Marine Mammal Science

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The Decline of Humpback Whales in Prince William Sound, Alaska, Following the 2014–2016 Northeast Pacific Marine Heatwave

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In the early 1970s, all populations of humpback whales (*Megaptera novaeangliae*) were listed as endangered under the US Endangered Species Conservation Act of 1969 (Public Law 91-135, n.d.) and the Endangered Species Act in 1973 (Public Law 93-205, n.d.). Three decades later in 2006, the humpback whale population in the North Pacific Ocean had increased from approximately 1200–1400 (Johnson and Wolman 1984) to at least 21,000 individuals (Barlow et al. 2011) and continued increasing to over 30,000 individuals by 2013 (Cheeseman et al. 2024). In 2016, the National Marine Fisheries Service of the United States (NMFS) reassessed the listing of humpback whales under the Endangered Species Act. Worldwide, 14 distinct population segments (DPS) were identified, with four inhabiting the North Pacific. The Hawai'i DPS, that includes approximately 89% of the individuals that migrate to the Gulf of Alaska (Wade 2021), was delisted from the Endangered Species Act, the Mexico DPS was listed as threatened, while the Western North Pacific and Central American DPSs remained classified as endangered (Federal Register 2016). Coincident with this revised listing of humpback whales was the northeast Pacific marine heatwave (PMH), one of the strongest marine heatwaves recorded in recent decades (Di Lorenzo and Mantua 2016; Hobday et al. 2018).

The PMH of 2014–2016 affected many species across trophic levels with some marine mammals and marine bird populations in the Gulf of Alaska showing strong negative effects (Suryan et al. 2021). Common murres (*Uria aalge*) (Bien et al. 2024; Piatt et al. 2020; Renner et al. 2024), Steller sea lions (*Eumetopias jubatus*) (Hastings et al. 2023; McHuron et al. 2024), and humpback whales (Cartwright et al. 2019; Cheeseman et al. 2024; Frankel et al. 2022; Gabriele et al. 2022) all responded negatively to a decline in forage fish abundance and nutritional value (Arimitsu et al. 2021; von Biela et al. 2019). The impact of the PMH on humpback whales and fin whales (*Balaenoptera physalus*) resulted in the declaration of an unusual mortality event by NMFS in Alaska and British Columbia (Savage 2017). A subsequent analysis in 2024 estimated a loss of ~7000 humpback whales from the North Pacific population following the PMH with the Hawai'i DPS suffering a decline of 34% from 2013 (Cheeseman et al. 2024). In the Gulf of Alaska, humpback whales prey on Pacific herring (*Clupea pallasii*), Pacific capelin (*Mallotus catervarius*), eulachon (*Thaleichthys pacificus*), juvenile walleye pollock (*Gadus chalcogrammus*), juvenile salmon (*Oncorhynchus* spp.), Pacific sand lance (*Ammodytes personatus*), and euphausiids (Boswell et al. 2016; Burrows et al. 2016; Chenoweth et al. 2017; Nemoto 1957; Szabo 2015; Witteveen et al. 2008). Within the waters of Prince William Sound, Alaska (PWS), Pacific herring dominate the diet of humpback whales particularly in the spring when herring aggregate to spawn and during the fall and winter when large overwintering shoals form (Moran et al. 2018; Straley et al. 2018). During the PMH, forage fish abundance declined dramatically in PWS (Arimitsu et al. 2021; Branch 2025; Dias et al. 2022; McGowan et al. 2021). PWS herring reached historical lows between 2016 and 2018, followed by a recovery, reaching pre-heatwave levels by 2022 (Branch 2025; Morella 2025).

