PACIFIC WHALE FOUNDATION

2021 RESEARCH REPORT

1.0 Background

The Pacific Whale Foundation (PWF) conducts applied research throughout the Pacific Ocean which directly supports conservation and management outcomes. Since 1980, PWF researchers have published over 100 peer-reviewed publications, reports, and books that have been used to advance our knowledge on cetacean ecology and inform better management of species. The long-term goal of PWF's research program is to identify and assess major threats to cetaceans around the world and develop science-based solutions to mitigate these issues.

In 2021, we created a framework for strategic expansion of the research program with a goal of producing meaningful and lasting impact. PWF's Global Impact Plan is our strategy to support the conservation of entire populations of cetaceans by shifting to short-term threat-based projects, supplemented by our long-term photo-ID catalogues. We are investing more resources into our research projects in Hawai'i, East Australia and Ecuador with expansions planned in additional regions.

This report is a summary of PWF's research activities over the last year, with a recap of some recently published work and preliminary results from our latest projects. The goal of this report is to provide an overview of the research being conducted by PWF to encourage dialogue and opportunities for partnership.

2. 0 Research Overview

2.1 Long-term monitoring of cetaceans in the Pacific Ocean

The goal of this study is to maintain long-term continuous monitoring of cetacean species in the Pacific Ocean. Data are collected from three important marine eco-regions; Maui, Hawai'i, Hervey Bay, Australia and Machalilla National Park, Ecuador. Continuous, long-term studies like this are the benchmark in cetacean research and allow scientists to assess population changes over time. To do this we collect data to monitor trends in abundance, distribution and health using a combination of photos and videos, behavioral observations, and biological samples. These data can then be used to identify any negative impacts of anthropogenic activity and help guide mitigation measures where necessary.

Photo-identification forms the basis of our long-term monitoring studies. PWF conducts dedicated surveys from our research vessels to collect photos of cetaceans to add to our growing databases. We use photo-identification catalogues to collate all the photographed individuals from which we can track individuals through time and produce estimates of population abundance. To increase our sample size, we can also collect data from PWF's commercial whale watch vessels as 'platforms of opportunity'. In addition, our databases are bolstered through public donations, whereby members of the public can donate photos they have taken of whales to add to our catalogue.

Humpback whale monitoring in the Pacific Ocean

Monitoring humpback whales (*Megaptera novaeangliae*) has been the foundation of PWF's research since 1980. In the years since, we have expanded our research focus to other cetacean species, however, our humpback monitoring project is our most comprehensive and long running project. To date, we have identified 4,642 individual humpback whales from the North Pacific and 6,895 from the South Pacific. We have been able to track many of these individuals through collaborative research and document the movement of individuals (Figure 1).

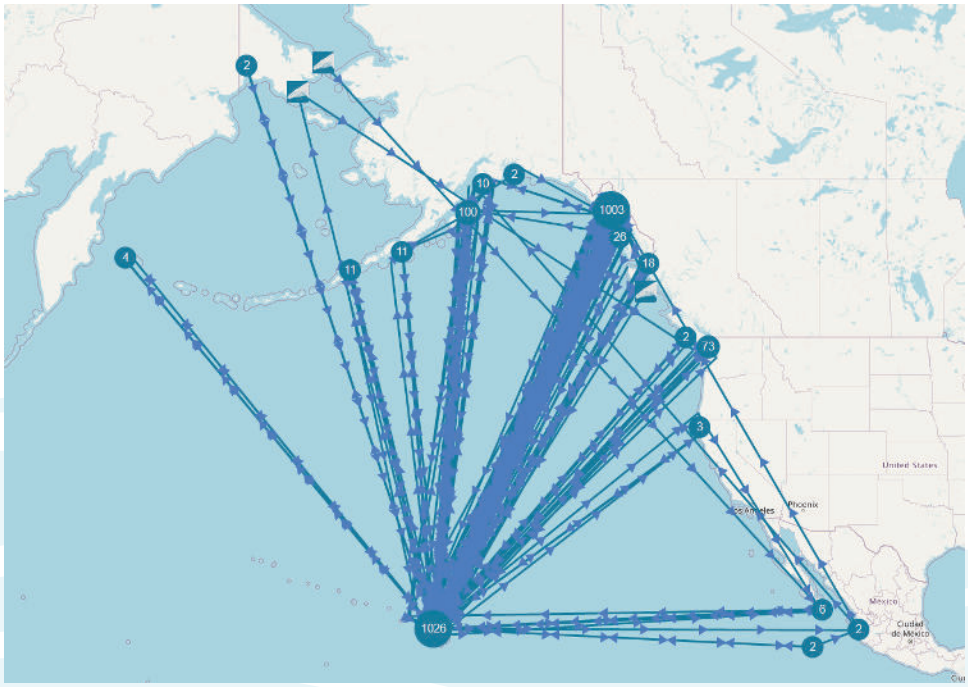

Figure 1 Map showing connections of humpback whales photographed on research surveys in Hawai'i with connections to other areas around the Pacific (source: Happywhale.com)

During 2021, we conducted surveys in all three eco-regions using both dedicated research vessels and platforms of opportunity. We also received photo donations from members of the public in Hawai'i and Australia (Table 1).

Table 1 An overview of the survey effort conducted by PWF in 2021. Including information on the number of individual humpback whales sighted and public photo donations.

