Interim Report on Post-Delisting Monitoring of Nine Distinct Population Segments of Humpback Whales (*Megaptera novaeangliae*)

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U.S. Department of Commerce
National Oceanic and Atmospheric Administration
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NOAA Technical Memorandum NMFS- F/SPO-230
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Gina M. Raimondo, Secretary

National Oceanic and Atmospheric Administration
Richard W. Spinrad, NOAA Administrator

National Marine Fisheries Service
Janet Coit, Assistant Administrator for Fisheries

Recommended citation:

Schakner, Z. A., Chan, A., Kurtz, Graham, K. Young, N., Teerlink, N. 2022. Interim Report on Post-Delisting Monitoring of Nine Distinct Population Segments of Humpback Whales (*Megaptera novaeangliae*). NOAA Tech. Memo. NMFS- F/SPO-230. 22 p.

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Table of Contents

Introduction

In 2016, the National Marine Fisheries Service (NMFS) revised the species-wide Endangered Species Act (ESA) listing for humpback whales (81 FR 62259, September 2016), listing 4 of the 14 distinct population segments (DPSs) as endangered, one as threatened, and leaving nine DPSs not listed. Under section 4(g) of the ESA, and joint guidance from NMFS and U.S. Fish and Wildlife Service (USFWS), NMFS is to monitor, for a minimum of five years, any species delisted due to its recovery (USFWS and NMFS, 2008). Although nine DPSs of humpback whales no longer qualified for listing and thus were technically not "delisted," for the reasons explained in the ESA listing final rule, NMFS considered it appropriate to monitor the status of the populations that are no longer listed. As a result, in 2016, NMFS completed a plan to carry out the required monitoring for nine DPSs of humpback whales: the Hawaiʻi, West Indies, Brazil, West Australia, East Australia, Southeastern Pacific, Oceania, Southeast Africa/Madagascar, and Gabon/Southwest Africa DPSs (NMFS, 2016).

The monitoring plan has three primary goals:

1. Monitor each DPS to detect changes in trends in the production of calves and adult/juvenile abundance and population growth rates, and distinguish if changes are a threat to the DPS or a signal that the DPS is approaching or has surpassed the DPS's carrying capacity;
2. Monitor the DPSs to detect changes in spatial and temporal distribution; and
3. Monitor residual or emerging threats and identify new threats that could affect the sustainability of the recovery of the humpback whale DPSs.

The monitoring plan specifies that annually, during the 10-year monitoring period (2017-2026), NMFS will review and summarize available data on various parameters such as abundance trends, population growth rates, spatial and temporal distribution, and existing/emerging threats (NMFS, 2016). This is the first "interim report" consolidating and evaluating available monitoring data from several-year intervals to summarize the best available information regarding the status of the nine non-listed humpback whale DPSs. We plan to complete subsequent annual reports at approximately 12-month intervals from this report's completion date. This interim report covers the major data categories described in the post-delisting monitoring plan (NMFS, 2016). This ongoing monitoring is designed to detect any population declines, changes in spatiotemporal distribution, or threats that may warrant implementing measures to ensure that humpback whales remain secure from the risk of extinction.

Methods

Beginning in June 2020, NMFS convened a post-delisting monitoring plan group (PDMP working group) to assemble, review, and discuss any updated data on the nine non-listed DPSs. NMFS contacted federal and state wildlife and natural resource agencies, non-governmental organizations, and management entities and requested updated information regarding the abundance, status, and management of humpbacks in their respective locales. NMFS also reviewed any relevant recent information available, including publications or reports on humpback whale abundance, trends, and threats. At least some humpback whales from each of the nine non-listed DPSs occur in waters outside United States jurisdiction. Therefore, in addition to coordinating with the appropriate U.S. federal and state agencies, NMFS is coordinating with the International Whaling Commission (IWC), foreign nations, and other non-governmental organizations to monitor the species' status throughout their range. These efforts are ongoing.

NMFS worked with the PDMP working group to review available data and publications and prepare this report. Most of the information in this report was derived from peer-reviewed publications or reports. These data and information were used to assess whether any of the "response triggers" identified in the plan have been reached, including:

Negative triggers:

- Any significant decline in abundance or range;
- A decline in birth or survival rates of humpback whale populations, or new estimates of birth rate, which indicate that any humpback whale DPS is negatively responding to a new threat or an increase in a previously identified threat;
- Large contraction of spatial distribution or change in temporal distribution for any humpback whale DPS;
- Whether a new threat has emerged, the magnitude of an existing threat has increased, and/or that the cumulative effects from threats are likely greater than previously understood, such that it (they) may pose a threat to local or range-wide reproduction or survival of any humpback whale DPS; or
- Evidence of a decline in a significant health factor (e.g., body condition as a result of disease or malnutrition) beyond what would be expected as populations approach their natural carrying capacity.

Positive triggers:

- An increase in the estimated rate of survival or new estimates of birth rate, which indicate that individuals from any humpback whale DPS are not being negatively affected by new threats or an increase in a previously identified threat;
- Evidence suggesting or indicating an increase in non-calf numbers and/or high reproductive rate is occurring in any humpback whale DPS;
- Maintenance or expansion of spatial distribution;
- Results from threats monitoring that indicate that no new threats have emerged or the strength of any existing threat has not increased; or
- Evidence of an improvement in a significant health factor.