We monitored humpback whale abundance within PWS (60°35′N, 147°10′W) from 2007 to 2024. PWS is 10,000 km^2 of relatively protected waters in the northern Gulf of Alaska, characterized by complex coastlines of glacial fjords and islands. Of the humpback whales feeding in the Gulf of Alaska, 89% breed in Hawaiian waters and 11% breed off the coast of Mexico

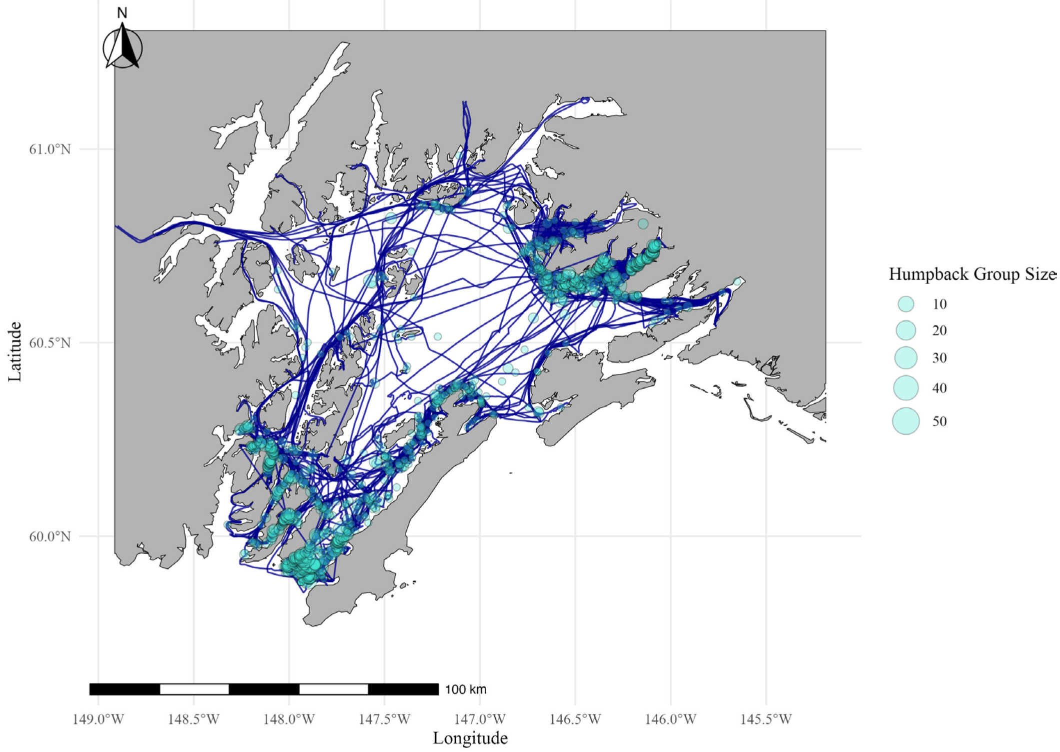

FIGURE 1 | The distribution of humpback whale sightings and survey coverage in Prince William Sound, AK. Group size ranged from 1 to 50 with a mean of 2.5.

(Wade 2021). Within PWS, humpback whales are present throughout the year with numbers peaking in October through November, then dropping during late December through early January (Moran et al. 2018; Straley et al. 2018); however, some individuals have skipped the migration south and remained in Alaska waters over winter (Moran et al. 2018; Straley 1990; Straley et al. 2018). Although there is some exchange between feeding areas, adults tend to show a strong fidelity to a specific feeding ground (Baker et al. 2013; Cheeseman et al. 2023; Martien et al. 2023). Migration between the Gulf of Alaska and the breeding grounds take approximately 30 days (Mate et al. 1998; Gabriele et al. 1996) with limited opportunity to feed along the way, especially for individuals migrating to Hawai'i (Frisch-Jordán et al. 2019; Gendron 1993; Lammers et al. 2024; Ransome et al. 2024); thus, a healthy forage base in high latitude waters is critical to support the year-round energy budget for North Pacific humpback whales. In PWS, large shoals of Pacific herring made up the majority of prey for humpback whales (Straley et al. 2018).