Region	R/V Surveys	Survey Period	Platforms of opportunity	Donations	Individuals	Matched	New
Hawai'i	20	Jan, Mar	0	101	381	123	258
Australia	13	Aug-Oct	19	25	156	56*	85*
Ecuador	0	Jun-Sep	111	0	250	UK*	UK*

*Some photos are still being processed and these numbers will change to match the individuals

Biology and recovery status of false killer whales in Maui, Hawai'i

Our new false killer whale sightings hotline (808)-HELP-FKW was successfully launched in 2021. This hotline allows the public to report sightings of false killer whales and led to five 'Rapid Responses' by PWF this year.

In 2021, the research team had 14 sightings of false killer whales (*Pseudorca crassidens*) where we collected photo-ID and/or underwater footage. The sightings included five by members of the public who donated photos to us for inclusion in our photo-ID catalog (Figure 2). The false killer whale photo-ID catalog currently has 132 individuals. Two new individuals were added to the catalog from photos collected in 2021 and there were 21 re-sightings of known individuals. Two animals were seen in 5 of the sightings in 2021. In May, we confirmed that one of the animals in our catalog was a female, after sighting her with a small calf for the first time.

In August, we completed processing all underwater footage and photographs from all false killer whale sightings between 2013 and 2021 in order to identify the sex of individuals and document any scars on their body and head. Identifying scars can help us assess the degree of fisheries interactions the false killer whales have had.

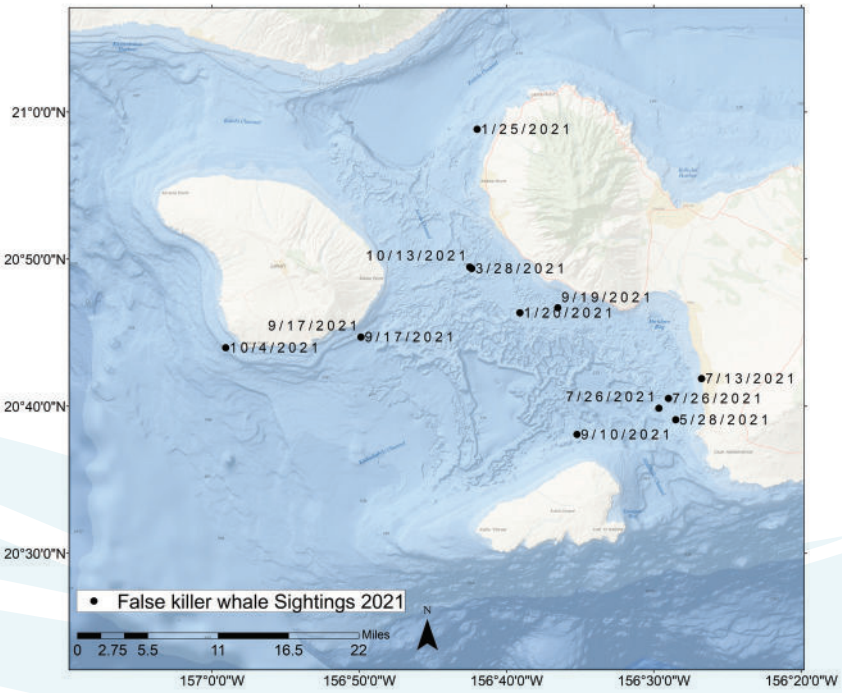

Figure 2 *(right)* A map of the false killer whale encounters and public sightings off Maui, Hawai'i, for 2021.

In October, the research team conducted a 10-day dedicated field trip off Lāna'i with collaborators from the Marine Mammal Research Program at University of Hawai'i at Manoa and the Goldbogen Lab at Hopkins Marine Station Stanford University. The purpose of this trip was to test a suction-cup CATS tag on blackfish, particularly false killer whales, to determine their movements and behaviour around Maui. We encountered eight different odontocete species including; false killer whales, short-finned pilot whales, pantropical spotted dolphins, bottlenose dolphins, melon-headed whales, pygmy killer whales, rough-toothed dolphins, and Fraser's dolphins.

Figure 3 A tagging attempt using a CATS tag off Lāna'i, Hawai'i.

Abundance, distribution and habitat use of common bottlenose dolphins in Ecuador

In the spring of 2021, PWF completed pilot surveys to assess the feasibility of studying common bottlenose dolphins (*Tursiops truncatus*) in Ecuador. The study area was along the coast of mainland Ecuador, covering the SW coast of the Manabi province and NW coast of the Santa Elena province. During February and March 2021, ten bottlenose dolphin surveys were conducted during which four groups were encountered. The team collected photo-identification images and biological samples for sex determination and genetic variability. With the success of this pilot study, we have decided to proceed with year-round surveys from 2022 onward to learn more about this population. Our aim is to produce the first abundance estimates using photo-ID techniques for bottlenose dolphins in Ecuador, which also aids in identifying critical habitat of bottlenose dolphins for management purposes.

Figure 4 Common bottlenose dolphins travelling close to shore in the Machalilla National Park, Ecuador.

