Better Quantifying Human Impacts: a PhD Research Initiative

Jessie Hoffman, PhD student on sanctuary's response vessel, Koholā, holding collected breath sample from a humpback whale.

Authorization:

NOAA Fisheries Marine Mammal Health and Stranding Response Program (MMHSRP; permit #24359)

Objectives:

- Validate humpback whale breath samples as a tool to determine stress hormone levels.
- Determine variability of stress hormone concentrations between multiple parameters in humpback whales:
  1. Age class
  2. Sex
  3. Breeding vs. foraging grounds
  4. Uncompromised (seemingly healthy) vs. compromised (*i.e.,* entangled, vessel-struck)
- Quantify and compare body condition between uncompromised and compromised whales as a means to measure impacts of risk factors on the whales.
- Determine the energetic cost of movement in compromised humpback whales, its variability across the four parameters listed above, and the link of this cost to the related stress hormone concentrations.

PhD Student

Jessie Hoffman, student at the University of Alaska Fairbanks (UAF) College of Fisheries and Ocean Sciences, is originally from Iowa but moved to Hawai'i to obtain her Master of Science in Marine Science from Hawai'i Pacific University. She then worked as an intern with the University of Hawai'i where she helped on two entanglement responses in 2022. The responses and NOAA's Hawaiian Islands Humpback Whale National Marine Sanctuary's (Sanctuary) efforts to better understand the impacts from human-caused threats were the impetus for Jessie's PhD. She started her PhD in the Fall of 2023 and was awarded the Dr. Nancy Foster Scholarship, (NOAA) leading into her second year.

Research Collaboration and Methods

Jessie's PhD research will be done in conjunction with the Sanctuary's Health and Risk Assessment (HRA) monitoring program and secondarily with assistance from the research program, broadening the sanctuary's risk assessment of the whales and providing much-needed assistance. Data will be collected during four annual field seasons (December – April) from 2024 – 2027. The programs will collect breath via Uncrewed Aerial Systems (UAS, drones) and blubber biopsy samples, energetic data from Customized Animal Tracking Solutions (CATS) suction-cup tags (often deployed via UAS), and body size/condition measurements through UAS-obtained photogrammetry from photo-identified humpback whales. The goal is to collect the 'full suite" from all compromised whales (*e.g.,* ship-struck, entangled) and from at least 10 other individuals per season as a control dataset. The use of UAS provides for minimally invasive methods, that are safer for whales and humans and reduce any stress resulting from the sampling itself.

Responders aboard the sanctuary's vessel, Koholā, trying to cut a bundle of gear off an entangled whale. Credit: Zadra/NOAA Permit #24359

Photo ID image showing distinguishing markings, and trailing edge of a humpback whale's fluke. Credit: Harvey/NOAA Permit #24359

Health Assessment – Photo ID

For each encounter, the HRA team collects photos of the underside of the whales" tail (flukes) that uniquely identifies each whale. This photo-id, acting as their fingerprint, is submitted to the digital, AI catalog, Happywhale, to determine each whale's identity. Often, we can learn valuable life history information from Happywhale, including other times and locations it has been seen, age estimations, previous calves, and sometimes even sex determinations. This technique allows us to 'track' these whales without the use of more invasive satellite tagging methods. We can also see if there were previous confirmed cases of entanglement, vessel strike, or other illness/injuries.

Adult humpback breaking the surface right before exhaling, taken via UAS during breath collection. Credit: Hoffman/NOAA Permit #24359

Health Assessment – Breath

Jessie and the HRA team collect breath samples on petri dishes attached to a UAS flown through the whale's exhalation. Breath samples are then processed at Dr. Shannon Atkinson DeMaster's Endocrinology Lab in Seward, Alaska, to determine the whale's hormone levels. The first objective is to validate and calibrate humpback whale breath samples as a tool to determine stress hormone levels and use this tool to then quantify impacts of risk factors that otherwise might not be observed.