During the study period, we conducted 42 vessel-based surveys, ranging from 5 to 10 days of the areas most frequented by humpback whales in PWS during spring (March–April) and fall/winter (September–December). The timing of these surveys corresponded to the herring spawn in the spring and the migration of adult herring into PWS prior to overwintering (Bishop and Eiler 2018). We used systematic photographic surveys to identify individual whales over an 18-year period (September 2007–September 2024) (Figure 1) (Straley et al. 2018) to estimate inter-annual variation in abundance before, during, and after the PMH.

By using the unique markings on the flukes (Katona et al. 1979) from our surveys and opportunistically collected photographs, 381 whales were individually identified from November of 2007 through September of 2024 (allowing mark recapture abundance estimates through 2023). We used the Rcapture (Rivest and Baillargeon 2022) package (R version 4.1.3; R Core Team 2022) and Jolly-Seber-Cormack Estimator to estimate humpback whale abundance within PWS. The model uses encounter histories for the humpback whales as a function of year (resighting probability in a given year) and accounts for individual heterogeneity in resighting effect due to either poor fluke photo quality, individual behavior, or survey effort. We defined the year for a marking period beginning on 15 March to coincide with the migration cycle of humpback whales to the breeding grounds (i.e., a whale seen prior to 15 March would be included in year x, on or after that date they would be included in year $x+1$).

Because it is unlikely that we photographed all of the whales within PWS, 381 individuals photographed should be considered a minimum number of observed non-calf humpback whales found within PWS during the study period. The total estimated number of whales that inhabited PWS during our study period estimated from the Jolly-Seber-Cormack mark-recapture model (Rivest and Baillargeon 2022) was 473 (SE = 15.3) individuals, excluding calves of the year, and ranged from an annual high of 298 whales pre-PMH in 2012 to a low of 57 whales 7 years after the PMH (Table 1). This represents a 50% decline in the median population size before (2007–2014) versus after (2015–2023) the PMH. Counts of calves and the number of whales seen during fall surveys followed a similar pattern, with a decline after the PMH (Table 1).

In Summary, humpback whale numbers have failed to recover in PWS following a decline that was coincident with the 2014–2016 PMH in the Gulf of Alaska. The initial decline of humpback whales was also coincident with a decline in the aerial mile-days-of-milt (the linear distance and the duration of beaches receiving herring spawn) (Hulson et al. 2008), an index of the herring biomass, in PWS (Figure 2) (Morella 2025; Muradian et al. 2017), a key foraging opportunity for this local population of whales (Moran et al. 2018; Straley et al. 2018). The dramatic decline in herring spawn reflected an overall decline of herring biomass in PWS (Branch 2025; Dias et al. 2022; McGowan et al. 2021). The herring population increased to pre-PMH levels by 2022; however, the humpback whale population did not reflect the same increase (Figure 2).

TABLE 1 | Annual abundance estimates (±SE) derived from Jolly-Seber-Cormack (open) estimators for Prince William Sound.

Year	Estimated abundance	SE	Whales seen	Calf counts
2007	135	11.0	95	4
2008	196	11.5	71	7
2009	No survey	—	No survey	No survey
2010	No survey	—	No survey	No survey
2011	175	12.3	62	2
2012	298	15.4	81	5
2013	196	16.3	113	6
2014	270	22.4	181	1
2015	190	49.2	No survey	0
2016	No survey	—	No survey	No survey
2017	128	25.9	12	0
2018	106	24.1	17	1
2019	94	18.0	35	0
2020	85	27.3	14	2
2021	85	17.1	23	0
2022	98	21.2	19	1
2023	57	12.4	34	4

Note: Calves were excluded from mark-recapture abundance estimates but are provided to show relative changes over time. No surveys were done in 2009, 2010, or 2016.