Abundance, distribution and habitat use of dolphins in Hervey Bay, Australia

This year PWF launched photo-identification catalogues for Australian humpback dolphins (*Sousa sahulensis*), Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) and common bottlenose dolphins in Hervey Bay. To date, images of dolphins have largely been collected opportunistically, however, PWF aims to expand the research focus in Hervey Bay to include more dedicated surveys documenting the dolphins inhabiting the bay. This will allow robust abundance estimates to be produced for the resident species and contribute to their management and conservation. Photographs from 2005-2021 will be added to the catalogue over the coming months but, presently, 68 Indo-Pacific bottlenose dolphins, 13 Australian humpback dolphins and two common bottlenose dolphins have been added to their respective catalogues.

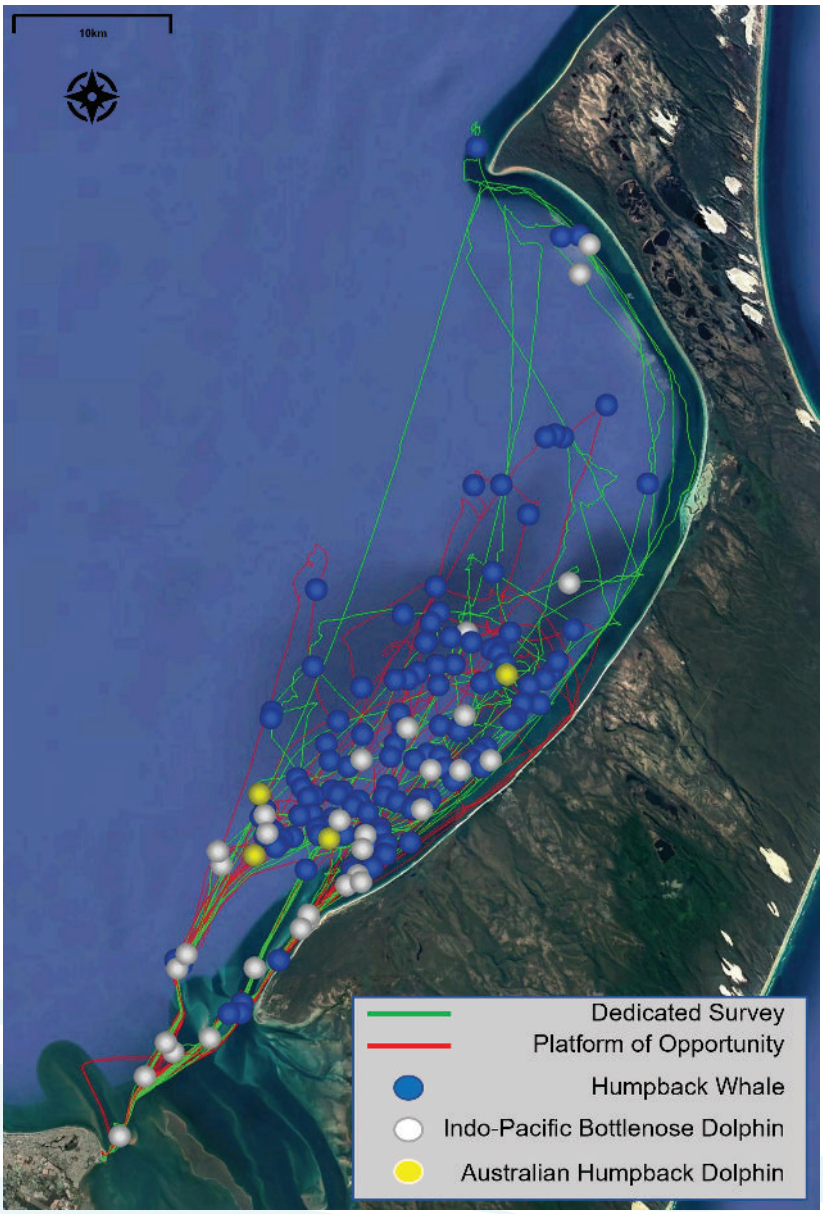

Figure 5 Map of Hervey Bay, Australia, showing the 2021 survey effort and cetacean encounters.

Google Earth Pro v7.3.4.8248 (12/14/2015). Hervey Bay, Australia. 24°59'53.52" S; 152°51'56.55" E, eye alt 107.92km. [19/11/2021].

2.2 Body condition and health of cetaceans

PWF uses unoccupied aerial systems (UAS) or 'drones', as a non-invasive method to assess cetacean body condition since 2019 (Figure 6). This method involves flying a drone above an animal at an altitude of 25m and recording high-resolution videos when it is at the surface. Images are then extracted from the video clips where measurements of length and width can be estimated. These measurements can then be used to estimate the body volume of the individual which is a good indicator of how healthy it is. These data can be used to assess the general health of populations between years and identify any patterns. If repeated measurements can be obtained from individuals within a season, growth rates and energy transfer rates (e.g., from mothers to calves) can also be estimated.

Body condition of humpback whales

This collaboration between the UH Marine Mammal Research Program and Hilo Marine Mammal Lab has been ongoing in Maui, Hawai'i since 2019, but this year PWF also started collecting data for a new five-year project assessing the health of the humpback whales in Hervey Bay. During 2021 PWF collected drone images from 635 individuals in Maui and 21 individuals in Hervey Bay. Biopsy samples, which are used to compare blubber cortisol and corticosterone concentrations in Maui's humpback whales and determine stress levels and overall health of individuals, were also collected from 162 individuals to complement the drone data during 2021 (Figure 7). This data collection was a joint effort between Pacific Whale Foundation, the Marine Mammal Research Program of the University of Hawaii at Manoa, the Marine Mammal Lab of the University of Hawaii at Hilo.