Results

Hawai‘i DPS

The Hawai‘i DPS consists of humpback whales breeding or frequenting the main Hawai‘ian Islands. Based on unpublished photo-identification data through 2020 from the Happywhale North Pacific Collaboration, about 40% of Hawai‘i DPS whales also have a feeding ground sighting[1]. About 3% of Hawai‘i DPS whales have been documented in the Mexico breeding grounds as well as Hawai‘i, including one whale that has been sighted in Central America and Hawai‘i[1]. Whales from the Hawai‘i DPS have been observed in most of the known feeding grounds in the North Pacific. Many whales from this population migrate to Southeast Alaska and Northern British Columbia, the Washington, California and Oregon coasts, the northern Gulf of Alaska, Aleutian Islands, Commander Islands, and Bering Sea (Wade, 2021). Presently, it is difficult to determine the proportion of whales that use each of these areas, as most of the areas do not have ongoing humpback whale population monitoring. In recent years, the advent of Happywhale automated fluke matching has revolutionized individual identification of humpback whales, and its citizen science component gathers sighting data from whale watchers and the general public in a variety of locations where whale research may or may not be underway.

The most recent estimate of humpback whale abundance in Hawai‘i from 2004–2006 was based on an international, multi-research group photo-identification (i.e., photo-ID) and tissue analysis (e.g., biopsy sampling) study termed “SPLASH” (Status of Populations, Levels of Abundance and Structure of Humpback Whales). That effort revealed an estimated 21,808 humpbacks in the North Pacific, of which 10,103 (excluding calves) were estimated to migrate to Hawai‘i and were considered a DPS (Barlow et al., 2011; Calambokidis et al., 2008). A recent analysis of SPLASH data found an estimate of 11,540 (cv=0.042) in Wade (2021). The SPLASH study also estimated an annual growth rate of humpback whale abundance in Hawai‘i up to around 6% (Calambokidis et al., 2008), a figure that agreed with the 7% annual growth rate calculated earlier by Mobley et al. (2001) based on aerial survey data. There are updated population estimates for the Hawai‘i DPS in preparation based on updated data. Recent ship-survey data from 2020-22, along with environmental variables, have been used to estimate the abundance of humpback whales in winter in the Hawaiian Islands EEZ. The resulting estimate of abundance was 11,278 (CV=0.56, 95% CI 4,049-31,412) (Becker et al., 2022), which is considered the best current estimate of abundance for Hawai‘i and for the DPS as a whole.

A prolonged and intense marine heatwave, with elevated sea surface temperatures up to 6.7º C above normal, dominated a broad swath of the Northeast Pacific Ocean from late 2013 through 2016 (Bond et al., 2015; Di Lorenzo and Mantua, 2016; Holbrook et al., 2019). In the Gulf of Alaska, abnormally warm water temperatures in the upper 250–300 m of the water column persisted through 2019 (Walsh et al., 2018; Suryan et al., 2021). During and after the heatwave, ecological disruptions and mass mortalities were detected throughout the marine food web,

[1] T. Cheeseman, T. [2021] Personal commun. Southern Cross University, Southern Cross University, Marine Ecology Research Centre, Southern Cross University, PO Box 157, Lismore, NSW 2480 Australia.

presumably linked to declines in the quantity and quality of zooplankton and key forage fish species (Piatt et al., 2020; Arimitsu et al., 2021; Suryan et al., 2021). Several lines of evidence indicate that humpback whales were strongly affected throughout their Alaskan feeding grounds. Early in the 2015–2016 humpback whale breeding season in Hawai‘i, tour companies on Hawai‘i Island began reporting lower than expected numbers of humpback whales for that time of year. This was initially thought to represent either a patchy distribution across the Hawai‘ian Islands or a delayed arrival. However, as the season progressed, additional reports were received from tour operators, fishers, and researchers on different islands that corroborated the concern of unusually low sightings throughout the islands. Looking back over data, a decreasing trend in sightings and lower calf production had been noted by researchers in both Hawai‘i and Alaska as early as 2013. In Alaska, observations of emaciated animals and changes in distribution (i.e., habitat use) were also noted (Moran et al., 2017; Zador and Yasumiishi, 2017; Moran and Straley, 2018). In response, NOAA Fisheries led and funded a collaborative study with several Southeastern Alaska researchers from multiple organizations and institutions to expand their survey efforts. This study was termed SPLISH: Survey of Population Level Indices for Southeast Alaska, and it used a rapid assessment approach to attempt to census whales throughout as much of Southeast Alaska as possible over two-week periods in 2016, 2017, and 2018 (Moran et al., 2017; NOAA, 2019). While SPLISH ended in 2018, the research and management community in both Hawai‘i and Alaska remain engaged in these multi-year projects to better understand the fluctuations occurring in this population, and early results demonstrate promising capabilities to detect both long- and short-term threats to humpback whale populations.

As changes in this DPS continued to be observed over subsequent seasons, researchers continued to investigate the trends and determine possible causal factors. In November 2018, HIHWNMS and NMFS convened key researchers and managers to examine recent trends in humpback whale abundance, distribution, and health in both Hawai‘i and Alaska (NOAA, 2019). Workshop participants presented data from boat-based transect surveys, boat-based photo-ID efforts, shore-based controlled scans using theodolite technology, passive acoustic monitoring (PAM), shore-based citizen science counts, and health assessments of individuals based on visual indices, including the use of unmanned aerial systems technology. The results indicated an overall reduction in sighting rates of humpback whale calves and non-calves in both Alaska (Southeast Alaska and Prince William Sound) and Hawai‘i (Hawai‘i Island and Maui Island) over the previous 4–5 years. These findings were consistent with data from PAM recorders concurrently deployed off Maui, indicating a significant reduction in sound pressure levels of the chorusing humpback whales over the same period (Kügler et al., 2020). However, systematic data are lacking to assess humpback whale trends in other areas of the Hawai‘ian Islands, particularly in the Northwestern Hawai‘ian Islands and elsewhere in the Pacific. There is evidence for a correlation between whale reductions and environmental factors such as a strong El Niño event, the 2014–2016 broad-scale oceanic heat wave in the northeast Pacific, and a warming period in the Pacific Decadal Oscillation cycle (Cartwright et al., 2019; Frankel et al., 2021). Several hypotheses were proposed to help explain reduced whale counts, including nutritional stress, changes in distribution, human impacts (e.g., entanglement), and natural cyclical variability.