Upper trophic level predators in the northeastern Gulf of Alaska, including PWS, appear to have been more affected by the PMH than adjacent areas. The largest counts of dead or moribund common murres occurred in the northeastern Gulf of Alaska during a PMH-associated mass murre mortality event (Piatt et al. 2020) that contributed to an estimated total mortality of four million murres, 50% of the population, in Alaska (Renner et al. 2024). Following the PMH, Steller sea lion pup production in the northeastern Gulf of Alaska was reduced by 33.5% (McHuron et al. 2024) and prime-age female survival rates in PWS dropped by −0.233 and took longer to recover than adjacent areas (Hastings et al. 2023; McHuron et al. 2024). The distinct population segment of North Pacific humpback whales with the greatest loss of individuals after the PMH (6561 individuals, 35% of the population) included those that migrate to the Gulf of Alaska (Cheeseman et al. 2024), with the PWS whale population exhibiting an even greater proportional decline post-PMH (50%). These subsequent analyses of predator populations are consistent with previous analyses indicating that mid and upper trophic-level species in the northeastern Gulf of Alaska were more negatively affected during the PMH (Suryan et al. 2021).

Humpback whale populations have the potential to increase up to 11.8% annually (Zerbini et al. 2010). Within the Gulf of Alaska, the Glacier Bay population increased at 5.1% annually between 1985 and 2013 (Gabriele et al. 2017). Given the recovery of their primary prey to pre-heatwave levels and observations of other populations showing signs of recovery, such as humpback whales in Glacier Bay, Alaska (Neilson et al. 2024; Neilson et al. 2025), we expected that humpback whale abundance in PWS would follow similar patterns.

Why humpback whale populations in PWS remain depressed 7 years after the PMH is unclear but is possibly related to mortality and low calf production. With strong foraging site fidelity in adult whales (Baker et al. 2013; Cheeseman et al. 2023;

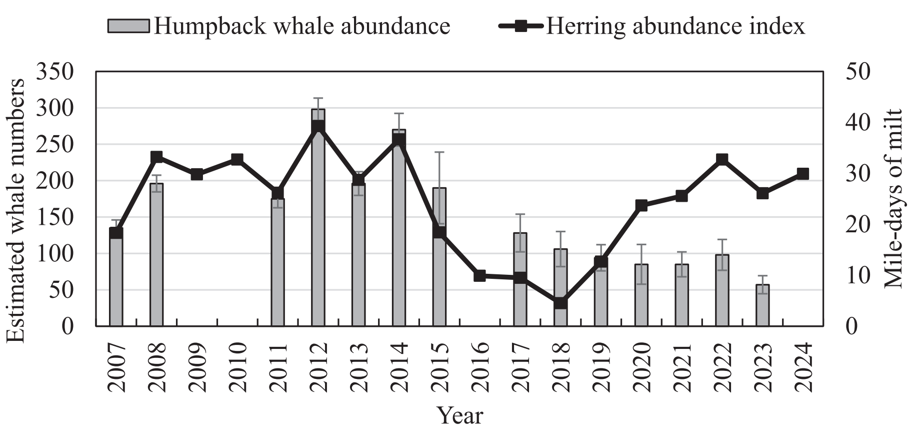

FIGURE 2 | Estimated annual humpback whale abundance in Prince William Sound, AK, and an index of herring abundance from aerial surveys during spawning (mile-days of milt). No whale surveys occurred in 2009, 2010, or 2016.

