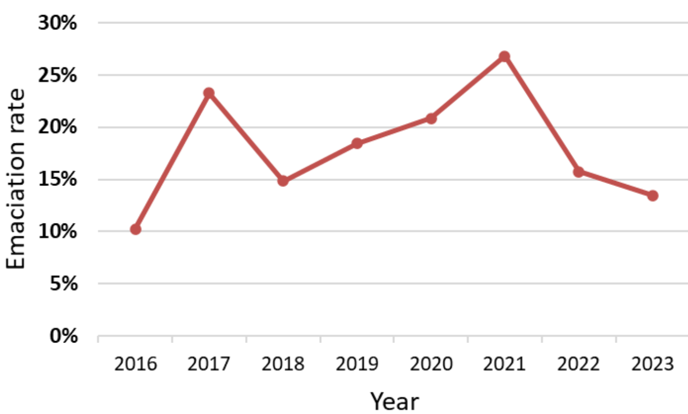

Figure 8. Rate of emaciation (number of "skinny" whales observed June 1-August 31 divided by the total number of whales during this period) in GB-IS whales in 2016-2023.

Prior to the PMH, we rarely observed "skinny" whales, except some mothers in the spring when whales return from fasting while on their tropical wintering grounds. Systematic photogrammetric studies conducted using aerial imagery from drones elsewhere in SEAK corroborate our opportunistic observations that whales were in significantly lower body condition in 2021 ([Alaska Whale Foundation 2024](#)).

Adult female #1480 (age 23), who had a calf in 2022, was notably emaciated in 2023 through at least August 18. Emaciation in whales is most likely attributable to insufficient food intake, with an increased risk of emaciation in lactating females because lactation is an energetically demanding life phase, even a year after they wean their calf (van Aswegen *et. al*, in prep.).

Whale Prey and Feeding Behavior

Whales in GB-IS predominantly feed on forage fish, although krill may be targeted in parts of Glacier Bay. Opportunistic observations of near-surface forage fish in 2023 documented the presence of capelin (Fig. 9), sand lance, herring, and walleye pollock near feeding humpback whales in the study area (Table 2).

Figure 9. Capelin boil to the surface in Berg Bay on August 15 as a whale lunges from below to feed on the school of fish.

Herring may have been more abundant in Icy Strait than in recent years, which is consistent with our observations of increased whale abundance in IS in 2023. On five occasions between June 21 and August 24, we heard the distinctive underwater humpback whale "feeding call" through the research vessel hull while near whales feeding in Icy Strait. This call is typically associated with whales feeding on herring.

In addition, there were several observations of humpback whales group bubblenet feeding in Icy Strait in 2023, a behavior typically associated with whales that are feeding on herring. In early July we received a report of group bubblenet feeding just east of Mud Bay for several days but then the behavior

Table 2. Species we identified near feeding humpback whales in GB-IS in 2023 (n = number of detections).

Species	n
Capelin (*Mallotus catervarius*)	7
likely capelin	1
Pacific sand lance (*Ammodytes personatus*)	4
Pacific herring (*Clupea pallasii*)	2
likely herring	12
Walleye pollock (*Gadus chalcogrammus*)	1
Unidentified forage fish	11

appeared to subside (S. Chev, pers. comm.). In mid to late July, we received several more reports of group bubblenet feeding at this same location (S. Petty and M. Metcalf, pers. comm.). On August 24, we observed 16 whales group bubblenet feeding off Point Adolphus.

We collected four opportunistic samples of forage fish near feeding whales in 2023 (July 10: herring at Point Adolphus; July 21: capelin at Point Carolus; July 24: capelin at Bartlett Cove; August 8: sand lance at Flapjack Island.) These opportunistic samples are analyzed by our collaborators at the U.S. Geological Survey for body condition and algal toxins (which when consumed, can bioaccumulate in apex predators like humpback whales and seabirds). Results from the 2023 forage fish and eDNA samples are not yet available.

Forage fish abundance in 2021-2023 may have increased following a drop in detections during and after the PMH, but our ability to link whale population dynamics to prey availability is limited by a lack of quantitative annual metrics on forage fish abundance and quality.