The meeting participants also identified various knowledge gaps and research priorities to address these gaps (NOAA, 2019). The top five research priorities were consistent with the monitoring methods outlined in the PDMP (NMFS, 2016) and included:

- Distribution of whales — Improve existing knowledge about humpback whale habitat use to determine whether lower numbers of whales observed indicate a shift in breeding and/or feeding habitat use. Do this via leveraging existing datasets and pursuing new studies.
- Population health — Increase assessment of humpback whale body condition and health using morphometrics and biomarkers over a broad geographic scale to assess whether health is a factor in decreased sightings.
- Demographics/trends — Determine whether humpback whale abundance, reproduction, and survival rates have changed over time in breeding and feeding areas and whether the apparent recent changes are beyond what one would expect from a population at equilibrium or "carrying capacity."
- Prey distribution and quality — Investigate potential changes in quality, quantity, and distribution of food sources to address the hypothesis that nutritional stress is a factor that is affecting humpback whale demography, habitat use, health, and behavior.
- Environmental and anthropogenic drivers — Investigate the role of environmental and anthropogenic factors in all of the above, including oceanographic conditions, climatic conditions, and land/sea connections.

Feeding ground monitoring

Many humpback whales from Hawaiʻi move to summer feeding areas in Alaska (Calambokidis et al. 2008). Photographic ID matches from the SPLASH project show that areas in Alaska and northern British Columbia appear to be the primary migratory destination for whales from Hawaiʻi (Wade et al, 2021). However, there are matches from Hawaiʻi to every summer feeding area that was sampled, except for California/Oregon.

A line-transect survey in 2018 throughout nearly all humpback whale habitat in British Columbia resulted in estimates of 4,935 (CV=0.13) for the offshore area, 1,816 (CV=0.13) for the North Coast area, and 279 (CV=0.40) for the Salish Sea area (inland waters of the Strait of Georgia and Strait of Juan de Fuca) (Wright et al. 2021)

Southeast Alaska and Prince William Sound are parts of the feeding range of whales from the Hawaiʻi DPS that have consistent humpback whale population monitoring. Population monitoring in and around Glacier Bay, Southeast Alaska has tracked the population trajectory since 1985. After decades of variable population growth and reproductive success, the 2014-2016 Northeast Pacific Marine Heatwave (PMH) appears to have brought about widespread ecological disruption that included humpback whales (Arimitsu et al., 2021). Mark-recapture analysis of data from the National Park Service's long-term population monitoring program in the Glacier Bay area of the Southeast Alaska feeding area documented a sharp decline in whale abundance, reproduction, and survival believed to be a result of food limitation, far beyond what one would expect from population density dependence alone (Gabriele et al., 2022).

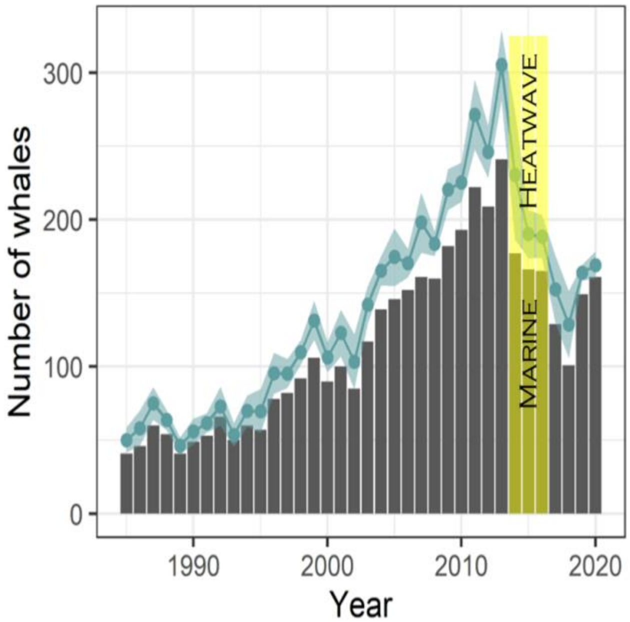

Figure 1. The number of different individually identified humpback whales sighted June-August 1985-2020 in Glacier Bay and Icy Strait (vertical bars). Blue line shows mark-recapture abundance estimates of humpback whales 1985-2020 with shading that denotes 95% confidence intervals. The years of the Northeast Pacific marine heatwave (2014-2016) are shaded in yellow. Adapted from Gabrielle et al. (2022).

Specifically, in Glacier Bay and Icy Strait, non-calf abundance decreased by 56% between 2013 and 2018 (Figure 1), followed by modest increases in 2019 and 2020. Prior to the PMH, calf production averaged one calf per three females (0.27 calves per adult female). In contrast, for a five-year period during and after the PMH (2015–2019) there was about one calf born for every 25 adult females (0.041 calves per adult female). Additionally, there was a tenfold drop in calf survival—from 0.396 between 1985 and 2013 to 0.032 between 2014 and 2020 (Gabriele et al., 2022). Poor whale body condition post-heatwave suggests that prey quantity or quality was limited. In 2016 through 2019, 10–23% of whales appeared abnormally thin (following the protocol of Bradford et al., 2012) including mothers and calves. This trend continued into summer 2021[2]. While it is not unusual for some whales to be noted as "thin" in the springtime, during and after the PMH, many individuals continued to appear thin into late summer and fall[2,3].