Health Assessment – Biopsy

To validate the use of breath for hormone analysis, the samples are 'ground truthed' against hormone levels determined from biopsy samples. Blubber biopsy samples will be collected from whales throughout the field season, and if possible, all compromised whales, are sent to the Endocrinology Lab to run comparable hormone analysis. Four hormones, 1) progesterone, 2) testosterone, 3) cortisol, and 4) corticosterone, are measured to provide a clearer picture of the whale's stress level and potential reasons for *the stress* level. The hormones found within blubber samples are referred to as "long term" hormones, giving a quantitative measurement of the chronic stress whales are under. The hormones found within the breath samples are referred to as "short term" hormones, giving a quantitative measurement of the acute, or 'right now,' stress the whale is under. Samples Jessie and the Sanctuary team collect during these field seasons will also be supplemented with archived blubber samples from the Sanctuary and other researchers to help paint a more detailed picture of the stress these whales have across age and sex classes, as well as between their breeding and feeding grounds.

Jessie Hoffman uses a crossbow and specialized dart to collect small blubber biopsy sample of whale. Credit: Lyman/ NOAA Permit #24359

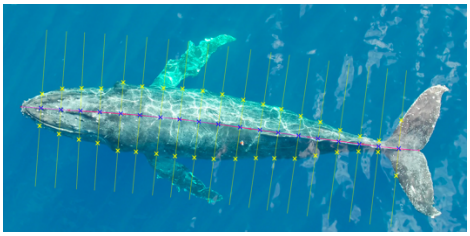
Energetics – CATS Tags

With the help of Ocean Alliance (OA), the Sanctuary team has successfully been able to drop Customized Animal Tracking Solutions (CATS) tags on humpback whales (n > 50 deployments). These CATS tags have multiple sensors, providing information on the whale's movement patterns and fluke beats – like a smart watch they can map activity levels. Thus, the data from these suction-cup tags tells us how much energy the whale is using as it moves through the water. The hypothesis is that entanglements and/or vessel strikes result in a substantial increase in energy use, thereby affecting the overall metabolic health of compromised whales. With OA's minimally-intrusive procedure of deploying the CATS tags with the UAS, eliminates the need to get close to the compromised whale, allowing for less stress on the whale and does not take away from the response efforts.

Image of a suction-cup tag being deployed by a drone. Credit: Lyman/NOAA Permit #24359

Health Assessment - Photogrammetry

Photogrammetry is a technique where photos are used to obtain actual measurements. Using UAS with a flat-port lens and an accurate LiDAR altimeter, Jessie and other pilots fly 100 feet over a whale while taking high-quality video. Using trigonometry, along with the camera specifications and the known altitude, the size of the image's pixels can be determined. Frame grabs while the whale is at the surface and as flat and straight as possible are used to get pixel counts of girth along the whale's length, which are then converted into centimeters. This provides the actual measurement of the whale, including the total length and its volume. These measurements give us an idea of the whale's condition and impacts posed by threats.



Aerial image of humpback whale measuring the total length & widths at every 5% interval. Credit: Moore & Hoffman/NOAA Permit #24359

SUPPORT

Jessie Hoffman and the Sanctuary team have obtained support for this project from NOAA's Office of National Marine Sanctuaries, NOAA Fisheries and their Marine Mammal Health and Stranding Response Program, the National Marine Sanctuary Foundation, Hawai'i Department of Land and Natural Resources, the University of Hawai'i Marine Mammal Research Program, and the non-profit Ocean Alliance. Financial support has been provided from grants and awards (including the Volgenau Foundation, Northern Gulf of Alaska Applied Research through UAF, Alaska Student Chapter of the Society for Marine Mammalogy, the Rybak Foundation and the Whaleman Foundation). This important research could not happen without everyone's generous support - Mahalo. And mahalo to the entire Sanctuary team, especially captains Ted Grupenhoff, Dani Klienhenz, and Jason Moore; Ed Lyman, Rachel Finn, and Maria Harvey on data collection; Dr. Marc Lammers and Maura Schonwald for extra days of data collection outside of HRA; and Jason Moore and LTJG Shelly Rofrits on UAS operations.

FUTURE EFFORTS

- Efforts will continue to collect samples and data to better quantify the impacts of threats, like entanglement and ship strikes, to the Hawaiian distinct population segment of humpback whales in the North Pacific.
- The Sanctuary and the response team they lead will continue responding to compromised whales, while garnering valuable information to mitigate threats.

Members of the HRA team. From left to right: Jessie Hoffman, Michael Rybak, Captain Jason Moore, Maria Harvey, Jim Peckarsky, Kerri Smith, and Ed Lyman. Credit: Lyman/NOAA Permit #24359.