Figure 6 PWF researchers launching a drone to collect aerial photogrammetry of cetaceans to assess their body condition.

Figure 7 A biopsy sample being collected from a humpback whale in Maui, Hawai'i.

Body condition of false killer whales in Maui, Hawai'i

During five of the false killer whale encounters in 2021, the research team was able to launch the drone to collect aerial morphometric measurements. Using the drone also helped us gain a new perspective on the behavior of this endangered population and allowed us to document foraging events (Figure 8). We collected UAS aerial morphometric data of 14 known individuals, including repeated measurements of four animals throughout the year (Figure 9). A special thanks to the on-water community for their timely reports and Cascadia Research Collective for notifying us when tagged false killer whales were in the area.

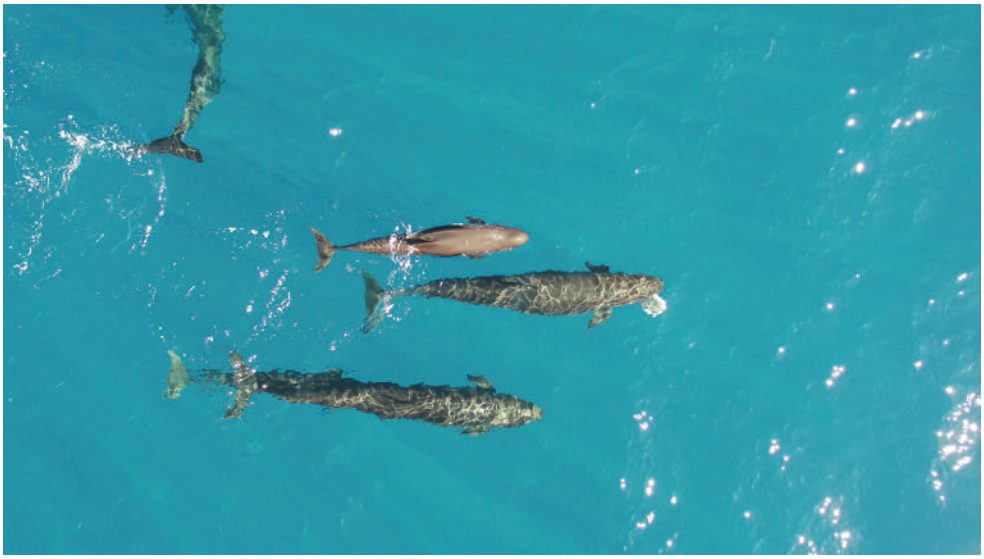

Figure 8 A drone image of false killer whales taken during a 2021 survey off Maui, Hawai'i. A prey item can be seen being held in the mouth by the leading adult. The perspective given by drone images has meant that PWF has been able to better document prey 'sharing' behavior by false killer whales.

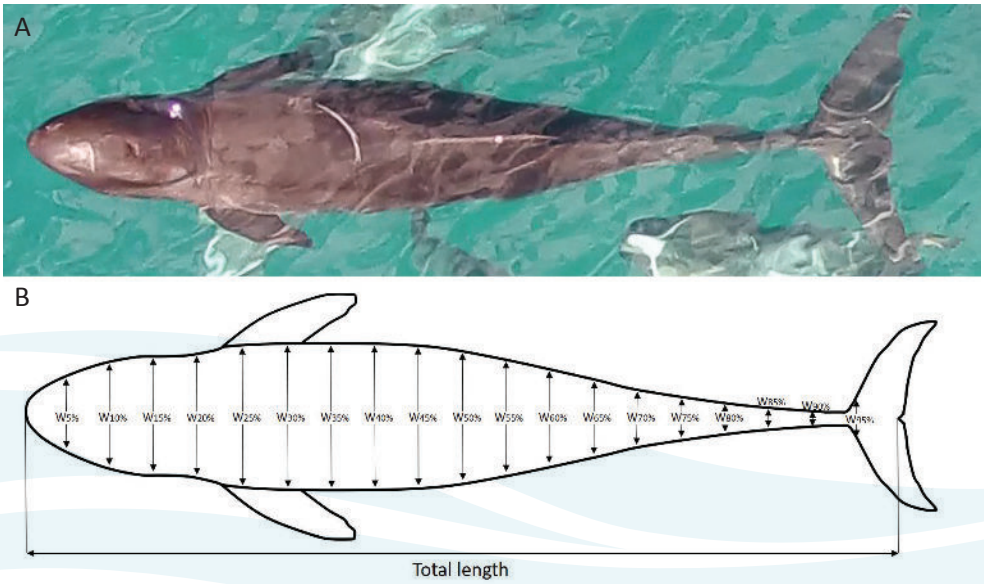

Figure 9 Aerial image of a pygmy killer whale taken using a drone (A) which can be used to obtain an estimate of body condition by measuring the length and width of the animal (B). Taken from Currie et al. (2021b).

2.3 Impacts of human activity on cetaceans

PWF published four peer-reviewed journal articles related to the impacts of human activity on cetaceans in 2021.

