Research at Hawaiian Islands Humpback Whale National Marine Sanctuary during the 2024-2025 research year

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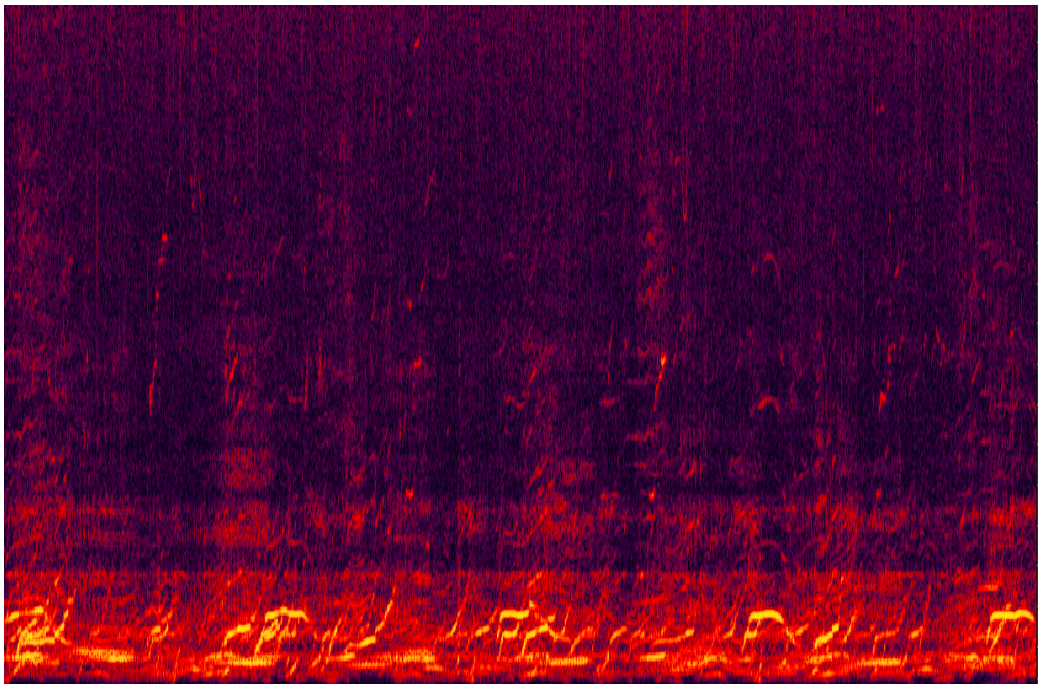
Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS) leads and collaborates in research efforts to study the segment of the North Pacific humpback whale population that breeds in the Hawaiian archipelago each winter and spring. Research on humpback whales and their habitat includes documenting trends in distribution and abundance, studying behavior within sanctuary waters, and monitoring potential human impacts. The HIHWNMS research team includes Dr. Marc Lammers (Research Ecologist, HIHWNMS) and Maura Schonwald (Research Coordination Assistant). Below is a summary of the team's activities and accomplishments during the 2024–25 research year (October 2024 – September 2025).

Acoustic monitoring of whale singing activity

Background: Between December and April, male humpback whale song becomes the dominant source of underwater ambient noise in many parts of Hawai'i, creating a chorus of whale singing. Because whale song can transmit over several miles, the acoustic energy produced by singing humpbacks can be used to track their relative presence, revealing the timing of arrival, peak abundance, and departure. Song abundance can also be used to compare the relative occurrence of humpbacks across locations and between years, providing a useful metric for studying geographic variability and annual trends in whale presence. Metrics of whale song abundance are obtained through bottom-moored acoustic recorders that measure the soundscape of an area (including whale chorusing) over the course of the breeding season. Automated algorithms are then used to quantify the amount of whale song present in recordings. In addition to monitoring whale song, the recorders are also used to quantify vessel traffic in various parts of sanctuary waters, offering a unique opportunity to examine human use patterns. Acoustic monitoring efforts are led by HIHWNMS in partnership with Oceanwide Science Institute and ONMS Sound, a NOAA Office of National Marine Sanctuaries (ONMS) project characterizing and monitoring soundscapes in national marine sanctuaries.