Between 2007 through 2020, spring and fall monitoring of feeding grounds in Prince William Sound, Alaska, documented a decline associated with the 2014–2016 PMH. During the 2020 fall survey, encounters for humpback whales were lower than in the preceding years (Figure 2; Moran and Straley, 2021). The reduced number of humpback whales sighted in Prince William

[2] Neilson, J. L., C. M. Gabriele, and A. R. Bendlin. 2022. Glacier Bay & Icy Strait Humpback Whale Population Monitoring: 2021 Update. National Park Service Resource Brief, Gustavus, Alaska. Available at https://irma.nps.gov/DataStore/DownloadFile/668731

[3] van Aswegen, M. 2020. Unpubl. data. University of Hawaii-Manoa

Sound may be attributed to the steep decline in herring biomass (an essential source of prey for these whales) and other prey-related impacts resulting from the PMH.

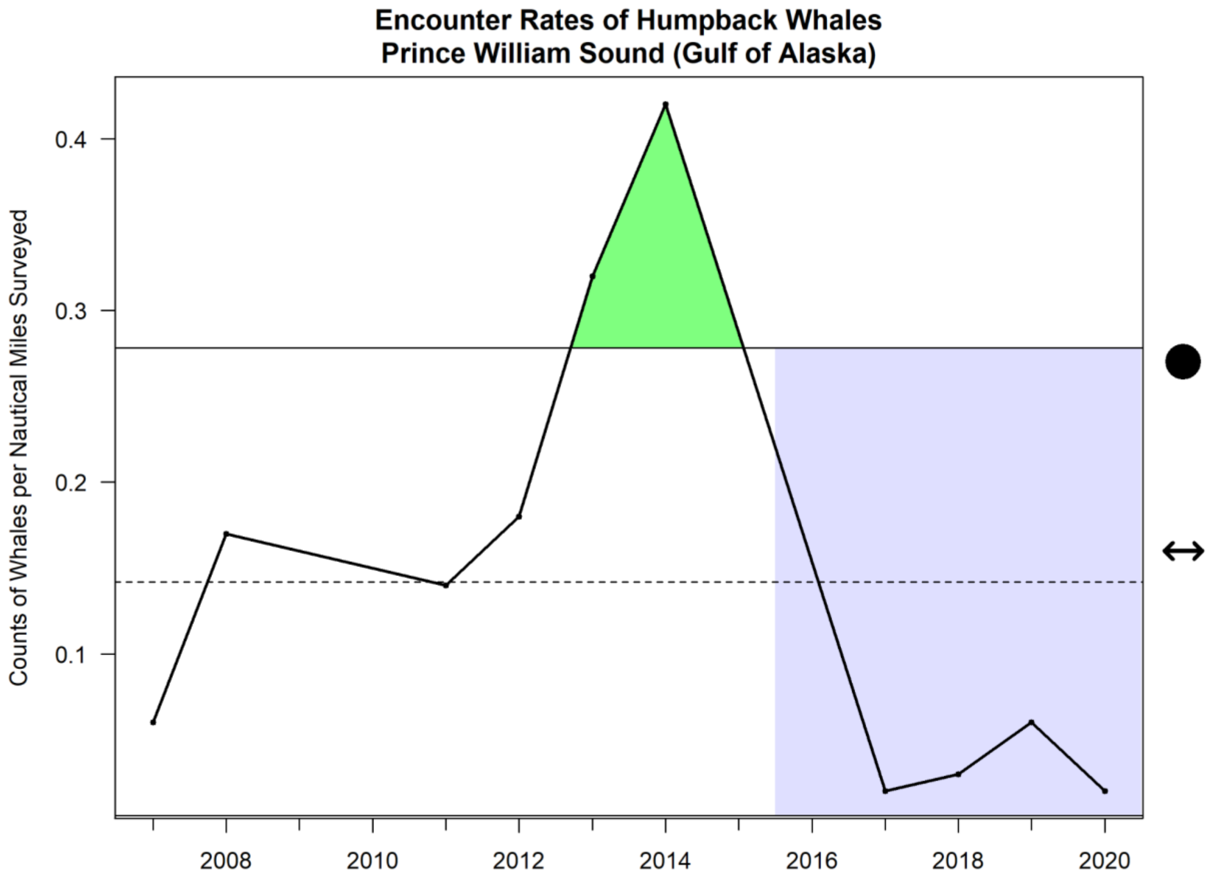

Figure 2: Encounter rates of humpback whales in Prince William Sound, calculated as the counts of observed whales divided by the nautical miles surveyed. All surveys occurred in September, except the 2011 survey, which occurred in October. For more information, see Table 1 in Moran and Straley (2021).