Witteveen and Wynne 2017), immigration to and emigration from PWS is likely low. Furthermore, with consistently low calf production in PWS since the heatwave (Table 1), the population has been slow to replace itself. Given the high energetic cost of gestation and migration (van Aswegen et al. 2025), the lack of late-season, energy-rich herring is likely a factor in the decline, whereas waters in Southeast Alaska supporting whales inhabiting Glacier Bay seemed to have provided a larger buffer with faster recovery for prey resources (Brooks et al. 2025). Given that oil from the *TV Exxon* Valdez oil spill has been sequestered in sediments and no longer bioavailable since at least 2015 (Lindeberg et al. 2018), it seems reasonable to rule out lingering oil spill effects in limiting post-heatwave recovery. The first sign of potential recovery for PWS humpback whales, however, occurred in 2023 when calf counts finally approached pre-PMH levels (Table 1). The response to heatwaves by whales is not unique to PWS. The effects on whales from heatwaves are diverse and have been widely reported (Barlow et al. 2023, Cartwright et al. 2019, Cheeseman et al. 2024, Frankel et al. 2022, Gabriele et al. 2022); however, PWS appears to be an extreme example of impacts to a local population, suggesting that the current Hawai'i breeding DPS designation may not fully capture finer scale trends in abundance that are affected by local conditions on disparate summer feeding groups. Our study demonstrates that it will be more than a decade post-heatwave before the local population of humpback whales in PWS recovers and highlights the importance of maintaining research and monitoring efforts to understand the long-term effects of major ecosystem perturbations.

Author Contributions

John R. Moran: conceptualization, data collection, funding acquisition, original draft, project administration. **Janice M. Straley:** conceptualization, data collection, data curation, funding acquisition, review, editing and permitting (NOAA and IACUC). **Jacek M. Maselko:** statistical analysis, review and editing. **Lauren A. Wild:** data collection, data curation, review, permit reporting and editing. **Robert M. Suryan:** data collection, funding acquisition, review and editing.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from Gulf Watch Alaska data portal, https://gulf-of-alaska.portal.aoos.org/#search?type_group=all&tag|tag=evos-gulf-watch-projects&page=1.

References

Arimitsu, M. L., J. F. Piatt, S. Hatch, et al. 2021. "Heatwave-Induced Synchrony Within Forage Fish Portfolio Disrupts Energy Flow to Top Pelagic Predators." *Global Change Biology* 27, no. 9: 1859–1878.

Baker, C. S., D. Steel, J. Calambokidis, et al. 2013. "Strong Maternal Fidelity and Natal Philopatry Shape Genetic Structure in North Pacific Humpback Whales." *Marine Ecology Progress Series* 494: 291–306.

Barlow, D. R., H. Klinck, D. Ponirakis, T. A. Branch, and L. G. Torres. 2023. "Environmental Conditions and Marine Heatwaves Influence Blue Whale Foraging and Reproductive Effort." *Ecology and Evolution* 13, no. 2: e9770.

Barlow, J., J. Calambokidis, E. A. Falcone, et al. 2011. "Humpback Whale Abundance in the North Pacific Estimated by Photographic Capture-Recapture With Bias Correction From Simulation Studies." *Marine Mammal Science* 27, no. 4: 793–818.

Bien, L., R. Suryan, M. L. Arimitsu, and J. Moran. 2024. "Seabirds and Humpback Whales Give Early Warning to Marine Heatwaves." *Open Access Government*: 388–389. https://doi.org/10.56367/OAG-042-10703.

Bishop, M. A., and J. H. Eiler. 2018. "Migration Patterns of Post-Spawning Pacific Herring in a Subarctic Sound." *Deep Sea Research Part II: Topical Studies in Oceanography* 147: 108–115.

Boswell, K. M., G. Rieucau, J. J. Vollenweider, et al. 2016. "Are Spatial and Temporal Patterns in Lynn Canal Overwintering Pacific Herring Related to Top Predator Activity?" *Canadian Journal of Fisheries and Aquatic Sciences* 73, no. 9: 1307–1318.

Branch, T. 2025. "Modeling and Stock Assessment of PWS Herring, Annual Project Report to the Exxon Valdez Oil Spill Trustee Council April 9, 2025." https://evostc.state.ak.us/restoration-projects/project-search/modeling-and-stock-assessment-of-prince-william-sound-herring-24120111-c/.

Brooks, M., E. Fergusson, M. Rogers, W. Strasburger, and R. Suryan. 2025. "Juvenile Salmon Body Condition in Southeast Alaska Is Buffered During Marine Heatwaves." *Marine Ecology Progress Series* 760: 135–149.