Management Implications: Acoustic monitoring helps HIHWNMS track multi-year trends in the occurrence and abundance of humpback whales in Hawai'i.



A spectrogram representation of whale song chorusing recorded off Olowalu, Maui. The vertical axis represents frequency from 0–6 kHz and the horizontal axis represents time over 30 seconds. Color brightness increases with acoustic energy. Photo: Marc Lammers/NOAA

Accomplishments: Beginning in October 2024, three Ecological Acoustic Recorders (EARs) were deployed in waters around Maui Nui (Maui, Molokaʻi, Lānaʻi, and Kahoʻolawe) at locations ranging in depth between 49 and 656 feet (15–200 meters). Some of these sites have been acoustically monitored since 2014, providing a time series of acoustic recordings that can be used to track inter-annual variability in humpback whale chorusing levels. A fourth EAR was deployed in mid-January 2025 in the middle of the ʻAuʻau channel between Maui and Lānaʻi to monitor the presence of vessels. In addition to the EARs, four SoundTrap recorders were deployed by the ONMS Sound team in sanctuary waters off Maui (Olowalu), Oʻahu (Makapuʻu Point), Kauaʻi (north shore), and Hawaiʻi Island (Kohala Coast). The SoundTrap placed off Hawaiʻi Island was deployed in partnership with the Hawaiʻi Marine Mammal Consortium (HMMC). The EARs and SoundTraps in HIHWNMS were recovered between May and July 2025. Preliminary results from the shallow-water EAR deployed off Olowalu show that chorusing levels did not vary greatly between 2020–2025, with observed annual variations primarily reflecting changes in the timing of whale singing activity (Figure 1, Appendix). Results from the EAR deployed in the ʻAuʻau channel comparing acoustic detections of vessel traffic in 2015 and 2025 reveal that vessel presence was reduced by approximately 80% as a result of the loss of Lahania Harbor in the 2023 Maui fires, significantly changing how much vessel traffic whales experienced off West Maui (Figure 2, Appendix).

Humpback whale tagging studies

Background: There is still much about humpback whale behavior that remains a mystery. Animal-borne sensor tags can dramatically expand our understanding of behavior. When placed on humpback whales, these tags provide insights into the lives of whales that are otherwise impossible to obtain through observations from the surface. Suction cup tags measure sound, dive behavior, and three-dimensional movements using tri-axial accelerometers and magnetometers, and in some cases also obtain video. The data generated provide unique insights into what whales do when they slip under the surface and out of our view, allowing us to examine questions about their communication, movements, and how they respond to disturbances.

Management implications: Tagging helps sanctuary staff understand humpback whale behavioral patterns in a less invasive manner than traditional methods (e.g., in-water observations by a human) and in much greater detail, providing valuable insights into how whales occupy sanctuary waters and how they are affected by various stressors. A better understanding of whale behavior is key for developing effective management strategies and mitigating anthropogenic impacts.

Drone deployment of a CATS tag on a humpback whale. Photo: Ed Lyman/NOAA, permit #20311

Accomplishments: During the 2025 field season, sanctuary research staff conducted a total of 36 tagging missions, resulting in 34 successful deployments on humpback whales. Collaborators from the University of Michigan, Syracuse University, Woods Hole Oceanographic Institution, Moss Landing Marine Lab, and the University of Hawai‘i at Hilo participated as part of a two-year project funded by the U.S. Navy’s Living Marine Resources Program. The project

focused on developing and testing a new version of the DTAG, the most widely used animal-borne tag in cetacean research. The data collected are being applied in multiple ways, including by HIHWNMS staff to quantify humpback whale behavioral activity cycles throughout the 24-hour day, including at night when little is known about their behavior in Hawai‘i.