An Unusual Mortality Event (UME) involving large whales in the Gulf of Alaska and British Columbia, Canada, occurred from May 22, 2015, to December 31, 2015, in the Gulf of Alaska and from April 23, 2015, to April 16, 2016, in British Columbia, Canada. The total number of humpback whale cases investigated was 28 in 2015 and 7 in 2016. Across large whale species, differential stranding causes included sonar/seismic testing, radiation, ship strike, infectious disease, predation, and oceanographic changes leading to algal toxin exposure or starvation due to shifts in prey species/distribution. NMFS concluded there was not a direct cause of the UME. But, because the strandings were concurrent with more general anomalous physical and biological shifts in the Alaskan marine environment (Savage, 2017), the UME was likely one of many indicators of broader, complex and dynamic ecological change (Savage, 2017). The humpback mortalities during the UME suggest the northeast Pacific marine heatwave was a temporary but significantly increasing threat. Ongoing climate change is expected to increase the intensity and duration of marine heatwaves through the end of the 21st century (Oliver et al., 2019), which could substantially impact the abundance and growth rates of humpback whale populations.

Breeding ground monitoring

Monitoring of the breeding grounds in Hawaiʻi has documented similar patterns of variability in the numbers of individuals observed in the area. An analysis of a 19-year time series (2001-2019) dataset of systematic, shore-based humpback whale counts off Kawaihae Bay, Hawaiʻi Island, found that whale numbers peaked in 2010, followed by a period of increased interannual variability lasting through 2015. Whale numbers dropped in 2016 to the lowest value since 2001 and remained low through 2019 (Frankel et al., 2021). The study also documented that the annual mean crude birth rate (the number of calves divided by the number of whales per area scanned, averaged across years) fell from 6.5% in 2001–2015 to 2.1% in 2016–2019 (Frankel et al., 2021). Frankel et al. (2021) noted that while both birth rate and counts have a positive trend within the 2016–2019 period, those values remain far lower than the previous trend during the 2001–2015 period, suggesting the population experienced a sharp decline in abundance and a decrease in abundance, but that it is now recovering. Frankel et al. (2021) also state that changes in whale migratory patterns between islands and reductions in the amount of time spent at migratory termini could account for some observed changes in whale numbers, but if whale numbers remain low over the next few years, a general population decline is the most likely hypothesis. They recommend that systematic monitoring at multiple sites within the Hawaiʻian Islands will be necessary to distinguish changes in whale distribution from population decline.

Several research organizations and agencies are collecting fluke ID data and/or biopsy samples to be stored in longstanding archives. The Hawaiʻian Islands Humpback Whale National Marine Sanctuary (HIHWNMS) is also engaged in a long-term acoustic monitoring effort to quantify annual whale abundance trends using song chorusing levels (Kügler et al., 2020). In the breeding grounds off western Maui Island, vessel-based surveys using distance sampling methods were conducted from 2018 to 2021 (three breeding seasons) to enumerate whale presence (Zang and Lammers, 2021). These data suggest that following a period of notable decline in whale presence in Hawaiʻi between 2015 and 2018, whale numbers have begun to generally increase over the three breeding seasons in west Maui.

Data from multiple line-transect surveys since 2002 have been used to develop and update species distribution models (SDMs) for cetaceans within the U.S. Exclusive Economic Zone (EEZ) around the Hawaiian Islands (Becker et al., 2022) but these surveys were primarily in summer and fall. Until recently, systematic ship survey data in the winter months were limited to a single focused survey of the Main Hawaiian Islands (MHI) from 6–24 February 2009), and a few ship transits in proximity to the MHI. To better understand the abundance and distribution of cetaceans in the winter months, a winter survey (Winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey, or WHICEAS) was conducted within offshore waters around the MHI from 18 January to 12 March 2020 (Yano et al., 2020). Becker et al. (2022) used the 2002-2020 survey data, along with environmental variables, to build an SDM to estimate the density and abundance of humpback whales in the Hawaiian Islands EEZ for recent years (2017-2020). Since a significant seasonal difference in abundance was evident for humpback whales, the final SDM was used to derive spatially-explicit monthly density estimates based on the average of weekly predictions spanning 2017–2020. To obtain a single abundance estimate, weekly predictions for this time period were averaged to estimate the density and number of whales within the study area during 2020, the most recent year in the time series and the year of the WHICEAS survey effort. This estimate represents the peak abundance of humpback whales in the Hawaiian Islands EEZ during 2020, but may under-represent the full abundance of whales that overwinter in the region because individual whales may not have a very long residence time in Hawaiʻi; Craig et al. (2001) found that for the majority of whales (66%), two weeks or less elapsed between their first and last identification within the same field season. Therefore, some individual whales might only be found in Hawaiʻi outside of the peak period. The resulting estimate of abundance was 11,278 (CV=0.56, 95% CI 4,049-31,412) (Becker et al., 2022), which is considered the best current estimate of abundance for Hawaiʻi and for the DPS as a whole. This estimate is not substantially different from the mark-recapture estimate from the SPLASH data in 2004-2006.

In order to better understand the status of humpback whales in the main Hawaiʻian Islands, additional monitoring efforts began to monitor whale presence in the northwestern Hawaiʻian Islands (NWHI). In April 2019, NMFS conducted vessel-based surveys in the Papahānaumokuākea Marine National Monument (PMNM) in the NWHI, an area that has previously had minimal research effort. Between January and March 2020, HIHWNMS, PMNM, and Jupiter Research Foundation conducted an acoustic survey examining the presence of humpback whales' song in the NWHI using a Wave Glider autonomous surface vehicle. These efforts are likely to increase our understanding of areas with less research focus and give a more comprehensive understanding of the Hawaiʻian breeding ground.