The impacts of vessels on humpback whale behavior in Maui, Hawai'i

Currie et al. (2021a) used three years of land-based theodolite tracking of humpback whales and vessels in Maui, Hawai'i to assess the impact that vessels have on whale behavior. Between December 2015 and March 2018, 73 surveys measured whale swim speed, respiration rates, dive times, and path directness for 316 humpback whale groups (943 individuals). These metrics were then modeled against vessel presence, proximity, and approach type (472 vessel approaches) to explain changes in whale behaviors.

Significant behavior changes were observed outside the currently recommended 100-yard approach distance for vessels, up to 400 meters. These included increases in swim speed, respiration rate and path directness, while decreasing dive times. Vessel guidelines which minimized whale avoidance included traveling at 12.5 knots and slowing down to 6 knots when within 400m of whales, limiting viewing time of mom/calf groups to 30 minutes, and operating only parallel and to the sides of whales, never directly in front or behind. Results support the conclusion that vessel presence impacts humpback behavior, suggesting that current vessel regulations are not sufficient in minimizing behavior responses. With growing concern over cumulative impacts of short-term disturbance, particularly for capital breeders with long migrations, a precautionary approach to management is recommended with stricter guidelines for vessel operation.

Figure 10 *(right)* Reasearchers use land-based theodolite tracking of humpback whales and vessels in Maui, Hawai'i.

The impacts of swim-with-whale tours on humpback whale behavior in Hervey Bay, Australia

Stack et al. (2021) used three years of data collected from a commercial swim-with-whale tour operator to assess the behavior of humpback whales before, during and after swim-with activities took place. The study also compared the impacts of swim-with tours to behavioral impacts collected from 'traditional' boat-based viewing tours. Between July and September of 2018, 2019 and 2020, data were collected from 42 swim-with-whale encounters and 85 boat-based encounters. Data on behavior state, group composition and changes in direction were recorded and these were compared during the three phases of the swim-with tours and between the 'during' phase of swim-with tours to the traditional boat-based tours.

There were significant behavior changes noted associated with the 'during' and 'after' phases of the swim-with tours. The number of direction changes significantly increased when swimmers entered the water and did not reduce after the swimmers had exited the water. There was also a 50% reduction in the time whales spent resting during swim-with tours compared to traditional boat-based tours. The time the whales spent engaged in different behaviors was affected by the approach distance of vessels in both tour types, highlighting the importance of regulated whale watch guidelines.

A series of follow-up studies to assess the education and conservation merits of the swim-with tours and to quantify the economic value of the tours are underway. A survey has been sent to all passengers from the swim-with tours to quantify their experience in terms of education and perceived conservation merits. These data will be analyzed and reported to the local government agencies.

Figure 11 A swim-with-whale tour operating in Hervey Bay, Australia. Swimmers are placed in the water tethered to a 'mermaid line' attached to the vessel during the encounter.

Fisheries interactions with dolphins in Maui, Hawai'i

Machernis et al. (2021) examined photographs of dolphins between 1996 – 2020 to assess the degree of scarring related to fisheries activity. Photos of 374 individual pantropical spotted dolphins (*Stenella attenuata*) and 255 individual common bottlenose dolphins were examined for evidence of scars from fisheries interactions. This paper highlights a novel technique to maximize the value from a photo-ID dataset.

The results found that 27% of bottlenose and 13% of spotted dolphins had evidence of one or more fisheries related scars. Use of the multi-pronged examination of mouthline, and underwater imagery increased scar detection rates by 51% for bottlenose dolphins and 41% for spotted dolphins. Results suggest fisheries interactions should be further investigated as a potential threat to bottlenose and spotted dolphins (Figure 12).