Sanctuary staff continued to use uncrewed aerial systems (UAS – drones) to deploy tags on humpback whales, a safer and less invasive method than traditional pole tagging. UAS-based deployment was first piloted in 2023 through a collaboration with Ocean Alliance, who pioneered the approach. Building on that foundation, additional staff members successfully executed UAS-based tag deployments, helping to establish HIHWNMS as a leader within NOAA in the use of UAS for research and whale entanglement response.

Little is known about how whales respond to disturbances, such as vessel traffic and other sources of human-generated noise. For the past two years, HIHWNMS has collaborated with the University of Hawai‘i at Hilo and Syracuse University to investigate the effects of anthropogenic noise on humpback whales. During the 2024-25 research season, 13 individual humpbacks were tagged via UAS and then exposed to controlled playbacks of recorded vessel noise under a special permit issued by NOAA Fisheries. Preliminary analyses indicate that humpback whales exhibited behavioral responses to vessel noise ranging from mild to strong, depending on the type of vessel noise experienced. These results will directly inform management guidelines aimed at minimizing human disturbance of humpback whales in sanctuary waters and beyond.

HIHWNMS staff and collaborators presented findings from the past several years of tagging work at scientific meetings, including a presentation titled “Too loud: A singing humpback whale responds to ship noise” at the *25th Biennial Conference on the Biology of Marine Mammals* in Perth, Australia and a presentation titled “The behavioral response of humpback whales on the Hawaiian breeding ground to playback and in vivo exposures of vessel engine noise” at the *Effects of Noise on Aquatic Life* conference in Prague, Czech Republic. Both presentations described separate situations in which humpback whales off Maui exhibited clear behavioral responses to noise from vessels.

Vessel surveys to quantify whale abundance

Background: The abundance and timing of whale presence in the Hawaiian Islands have fluctuated during the past several years, likely due to ecosystem changes in Alaska waters that have influenced whale migration patterns in the North Pacific. Acoustic monitoring conducted by HIHWNMS staff provides one estimate of whale presence in Hawai‘i based on the singing activity of males. However, because only male whales sing, acoustic monitoring of chorusing does not capture the presence of all whales. To better quantify overall whale numbers—including non-singing males, females, and calves— HIHWNMS also conducts vessel surveys in a focal study area off West Maui on multiple days each season.

Surveys are conducted using the R/V Koholā along a systematic transect line to record humpback whale sightings in the same area monitored by several bottom-moored acoustic recorders. The application of distance sampling methods during these surveys allows the estimation of absolute whale densities in the study area. These data are then used to create a time series of humpback whale abundance off West Maui, both within and across seasons.

Management Implications: Vessel surveys help HIHWNMS staff track multi-year trends in the relative abundance of humpback whales in Hawai‘i, providing a measure of population health.

A mother and calf observed off West Maui from a drone. Photo: Jason Moore/NOAA; permit #20311