Other ongoing monitoring efforts

Research efforts to monitor humpback whale abundance, health, distribution, and threats are ongoing in parts of the Hawai'i DPS's range. NMFS and Cascadia Research Collective are planning a follow-up project to SPLASH, called SPLASH-2, that will examine humpback whale populations in the North Pacific, including the Hawaiʻi DPS. Humpback whale researchers and managers from international and domestic regions throughout the North Pacific met in December 2020 to commence planning the SPLASH-2 project. Preliminary discussions from this meeting indicate that most of the awarded funding will be put towards analyzing existing humpback whale data (e.g., photo-ID catalogs). As of 2022, these efforts have yielded a database of 2200 individually identified humpback whales captured with UAS imagery which are being used to investigate body condition. These efforts are ongoing and will be shared in future PDMP annual reports as results become available.

Threats

HIHWNMS, NMFS, and other partners in the Marine Mammal Health and Stranding Response Network continue to monitor and respond to the primary anthropogenic effects to this DPS including entanglements, vessel strikes, and climate change. Following the November 2018 meeting (NOAA, 2019), NMFS internally discussed the possibility that one or more of the PDMP's response triggers was reached for the Hawaiʻi DPS. However, in the time since these internal discussions began, seasonal humpback whale sightings in Hawaiʻi had increased[4]. Taken

[4] Lammers, Marc. 2021. Personal commun. Hawaiian Islands Humpback Whale National Marine Sanctuary, 726 S. Kihei Rd., Kihei, HI 96753.

together, the trends presented in this report for the Hawai‘i DPS were not conclusive enough to reach a response trigger at that time. However, NMFS, HIHWNMS, and research partners will continue to closely monitor the status of the humpback whale Hawai‘i DPS, ongoing threats, and take appropriate action in accordance with the PDMP.

West Indies DPS

The breeding range of the West Indies DPS includes the Atlantic margin of the Antilles from Cuba to northern Venezuela, and its feeding range primarily includes the Gulf of Maine, eastern Canada, and western Greenland. While many West Indies whales also use feeding grounds in the central (Iceland) and eastern (Norway) North Atlantic, many whales from these feeding areas appear to winter in another location. The West Indies DPS's feeding areas are wide and scattered, requiring a basin-wide collaborative effort like Year of North Atlantic Humpback (YoNAH) to get an accurate, updated DPS-wide abundance estimate.

Feeding ground monitoring
Recent work assessing abundance in various feeding regions of the West Indies DPS appears to show that most groups are growing in abundance. Analysis of line-transect surveys of Icelandic and Norwegian feeding grounds estimate 25,000 humpback whales inhabit the feeding grounds off Norway, the Faroe Islands, Iceland, and Greenland during the summer feeding season (Pike et al., 2019; Leonard and Øien, 2020a,b). This is a substantial increase from earlier surveys from 1996 to 2001. Off the Canadian coast of Newfoundland and Labrador, analysis of aerial survey data estimates about 8,439 (CV=0.49) whales in the region, a marked increase from the previous survey in 2007 (Lawson and Gosselin, 2018). While demographic studies tracking population growth rates are unknown, increasing abundances are suggestive of growth rates matching those of many other populations of humpback whales around the world. In the Gulf of Maine stock, defined as a discrete subpopulation that utilizes the Gulf for foraging, the best available abundance estimate is 1,393 (95% credible intervals 1,351−1,429) based on a state-space model of individual whales' sighting histories identified using photo-ID techniques (Robbins and Pace, 2018). The Gulf of Maine population growth rate (1.05%, calculated based on data from 2004 to 2016) appears to be lower than those apparent rates of other feeding ground assessments, which are based upon line-transect surveys (Robbins and Pace, 2018).

In January 2016, a humpback whale UME was declared for the U.S. Atlantic coast due to elevated numbers of mortalities (a total of 140 strandings from 2016 to 2020[5]). Partial or full necropsy examinations were conducted on approximately half of the whale carcasses. Of the whales examined, about 50% had evidence of human interaction, which includes both ship strikes and entanglements.

Breeding ground monitoring
There is ongoing research focusing on the breeding grounds of the West Indies DPS, including the composition of the wintering population. Still, the use of breeding grounds by

[5] NOAA Fisheries. 2022. 2016–2022 Humpback Whale Unusual Mortality Event Along the Atlantic Coast. Office of Protected Resources. Available at https://www.fisheries.noaa.gov/national/marine-life-distress/2016-2020-humpback-whale-unusual-mortality-event-along-atlantic-coast

various feeding groups is poorly understood in terms of arrival times, stay times, and mixing. Photo-ID data collection from aerial and ship-based surveys on the breeding grounds is ongoing. A recent analysis of movements within the West Indies suggested the potential repopulation of humpback whales' historical range in the Caribbean (but not areas in Puerto Rico); however, this work is still preliminary (MacKay et al., 2019).

Threats

For the West Indies DPS, the following threats have been documented: potential overlap with shipping vessels (Brown et al., 2019), entanglements (Basran et al., 2019), and sound in the Caribbean (Heenehan et al., 2019). However, based on the most recent information on the DPS's abundance and trends, these threats do not appear to be substantially affecting its recovery at this time.

Southern Ocean DPSs (Brazil, West Australia, East Australia, Southeastern Pacific, Oceania, Southeast Africa/Madagascar, Gabon/Southwest Africa)

The IWC completed the first comprehensive Southern Hemisphere humpback whale assessment in 2015 (Jackson et al., 2015), prior to the 2016 revision the species-wide Endangered Species Act (ESA) listing for humpback whales (81 FR 62259, September 2016). In general, the assessment projected an overall recovery trajectory for Southern Ocean humpback whale DPSs, and a total abundance of Southern Hemisphere humpback whales was estimated to be about 98,000 in 2015, compared to 140,000 prior to modern whaling (Jackson et al., 2015). This assessment suggested, however, differing population recovery trajectories between populations and oceans. Given that this assessment was conducted several years ago, we discuss recent data or publications for each Southern Ocean DPS below.