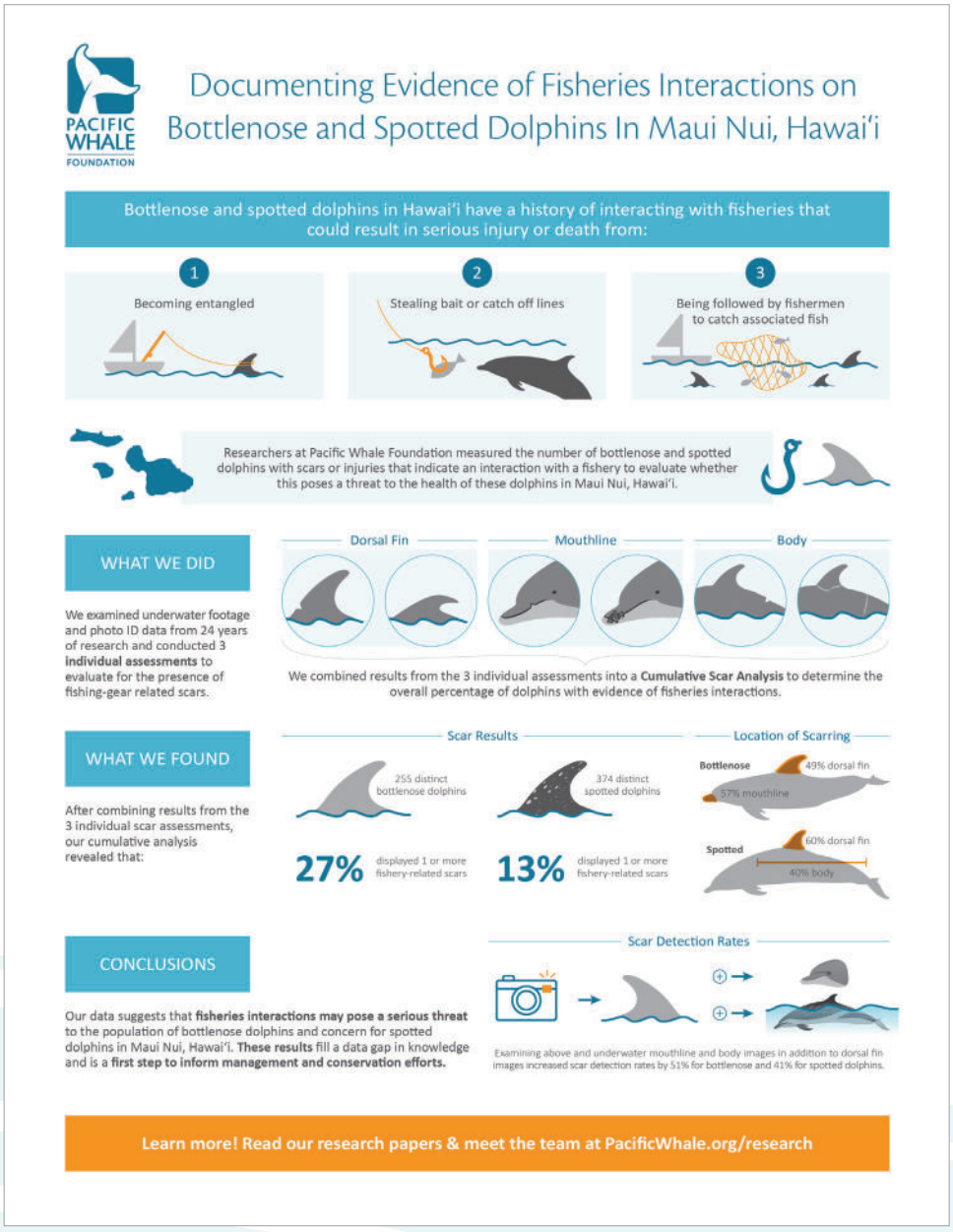

Figure 12 An infographic detailing the methods and results used by Machernis et al. (2021) to highlight the issues associated with fisheries interactions.

Rapid weight loss in pygmy killer whales and implications for human disturbance of cetaceans

Currie et al (2021b) used drone morphometric data to document the rapid weight loss of six pygmy killer whales (*Feresa attenuata*) during the last 17 days of a 21-day stranding event in August and September 2019 in Maui, Hawai'i. The pygmy killer whales were not feeding during this time and as a result lost 2% of their total body mass each day during the foraging disruption, and lost up to 27% of their total body weight over 17 days (Figure 13), demonstrating how quickly an individual can suffer detectable health repercussions from behavior disruption.

The accuracy and utility of drone (UAS) photogrammetry was confirmed through post-mortem measurements of the stranded animals; showing length estimates to be within 1.5% of actual body length and body volume measurements within 10-13% of truth. Anthropogenic disturbance to cetaceans can have serious health consequences for individuals and populations.

2.4 Preventing Ocean Pollution

The Covid-19 pandemic provided the research team with a unique opportunity to study how reduced beach use and tourism on Maui affected marine debris accumulation. In May 2020 we began a year-long research project, conducting weekly beach surveys at two public beach sites previously surveyed for marine debris accumulation in 2018. This allowed us to compare current counts to our historical dataset. There was a 99% reduction in tourist arrivals in May 2020 and it will be interesting to see how this drastic shift in tourist numbers impacted marine debris, particularly on Maui's leeward shores, which receive most of the land-sourced debris. We finished this field work in May 2021 and are now working on data analysis and drafting a manuscipt.