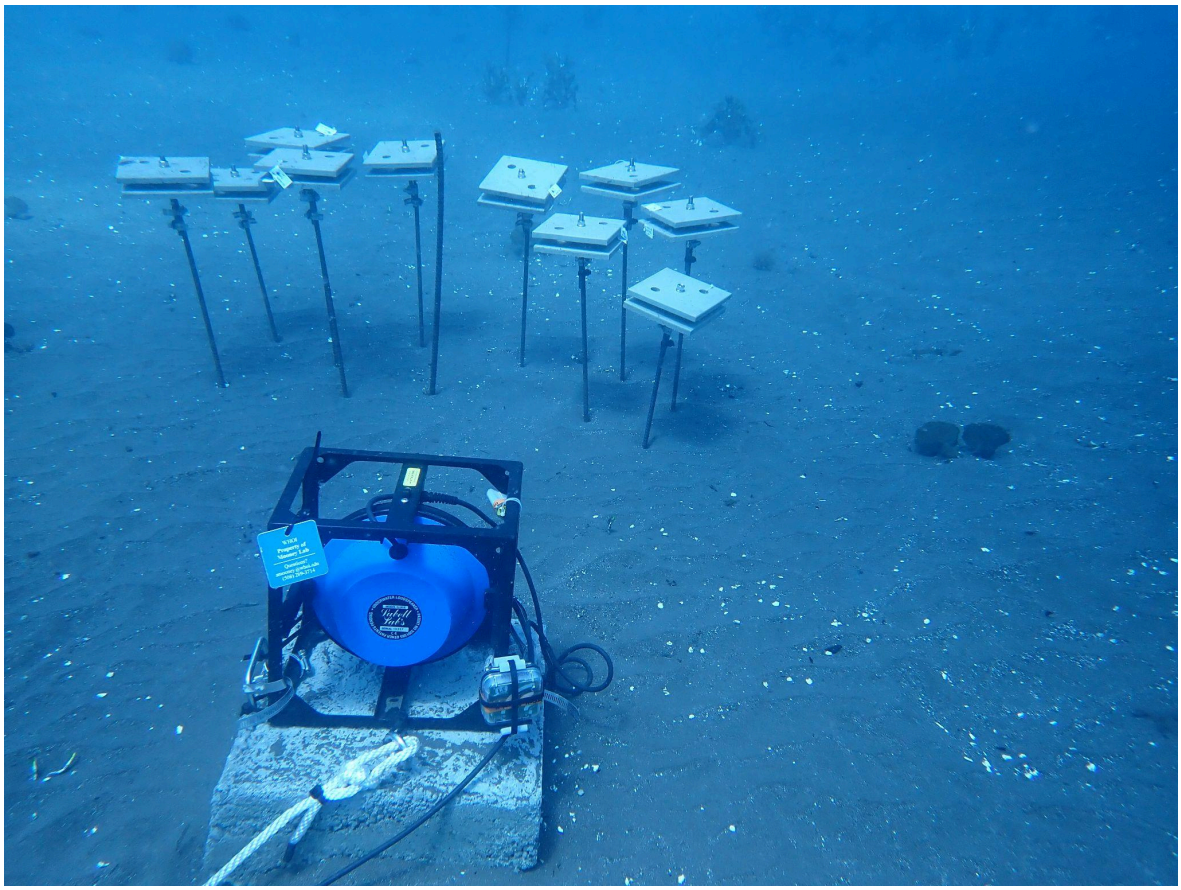
Accomplishments: Seven vessel surveys were conducted between December 17, 2024, and April 10, 2025. Observations were processed using distance sampling methods to calculate the density of whales off West Maui for each survey day. These results were used to compare whale abundance trends with previous years and to relate whale density to song chorusing levels. Figure 3 in the appendix shows preliminary results for the surveys conducted between 2018 and 2025. The data reveal that whale densities off West Maui were relatively constant between 2019 and 2022, but were substantially higher in 2023 and lower in 2024. The cause of this inter-annual variation is still unclear, but does suggest that humpback whale presence off Maui is being influenced by exogenous drivers.

Acoustic enhancement of coral reefs

Background: Sound is an important component of many marine habitats, including coral reefs. Many animal species use sound for important life functions, such as communication, reproduction, and orientation. Promising results from multiple efforts globally have demonstrated the potential benefit of active playback of “healthy” coral reef sounds for coral reef restoration through enhanced larval recruitment. HIHWNMS is a partner in a collaborative effort with Woods Hole Oceanographic Institution (WHOI), the State Division of Aquatic Resources (DAR), Maui Ocean Center (MOC), and The Nature Conservancy (TNC) to examine

whether sound plays a role in larval recruitment on coral reefs in Maui. The effort combines both laboratory and in-situ experiments to determine whether coral larval settlement is influenced by exposure to reef sounds. Building on laboratory efforts conducted in 2024, the summer of 2025 marked a transition to large-scale field trials at multiple reef sites around West and South Maui.