Burrows, J. A., D. W. Johnston, J. M. Straley, et al. 2016. "Prey Density and Depth Affect the Fine-Scale Foraging Behavior of Humpback Whales *Megaptera novaeangliae* in Sitka Sound, Alaska, USA." *Marine Ecology Progress Series* 561: 245–260.

Cartwright, R., A. Venema, V. Hernandez, C. Wyels, J. Cesere, and D. Cesere. 2019. "Fluctuating Reproductive Rates in Hawaii's Humpback Whales, *Megaptera novaeangliae*, Reflect Recent Climate Anomalies in the North Pacific." *Royal Society Open Science* 6, no. 3: 181463.

Cheeseman, T., J. Barlow, J. M. Acebes, 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* 11, no. 2: 231462.

Cheeseman, T., K. Southerland, J. M. Acebes, et al. 2023. "A Collaborative and Near-Comprehensive North Pacific Humpback Whale Photo-ID Dataset." *Scientific Reports* 13, no. 1: 10237.

Chenoweth, E. M., J. M. Straley, M. V. Mcphee, S. Adkinnson, and S. Reifenstuhl. 2017. "Humpback Whales Feed on Hatchery-Released Juvenile Salmon." *Royal Society Open Science* 4, no. 7: 170180.

Di Lorenzo, E., and N. Mantua. 2016. "Multi-Year Persistence of the 2014/15 North Pacific Marine Heatwave." *Nature Climate Change* 6, no. 11: 1042–1047.

Dias, B. S., D. W. McGowan, R. Campbell, and T. A. Branch. 2022. "Influence of Environmental and Population Factors on Prince William Sound Herring Spawning Phenology." *Marine Ecology Progress Series* 696: 103–117.

Federal Register. 2016. *Endangered and Threatened Species; Identification of 14 Distinct Population Segments of the Humpback Whale (Megaptera novaeangliae) and Revision of Species-Wide Listing*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, 50 CFR Parts 223 and 224 [Docket No. 130708594-6598-03] RIN 0648-XC751.

Frankel, A. S., C. M. Gabriele, S. Yin, and S. H. Rickards. 2022. "Humpback Whale Abundance in Hawai'i: Temporal Trends and Response to Climatic Drivers." *Marine Mammal Science* 38, no. 1: 118–138.

Frisch-Jordán, A., N. Ransome, O. Aranda-Mena, and F. Romo-Sirvent. 2019. "Intensive Feeding of Humpback Whales (*Megaptera novaeangliae*) in the Breeding Ground of Banderas Bay, Mexico." *Latin American Journal of Aquatic Mammals* 14, no. 1: 27–33.

Gabriele, C. M., C. L. Amundson, J. L. Neilson, J. M. Straley, C. S. Baker, and S. L. Danielson. 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* 102, no. 4: 1113–1131.

Gabriele, C. M., J. L. Neilson, J. M. Straley, C. S. Baker, J. A. Cedarleaf, and J. F. Saracco. 2017. "Natural History, Population Dynamics, and Habitat Use of Humpback Whales Over 30 Years on an Alaska Feeding Ground." *Ecosphere* 8, no. 1: e01641.

Gabriele, C. M., J. M. Straley, L. M. Herman, and R. J. Coleman. 1996. "Fastest Documented Migration of a North Pacific Humpback Whale." *Marine Mammal Science* 12, no. 3: 457–464.

Gendron, D. 1993. "Evidence of Feeding by Humpback Whales (*Megaptera novaeangliae*) in the Baja California Breeding Ground, Mexico." *Marine Mammal Science* 9, no. 1: 76–81.

Hastings, K. K., T. S. Gelatt, J. M. Maniscalco, et al. 2023. "Reduced Survival of Steller Sea Lions in the Gulf of Alaska Following Marine Heatwave." *Frontiers in Marine Science* 10: 1127013.

Hobday, A. J., E. C. Oliver, A. S. Gupta, et al. 2018. "Categorizing and Naming Marine Heatwaves." *Oceanography* 31, no. 2: 162–173.