Brazil DPS

This DPS consists of whales that breed between 3°S and 23°S in the southwestern Atlantic along the coast of Brazil with a prominent concentration around the Abrolhos Bank (15°–18°S), and feed off South Georgia and the South Sandwich Islands. There are ongoing sighting and photo-ID collection efforts. Ship surveys on breeding and feeding grounds for estimating recent abundance and trends (Bortolotto et al., 2016; Bortolotto et al., 2017) occurred in 2008 and 2012. There is evidence that this DPS has recovered strongly, and the current abundance estimate is close to 25,000 whales, which is estimated to be about 93% of their pre-exploitation levels (Zerbini et al., 2019). Additionally, efforts to track humpback whale movements are ongoing. Land-based surveys suggest the reoccupation of a wintering area in Serra Grande, Bahia state, Brazil (Gonçalves et al., 2018), which provides further evidence of ongoing recovery for this DPS.

Threats
For the Brazil DPS, the following threats have been documented: human disturbance (Brown et al., 2019), entanglements (Ott et al., 2016), and ship strikes (Bortolotto et al., 2016). However,

based on the most recent information on the DPS's abundance and trends, these threats do not appear to be substantially affecting its recovery at this time.

West Australia DPS

The West Australia DPS consists of the whales whose breeding/wintering range includes the West Australia coast, primarily in the Kimberly Region. Individuals in this population migrate to feeding areas in the Antarctic, mainly between 80°E and 110°E, based on tagging data. There is survey work in IWC Breeding Stock D (Eastern Indian Ocean) aimed at quantifying abundance and trend, which can likely provide robust data for these analyses, but these efforts are still ongoing. There is emerging and preliminary evidence for an expanded breeding ground based upon aerial surveys and observations of neonates farther south than previously observed (Irvine et al., 2017). This may suggest expanded or reoccupation of breeding grounds as seen in other populations of recovering humpbacks (Irvine et al., 2017). Unmanned aircraft systems (UAS) have been and are being used to assess body condition for this DPS (Christiansen et al., 2020); these efforts are preliminary and ongoing but might provide an important baseline for tracking population health.

Threats
A recent tagging study (Bejder et al., 2019) of humpback whale mothers and calves on this DPS's breeding grounds suggested that lactating humpback whales lower their energy expenditure by resting stationarily at shallow depths. This resting behavior and potential overlap with shipping lanes suggest a potential for vessels strikes. Additionally, acoustic monitoring efforts suggest the majority of soundscape is from biological resources, suggesting even moderate novel anthropogenic noise from vessels could impact whale communication (Bejder et al., 2019). Based on this study, vessel strikes and anthropogenic sound impairing communication are potential threats to this population (Bejder et al., 2019) but based upon the most recent information on the DPS's abundance and trends, these threats do not appear to be substantially affecting its recovery at this time. Of note, the Australia has removed humpback whales from the endangered species list.

East Australia DPS

The East Australia DPS consists of the whales breeding/wintering along the eastern and northeastern Australian coast. Based upon tagging, telemetry, and re-sighting data, individuals in this population migrate to Antarctic feeding areas ranging from 100°E to 180°E, but are concentrated mostly between 120°E and 180°E. Long-term, consistent survey data on IWC Breeding Stock E1 (Western South Pacific) provide robust estimates of increasing abundance and trend. The surveys since 2004 have shown a continued and consistently high rate of increase in the East Australian DPS (Noad et al., 2019). The most recent analysis of these survey data suggests that the population grows at a long-term average rate of 10.9% per annum. The latest abundance estimate, derived from 2015 survey data, is 24,545 whales (95% CI=21,631–27,851), with little evidence of the growth rate slowing down. According to Noad et al. (2019), the rate of growth and abundance suggests this DPS is on track for higher than the expected abundance of at least 40,000 whales and a peak in whale abundance in 2021–2022. Correspondingly, citizen scientists collect long-term data using shore-based counts (Pirotta et al., 2020). Analysis of these data estimated an exponential growth rate of 0.099 (95% CI=0.079–0.119) equating to 10% per annum growth in sightings since 1997 (Pirotta et al., 2020). Altogether, the data suggest the East Australia DPS exhibits robust growth and increasing abundance.

Threats
A review of 25 years of stranding data of humpback whales on the east coast of Australia suggests that vessel strikes and fishing entanglements are the primary threats to this population (Meynecke and Meager, 2016; Harrison and Woinarski, 2018). Based upon the most recent information on the DPS's abundance and trends, these threats do not appear to be substantially affecting its recovery at this time.

Southeastern Pacific DPS

The Southeastern Pacific DPS consists of whales that breed/winter along the Pacific coasts of Panama to northern Peru (9°N–6°S), with the main wintering areas concentrated in Colombia. Feeding grounds for this DPS are thought to be concentrated in the Chilean Magellan Straits and the western Antarctic Peninsula. These cross-equatorial breeders feed in the Southern Ocean during much of the austral summer.

According to the IWC Southern Ocean assessment, this DPS appears very close to recovery (>90% of pre-exploitation abundance). There are preliminary, localized photo-ID data collection efforts in progress. A long-term analysis (1988–2018) of arrival and departure times to the breeding ground of Gorgona National Park, Colombia, found that whales have significantly changed their arrival time, arriving earlier and staying one month longer than in the past (Avila et al., 2020). Additionally, hormonal analysis from tissue samples of individuals on their feeding grounds in the Western Antarctic Peninsula suggests high pregnancy rates (Pallin et al., 2018). These data are aligned with global recovery patterns.