In 2023, we received more reports of whales feeding in the upper reaches of the West and East Arms than in past years. From early August through October, 1-3 whales were regularly observed by NPS staff in Tarr and Johns Hopkins Inlet, including near the face of the glaciers, which is not typical for these areas.

In addition, in response to reports of numerous whales in the upper East Arm we conducted a survey of the upper East Arm on September 11, during which we identified four whales, including #2605 at the head of McBride Inlet (Fig. 10). This whale's only other 2023 sighting was in May near the mouth of the East Arm.

Whale/Human Interactions

No vessel collisions were reported in the study area in 2023 but there were numerous close calls between cruise ships and humpback whales in the upper West Arm.

On May 18, a humpback whale briefly became entangled in a boat mooring near the Gustavus dock in Icy Passage; the whale was able to self-release after a few minutes. At ~1230h, witnesses reported a whale thrashing in a mooring line for a few minutes and dragging the mooring buoy underwater (A. Wildman, pers. comm.). Subsequent review of a video taken by a bystander (K. Tippery, pers. comm.) allowed us to identify it as adult male #1083. At ~1330h, we observed #1083 traveling rapidly towards Point Adolphus after he self-released. We encountered #1083 several more times in 2023 and assessed him for new injuries, but could see none. This whale has a pre-existing severe laceration injury in his left fluke that was most likely acquired during an entanglement in commercial longline gear in June 2015 (Neilson and Gabriele 2016).

Figure 10. Whale #2605 feeds near McBride Glacier in September. Whale sightings inside McBride Inlet are unusual.

On October 10, an entangled humpback whale in Icy Passage was reported by observers on the Gustavus dock (S. Hazen and K. Williams, pers. comm., Fig. 11, https://www.nps.gov/articles/000/whale-disentanglement-october-2023.htm). The next day, trained NPS staff worked with Dr. Fred Sharpe (Alaska Whale Foundation) to disentangle the whale from commercial grade tanner crab pot gear. The whale was identified as #5490, a juvenile estimated to be 3-4 years old who was new to the GB-IS area in 2023 but had been sighted elsewhere in SEAK beginning in 2021 (Alaska Whale Foundation 2024). This whale also had a propeller scar across its back that appeared to be from a small vessel collision that it had acquired since mid-August.

We continue to witness rapid growth in the number of commercial whale watching vessels in non-park waters in Icy Strait, especially around Point Adolphus and the Pleasant Island reef. Near Juneau, the whale watching fleet has also grown rapidly in recent years. Strengthening whale watching regulations and encouraging operator participation in voluntary best practices were recommended to ensure the sustainability of the industry (Schuler *et al.* 2019).

Whale Waters

Six temporary whale waters areas with 13-knot vessel speed limits were designated in mid GB and the West Arm to protect shifting distributions of whales in 2023. By July 20, the west side of lower GB warranted a 13-knot vessel speed limit. From July 25-August 11, the speed limit was expanded to include all of lower GB. From mid-September until the end of cruise ship season in late October, a 10-knot speed limit for vessels >200 ft in length was designated in Johns Hopkins and Tarr Inlets. In addition, the 20-knot speed limit in lower GB, which normally ends on September 30, was extended until the end of October.

Figure 11. A trained team approaches entangled whale #5490 with specialized cutting tools as part of a disentanglement effort authorized under the authority of NOAA Fisheries' Marine Mammal Health and Stranding Response Program Permit No. 24359. (Photo credit Sean Neilson)

Acknowledgements

We thank GBNPP staff, volunteers, external researchers, and visitors for contributing whale sightings. We are grateful to volunteer Mel McKenzie (University of Cumbria) for her help in the office and the field. Thanks to Yumi Arimitsu and Caitlin Marsteller (USGS) for analyzing our forage fish samples and extra thanks to Yumi for identifying forage fish species in our photos. We are grateful to Rhayne Loggins and Jessica Glass (University of Alaska Fairbanks) for their essential roles in helping us pilot a forage fish eDNA study. Thanks to Justin Parker, Lori Williams, Kenny O'Brien, Sara Chev, Steve Petty, Matt Metcalf, Ann Wildman, Katelyn Tippery, Sesylia Hazen, Kamille Williams, and Martin van Aswegen for sharing their observations with us. A whale-sized thank you to Ted Cheeseman and Ken Southerland (www.Happywhale.com) for revolutionizing humpback whale fluke matching and for facilitating data sharing. Happywhale sightings cited in this report are thanks to [1]Whale Watch Cabo, [2]John Moran (NOAA/ Gulf Watch Alaska), and [3]Kristina Rau/Captain Steve's Rafting Adventures. All GBNPP whale photos were taken under NMFS ESA/MMPA Permits 21059 and 27027.