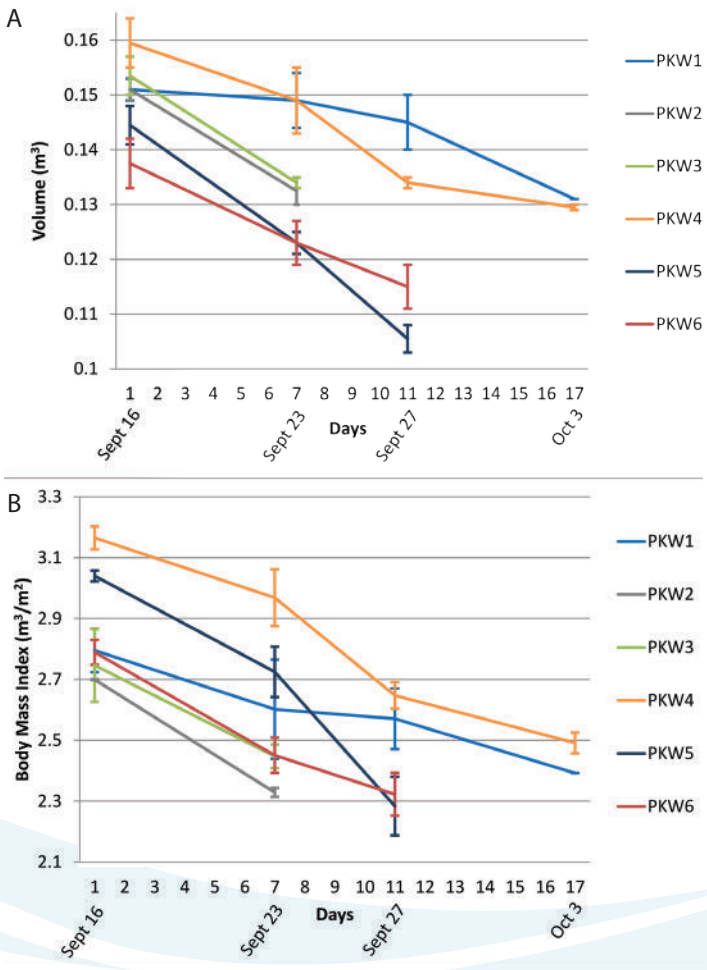

Figure 13 *(right)* The (A) volume and (B) body mass index of the six pygmy killer whales during the last 17 days of a 21-day stranding event that occurred in 2019 in Maui, Hawai'i. Estimated from drone morphometric measurements. Taken from Currie et al. (2021b).

3.0 New Research in 2022

PWF will continue with long-term monitoring of cetaceans in support of our Global Impact Plan. As part of this plan however, we aim to broaden our research focus in these regions and expand the scope of our current reach. We have some exciting new research projects coming in 2022.

Maui Nui, Hawai'i

In 2022, we will expand our survey areas to better cover all of Maui Nui. After a successful field effort off Lāna'i in October 2021, we plan to conduct 10-day field efforts on the north shore of Maui, and around the islands of Kaho'olawe, Lāna'i, and Moloka'i. This expansion will greatly improve our knowledge of the cetacean communities in Hawai'i and will help us better understand the relationship between humans activities and cetaceans in Hawai'i.

Hervey Bay, Australia

As mentioned previously, PWF intends to expand our focus in Hervey Bay to include more odontocete surveys. To do this, we aim to undertake an initial pilot project in 2022 to estimate the abundance of Indo-Pacific bottlenose dolphins and Australian humpback dolphins using distance sampling techniques. This method uses line transect surveys of an area to generate an abundance estimate from a specific timeframe. We will continue our photo-identification work to produce abundance estimates over longer time periods, but this pilot study will give us a good base from which to develop our future research.

Chiloe Island

PWF is pleased to share that we will be supporting Barbara Galletti & The Blue Whale Project in Chile once again in 2022. This project collects data with the aim to conserve and protect endangered blue whales in one of the most important known feeding grounds in the southern hemisphere. PWF will be working collaboratively to map the risk of Chilean blue whales to ship strike and scope out future projects under our Global Impact Plan.

Okinawa, Japan

PWF is expanding our swim-with-whales research through a new partnership with Dr. Nozomi Kobayashi, of the Okinawa Churashima Foundation (OCF) Research Center. Dr. Kobayashi and her team will collect data this winter as a pilot season to assess the feasibility of conducting a swim-with-whales study in Japan, replicating the work we conducted in Hervey Bay (see: Stack et al. 2021). This is a great example of our new model for the Global Impact Plan; a systematic approach to tackling the major threats to cetaceans by working with local partners around the world.

4.0 Partners and Acknowledgements

We are grateful to work collaboratively on these projects with a number of partners. Our partners have been instrumental in building capacity locally in the regions where we operate and we are grateful for their support and expertise.

In Hawai'i

Dr. Adam Pack, Marine Mammal Laboratory, University of Hawai'i at Hilo
Dr. David Lusseau, Technical University of Denmark
Ed Lyman, Hawai'ian Islands Humpback Whale National Marine Sanctuary
Dr. Elizabeth Madin, Hawai'i Institute of Marine Biology, University of Hawai'i at Manoa
Dr. Kristi West, Hawai'i Institute of Marine Biology, University of Hawai'i at Manoa
Dr. Lars Bejder, Marine Mammal Research Program at the University of Hawai'i
Dr. Marc Lammers, Hawaiian Islands Humpback Whale National Marine Sanctuary
Mark Manuel, NOAA Marine Debris Program
Dr. Robin Baird, Cascadia Research Collective
Ted Cheeseman, Southern Cross University and Happywhale.com

In Australia

Dr. Daniele Cagnazzi, Southern Cross University
Dr. Olaf Meynecke, Whales and Climate Program at Griffith University
Dr. Susan Bengston-Nash, Southern Ocean Persistent Organic Pollutants Program, Griffith University
Dr. Wally Franklin, The Oceania Project

In Ecuador

Dr. Fernando Felix, Museo de Ballenas
Dr. Koen Van Waerebeek, Centro Peruano de Investigación de Cetáceos

Acknowledgements

Our offices at Ma'alaea Bay, Maui are situated in the ahupua'a of Waikapū, within the moku of Wailuku. These lands and waters were wrongfully taken from the people of Hawai'i through unforgivable acts of colonization. We recognize and respect nā kanaka maoli, the people of Hawai'i, as the traditional custodians of the land and sea.

Our research in Hervey Bay, Australia takes place in the traditional land and waters of the Butchulla people. We recognize and respect their continuing connection to land, water, and community.

Funding for this research is provided by PacWhale Eco-Adventures, Members of the Pacific Whale Foundation, the NOAA Marine Debris Program, the National Marine Sanctuary Foundation, and a number of private donors. We thank the Lana'i Harbor Master Joelle Aoki, as well as John and Rachael Sprague for their assistance with our field work in October. Thank you to PacWhale Eco-Adventures for providing support during our Lana'i field effort, tag retrieval trips, and for reporting sightings to our false killer whale hotline year-round. Thank you to PWF Eco-Adventures Australia for providing in-kind support for the swim-with-whale study. Thank you to Palo Santo Travel in Ecuador for providing your vessels and supporting our research.