Hulson, P. J. F., S. E. Miller, T. J. Quinn, G. D. Marty, S. D. Moffitt, and F. Funk. 2008. "Data Conflicts in Fishery Models: Incorporating Hydroacoustic Data Into the Prince William Sound Pacific Herring Assessment Model." *ICES Journal of Marine Science* 65, no. 1: 25–43.

Johnson, J. H., and A. A. Wolman. 1984. "The Humpback Whale, *Megaptera novaeangliae*." *Marine Fisheries Review* 46, no. 4: 30–37.

Katona, S., B. Baxter, O. Brazier, S. Kraus, J. Perkins, and H. Whitehead. 1979. "Identification of Humpback Whales by Fluke Photographs." In *Behavior of Marine Animals*, edited by H. E. Winn and B. L. Olla. Springer.

Lammers, M. O., J. Zeh, A. A. Pack, E. Zang, and E. Lyman. 2024. "Humpback Whale Feeding Behavior and Defecation Observed on the Hawaiian Breeding Grounds." *Marine Mammal Science* 40: 2e13177.

Lindeberg, M. R., J. Maselko, R. A. Heintz, C. J. Fugate, and L. Holland. 2018. "Conditions of Persistent Oil on Beaches in Prince William Sound 26 Years After the Exxon Valdez Spill." *Deep Sea Research Part II: Topical Studies in Oceanography* 147: 9–19.

Martien, K. K., B. L. Taylor, A. R. Lang, et al. 2023. "The Migratory Whale Herd Concept: A Novel Unit to Conserve Under the Ecological Paradigm." *Marine Mammal Science* 39, no. 4: 1267–1292.

Mate, B. R., R. Gisiner, and J. Mobley. 1998. "Local and Migratory Movements of Hawaiian Humpback Whales Tracked by Satellite Telemetry." *Canadian Journal of Zoology* 76, no. 5: 863–868.

McGowan, D. W., T. A. Branch, S. Haught, and M. D. Scheuerell. 2021. "Multi-Decadal Shifts in the Distribution and Timing of Pacific Herring (*Clupea pallasii*) Spawning in Prince William Sound, Alaska." *Canadian Journal of Fisheries and Aquatic Sciences* 78, no. 11: 1611–1627.

McHuron, E. A., K. L. Sweeney, and B. S. Fadely. 2024. "Effects of the 2014-2016 Marine Heatwave on Steller Sea Lions in the Gulf of Alaska and Implications for Top-Down Forcing." *Marine Ecology Progress Series* 736: 129–145.

Moran, J. R., R. A. Heintz, J. M. Straley, and J. J. Vollenweider. 2018. "Regional Variation in the Intensity of Humpback Whale Predation on Pacific Herring in the Gulf of Alaska." *Deep Sea Research Part II: Topical Studies in Oceanography* 147: 187–195.

Morella, J. 2025. "Herring Surveys and Age, Sex, and Size Collection and Processing. Annual Project Report to the Exxon Valdez Oil Spill Trustee Council March 1, 2025." https://evostc.state.ak.us/restoration-projects/project-search/surveys-and-age-sex-and-size-collection-and-processing-24160111-f/.

Muradian, M. L., T. A. Branch, S. D. Moffitt, and P. J. F. Hulson. 2017. "Bayesian Stock Assessment of Pacific Herring in Prince William Sound, Alaska." *PLoS One* 12, no. 2: e0172153.

Neilson, J. L., C. M. Gabriele, and H. K. Hoffbauer. 2025. *Glacier Bay & Icy Strait Humpback Whale Population Monitoring: 2024 Update*. National Park Service Resource Brief.

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.

Nemoto, T. 1957. "Foods of Baleen Whales in the Northern Pacific." *Scientific Reports of the Whales Research Institute, Tokyo* 12: 33–89.