Threats
Vessel strikes, acoustic masking from dense vessel traffic (Guzman et al., 2020; Jeri et al., 2020) and fisheries bycatch (Alava et al., 2019) appear to be the primary threats to this DPS. Based upon the most recent information on the DPS's abundance and trends, these threats do not appear to be substantially affecting its recovery at this time.

Oceania DPS

The Oceania DPS consists of whales that breed/winter in the South Pacific Islands between ~160°E (west of New Caledonia) to ~120°W (east of French Polynesia), including American Samoa, the Cook Islands, Fiji, French Polynesia, Republic of Kiribati, Nauru, New Caledonia, Norfolk Island, New Zealand, Niue, the Independent State of Samoa, Solomon Islands, Tokelau, Kingdom of Tonga, Tuvalu, Vanuatu, and the Territory of the Wallis and Futuna Islands. Individuals in this population are believed to migrate to a largely undescribed Antarctic feeding area.

According to the IWC assessment, recovery for the Oceania DPS is ongoing and the population is still around <50% of pre-exploitation abundance. There is ongoing work using mark-recapture analysis, in addition to dedicated land and sea surveys, to monitor humpback whale presence from locations such as the South Lagoon breeding site. Long-term analysis of humpback whale distribution patterns in the South Lagoon show persistent space usage and increasing occurrence over the past two decades (Derville et al., 2019a).

There are also extensive monitoring efforts on the breeding ground of New Caledonia spanning several decades (1995−2018). A recent analysis of recapture histories for 607 females of the New Calendonian portion of the Oceania DPS found a high reproductive capacity and revealed relatively short calving intervals between 2.83 and 1.49 years, reflective of overall recovery (Chero et al., 2020).

Threats
Climate change creates warmer water temperatures, which appear to alter breeding habitat suitability for the Oceania DPS (Derville et al., 2019b). Additionally, negative effects from whale watching and swim-with tourism (e.g., harm, harassment) have been documented (Fiori et al., 2019). Based upon the most recent information on the DPS's abundance and trends, these threats do not appear to be substantially affecting its recovery at this time.

Southeast Africa/Madagascar DPS

The Southeast Africa/Madagascar DPS includes whales breeding in at least three different areas in the western Indian Ocean: one associated with mainland coastal waters of southeastern Africa, extending from Mozambique to as far north as Tanzania and southern Kenya; a second found in the coastal waters of the northern Mozambique Channel Islands and the southern Seychelles; and the third found in the coastal waters of eastern Madagascar. The feeding grounds of this DPS in the Southern Ocean are not well defined but are believed to include multiple localities to the west and east of the region bounded by 5°W–60°E.

Some tagging work is ongoing to delineate breeding grounds (Cerchio et al., 2016). The IWC Southern Ocean Assessment suggested that Breeding Stock C's (Western Indian Ocean: C1−Mozambique; C3−Madagascar) recovery levels are estimated around 90% of pre-exploitation abundance for humpback whales breeding along the east coast of Africa. However, there is uncertainty in the estimate (probability interval spanning 50−100%) because of ambiguity in population identity and abundance of the Madagascar DPS (IWC, 2015). Based upon an analysis of opportunistic data from whale watching, Trudelle et al. (2018) documented the poorly known breeding ground around Sainte Marie Channel off Madagascar. The authors found no clear trend over the 5-year study period, and interannual variability in the encounter rate of mothers with calves. There are other efforts ongoing that will provide necessary baseline information for tracking the recovery of this population (Van Driessche et al., 2020).

Threats
There is insufficient information to assess threats to this DPS.

Gabon/Southwest Africa DPS

This DPS consists of whales that breed and calve off central western Africa between ~6°S and ~6°N in the eastern Atlantic, including the coastal regions of northern Angola, Congo, Togo, Gabon, Benin, other coastal countries within the Gulf of Guinea and possibly further north. This DPS is thought to feed offshore of west South Africa and Namibia south of 18°S and in the Southern Ocean beneath western South Africa (20°W–10°E).

According to the IWC Southern Ocean assessment, the Gabon/Southwest Africa DPS (BSB1 and BSB2) exhibits substantial uncertainty in recovery since the breeding grounds are not well known (Jackson et al., 2015). As a result, abundance and trend from the IWC assessment were inferred using mark-recapture data and the population's growth rate is estimated to range between 2.9% and 4.1% annually from 2010−2015 (Jackson et al., 2015), but these estimates are expected to be downwardly biased. It is important to note these estimates were produced prior to the DPS listing (Bettridge et al., 2015), and there are no recent abundance estimates for this population.

Threats
There is insufficient information to assess threats to this DPS.

Overall Conclusion

None of the PDMP response triggers (NMFS, 2016) have been reached. Monitoring data collection efforts are underway with federal and state agencies, the IWC, non-governmental organization partners, and academic partners. Generally, the surveyed data suggest that each of the nine non-listed DPSs share common threats: entanglement, climate change, vessel collisions, and acoustic masking. Climate change creates warmer water temperatures that appear to influence breeding habitat suitability and prey availability in potentially negative ways. The responses of the Hawai‘i DPS to marine heatwaves are signs of potential vulnerability. Despite this, overall, the published literature suggests the nine non-listed DPSs are considered stable to increasing in abundance. Based on the analyses described above, we conclude for the first interim report of the Post-Delisting Monitoring Plan (NMFS, 2016) that the standards described in Section IV of the PDMP have been met, indicating that the non-listed humpback whale DPSs remain secure without ESA protections.

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