The research activities described here are conducted under the appropriate state and federal permits. In Ecuador, we operate under a research permit issued by Machalilla National Park. In Hawai'i, our activities are authorized under NMFS research permit #21321 issued to PWF, #21476 issued to Lars Bejder and #19655 issued to Adam Pack. In Australia, our activities are conducted under a scientific research permit and a marine park permit authorized by the Queensland Department of Environment and Science. Drone operators hold additional certifications; in Hawai'i the drone pilots hold FAA Part 107 authorization and in Australia, drone operators hold a CASA remote pilot license and operate under a CASA operating certificate. All images in this document were taken under the relevant permits. For more information on Pacific Whale Foundation's research program, visit **pacificwhale.org/research** or email **research@pacificwhale.org**

5.0 2021 Research Outputs

Our publications are freely available to download on our website: **pacificwhale.org/research/publications**

Peer-reviewed articles

Currie, J.J., McCordic, J.A., Olson, G.L., Machernis, A.F., & Stack, S.H. (2021a) The impact of vessels on humpback whale behavior: The benefit of added whale watching guidelines. Frontiers in Marine Science, 8: 601433. **https://doi.org/10.3389/fmars.2021.601433**

Currie, J.J., van Aswegen, M., Stack, S.H., West, K.L., Vivier, F., & Bejder, L. (2021b) Rapid weight loss in free ranging pygmy killer whales (Feresa attenuata) and the implications for anthropogenic disturbance of odontocetes. Scientific Reports, 11: 8181. **https://doi.org/10.1038/s41598-021-87514-2**

Currie, J.J. & Stack, S.H. (2021) Getting butts off the beach: Policy alone is not effective at reducing cigarette filter litter on beaches in Maui, Hawai'i. Marine Pollution Bulletin 173, 112937. **https://doi.org/10.1016/j.marpolbul.2021.112937**.

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Machernis, A.F., Stack, S.H., Olson, G.L., Sullivan, F.A., and Currie, J.J. (2021) External scarring as an indicator of fisheries interactions with bottlenose (*Tursiops truncatus*) and pantropical spotted (*Stenella attenuata*) dolphins in Maui Nui, Hawai'i. Aquatic Mammals 47(5), 482-498. DOI 10.1578/AM.47.5.2021.482.

Self, H., Stack, S.H., Currie, J.J., Lusseau, D. (2021) Tourism informing conservation: The distribution of four dolphin species varies with calf presence and increases their vulnerability to vessel traffic in the four-island region of Maui, Hawai'i. Ecological Solutions and Evidence, 2:e12065. **https://doi.org/10.1002/2688-8319.12065**.

Stack, S.H., Sprogis, K.R., Olson, G.L., Sullivan, F.A., Machernis, A.F. and Currie, J.J. (2021) The behavioural impacts of commercial swimming with whale tours on humpback whales (*Megaptera novaeangliae*) in Hervey Bay, Australia. Frontiers in Marine Science. DOI 10.3389/fmars.2021.696136.

Van Cise, A.M., Baird, R.W., Harnish, A.E., Currie, J.J., Stack, S.H., Cullins, T., & Gorgone, A.M. (2021) Mark–recapture estimates suggest declines in abundance of common bottlenose dolphin stocks in the main Hawaiian Islands. Endangered Species Research 45: 37-53. **https://doi.org/10.3354/esr01117**

Technical reports

Castro, C. and Félix, F. (2021) Identifying conservation areas and habitat preferences of bottlenose dolphins (*Tursiops truncatus*) in the Central Coast of Ecuador. Document SC/68C/SM/14 presented to the IWC Scientific Committee: 27 April – May 14. 8 pp.

Félix, F., Acevedo, J., Aguayo-Lobo, A., Ávila, I.C., Botero-Acosta, N., Calderón, A., Cáceres, B., Capella, J., Carnero, R., Castro, C., Cheeseman, T., Rosa, L.D., Dellabianca, N., Denkinger, J., Friedlaender, A., Guzmán, H., Haase, B., Haro, D., Hucke-Gaete, R., Llano, M., Oviedo, L., Pacheco, A., Pacheco, J., Palacious, D.M., Palacios-Alfaro, J., Pallin, L., Pérez, M.J., Rasmussen, K., Sanchez-Godinez, C., Santillán, L., Secchi, E., Torres., M., Vásquez, E. (2021) Humpback whale breeding stock G: updated population estimate based on photo-ID matches between breeding and feeding areas. Document SC/68C/ASI/02 presented to the IWC Scientific Committee: 27 April – May 14. 8 pp.

Stack, S.H. and Serra, S. (2021) Summary of swim-with-whales tourism around the globe. Document SC/68C/WW/03 Rev 1 presented to the IWC Scientific Committee: 27 April – May 14. 8 pp.

Supported or sponsored research

Harnish, A. (2021) Population structure, residency, and inter-island movements of common bottlenose dolphins (*Tursiops truncatus*) off O'ahu and Maui Nui. Master's Thesis. The Evergreen State College, Olympia, Washington, USA. (PWF data analyzed).

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