Piatt, J. F., J. K. Parrish, H. M. Renner, et al. 2020. "Extreme Mortality and Reproductive Failure of Common Murres Resulting From the Northeast Pacific Marine Heatwave of 2014–2016." *PLoS One* 15, no. 1: e0226087.

Public Law 91-135. n.d. "U.S. Endangered Species Conservation Act of 1969."

Public Law 93–205. n.d. "Endangered Species Act in 1973."

R Core Team. 2022. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing. https://www.R-project.org/.

Ransome, N., A. Frisch-Jordán, T. Cheeseman, et al. 2024. "Environmental Drivers of Persistent Humpback Whale *Megaptera novaeangliae* Feeding Events in a Mexican Breeding Area." *Marine Ecology Progress Series* 726: 161–179.

Renner, H. M., J. F. Piatt, M. Renner, B. A. Drummond, J. S. Laufenberg, and J. K. Parrish. 2024. "Catastrophic and Persistent Loss of Common Murres After a Marine Heatwave." *Science* 386, no. 6727: 1272–1276.

Rivest, L. P., and S. Baillargeon. 2022. "Rcapture: Loglinear Models for Capture-Recapture Experiments.", R package version 1.4-4, https://CRAN.R-project.org/package=Rcapture.

Savage, K. 2017. *Alaska and British Columbia Large Whale Unusual Mortality Event Summary Report*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources. https://repository.library.noaa.gov/view/noaa/17715.

Straley, J. M. 1990. “Fall and Winter Occurrence of Humpback Whales (*Megaptera novaeangliae*) in Southeastern Alaska.” *Report of the International Whaling Commission Special* 12: 319–323.

Straley, J. M., J. R. Moran, K. M. Boswell, et al. 2018. “Seasonal Presence and Potential Influence of Humpback Whales on Wintering Pacific Herring Populations in the Gulf of Alaska.” *Deep Sea Research Part II: Topical Studies in Oceanography* 147: 173–186.

Suryan, R. M., M. L. Arimitsu, H. A. Coletti, et al. 2021. “Ecosystem Response Persists After a Prolonged Marine Heatwave.” *Scientific Reports* 11, no. 1: 6235.

Szabo, A. 2015. “Immature Euphausiids Do Not Appear to Be Prey for Humpback Whales (*Megaptera novaeangliae*) During Spring and Summer in Southeast Alaska.” *Marine Mammal Science* 31, no. 2: 677–687.

van Aswegen, M., A. Szabo, J. J. Currie, et al. 2025. “Energetic Cost of Gestation and Prenatal Growth in Humpback Whales.” *Journal of Physiology* 603, no. 2: 529–550.

von Biela, V. R., M. L. Arimitsu, J. F. Piatt, et al. 2019. “Extreme Reduction in Nutritional Value of a Key Forage Fish During the Pacific Marine Heatwave of 2014–2016.” *Marine Ecology Progress Series* 613: 171–182.

Wade, P. R. 2021. “Estimates of Abundance and Migratory Destination for North Pacific Humpback Whales in Both Summer Feeding Areas and Winter Mating and Calving Areas.”, International Whaling Commission. SC/68c/IA/03. 32.

Witteveen, B. H., R. J. Foy, K. M. Wynne, and Y. Tremblay. 2008. “Investigation of Foraging Habits and Prey Selection by Humpback Whales (*Megaptera novaeangliae*) Using Acoustic Tags and Concurrent Fish Surveys.” *Marine Mammal Science* 24, no. 3: 516–534.

Witteveen, B. H., and K. M. Wynne. 2017. “Site Fidelity and Movement of Humpback Whales (*Megaptera novaeangliae*) in the Western Gulf of Alaska as Revealed by Photo-Identification.” *Canadian Journal of Zoology* 95, no. 3: 169–175.

Zerbini, A. N., P. J. Clapham, and P. R. Wade. 2010. “Assessing Plausible Rates of Population Growth in Humpback Whales From Life-History Data.” *Marine Biology* 157, no. 6: 1225–1236.