Literature Cited

Alaska Whale Foundation. 2024. 2023 Annual Research Report. Unpublished report. 18 pp.

Arimitsu, M.L., *et al*. 2021. Heatwave-induced synchrony within forage fish portfolio disrupts energy flow to top pelagic predators. Global Change Biology (doi:10.1111/gcb.15556)

Cheeseman, T., *et al*. 2024. Bellwethers of change: population modelling of North Pacific humpback whales from 2002 through 2021 reveals shift from recovery to climate response. Royal Society Open Science (doi.org/10.1098/rsos.231462)

Gabriele, C.M., *et al*. 2017. Natural history, population dynamics, and habitat use of humpback whales over 30 years at an Alaska feeding ground. Ecosphere 8: 1-18 (doi:10.1002/ecs2.1641)

Gabriele, C.M., *et al.* 2022. Sharp decline in humpback whale (*Megaptera novaeangliae*) survival and reproductive success in southeastern Alaska during and after the 2014-2016 Northeast Pacific marine heatwave. Mammalian Biology (doi.org/10.1007/ s42991-021-00187-2)

Gabriele, C.M., *et al.* 2023. Trends in humpback whale calving in Glacier Bay and Icy Strait. Pages 174-178 *in* Ferris, B.E. 2023. Ecosystem Status Reports 2023: Gulf of Alaska, Stock Assessment and Fishery Evaluation Report, North Pacific Fishery Management Council, 1007 West Third, Suite 400, Anchorage, Alaska.

Jurasz, C.M., and V.P. Palmer. 1981. Censusing and establishing age composition of humpback whales (*Megaptera novaeangliae*), employing photodocumentation in Glacier Bay National Monument, Alaska. National Park Service Unpublished Report, Anchorage, Alaska.

Neilson, J.L., and C.M. Gabriele. 2016. Humpback whale monitoring in Glacier Bay and adjacent waters 2015. Natural Resource Report NPS/GLBA/NRR—2016/1354. National Park Service, Fort Collins, Colorado.

Neilson, J.L., *et al*. 2018. Humpback whale monitoring in Glacier Bay and adjacent waters 2017: Annual progress report. Natural Resource Report NPS/GLBA/NRR-2018/1660. National Park Service, Fort Collins, Colorado.

Neilson, J.L. *et al*. 2023. Glacier Bay & Icy Strait humpback whale population monitoring: 2022 update. National Park Service Resource Brief, Gustavus, Alaska.

Neilson, J.L., *et al*. 2024. Inferred mass mortality of humpback whales in Southeast Alaska since the Northeast Pacific marine heatwave. Presented at the 2024 Alaska Marine Science Symposium in Anchorage, Alaska, January 29-February 2, 2024.

Schuler, A.R., *et al.* 2019. Humpback whale movements and behavior in response to whale-watching vessels in Juneau, AK. Frontiers in Marine Science (doi.org/10.3389/fmars.2019.00710)

Suryan, R.M., *et al.* 2021. Ecosystem response persists after a prolonged marine heatwave. Scientific Reports (doi:10.1038/ s41598-021-83818-5)

Suggested Citation

Neilson, J.L., C.M. Gabriele, and L.E. McCaslin. 2024. Glacier Bay & Icy Strait humpback whale population monitoring: 2023 update. National Park Service Resource Brief, Gustavus, Alaska.

For more information

Chris Gabriele	Janet Neilson
Chris_Gabriele@nps.gov	Janet_Neilson@nps.gov
907-697-2664	907-697-2658

https://www.nps.gov/glba/learn/nature/whales.htm