Management Implications: Healthy coral reefs are critical for ecosystem resilience and are directly tied to the health of humpback whale habitat. HIHWNMS staff contributed vessel support, logistics, and acoustic expertise to this WHOI-led effort, which strengthens partnerships among federal, state, and local organizations while advancing the use of innovative acoustic tools to support coral reef restoration in Hawai‘i.



The acoustic experimental setup, showing the blue playback speaker and white square settlement tiles. Photo: Sierra Jarriel

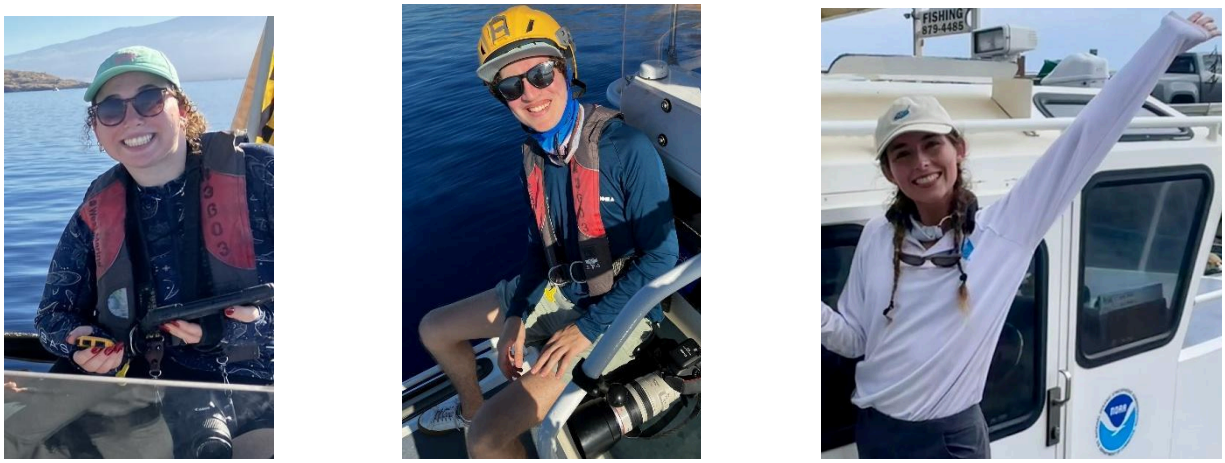
Accomplishments: Between May and August 2025, HIHWNMS played a central role in advancing this groundbreaking fieldwork. Working from the R/V Koholā, sanctuary staff assisted WHOI scientists and partners in establishing seven underwater experimental sites across South Maui and two sites near Olowalu. Over four days of intensive fieldwork beginning June 22, the team deployed underwater speakers, buoys, and structures holding more than 240 coral settlement tiles, which HIHWNMS staff had prepared for deployment beginning in April. For the next two months, recordings of healthy reef soundscapes were broadcast at selected sites off Olowalu and Kīhei. Previous controlled studies using similar methods have demonstrated

that coral larvae are 50 to 700 times more likely to settle in acoustically-enriched areas compared to control sites. Applying this approach in Maui waters has the potential to seed thousands of new coral recruits across the experimental tiles, laying the groundwork for reef recovery across Hawai‘i. Early observations during retrieval supported this potential: recruits were visible on the settlement tiles, and the sites showed vibrant ecological activity, including aggregations of domino damselfish, sergeant majors, mantis shrimp, crabs, bivalves, and even frogfish that had been drawn to the enriched reef soundscapes.

Beyond the fieldwork, the project emphasized community engagement and outreach. WHOI researchers presented their work at the Sanctuary's Sea Chat lecture series and at a local coral spawning event at Maui Ocean Center, highlighting how sound can help restore coral reefs in Hawai‘i. The project also reached international audiences when CNN Call to Earth film crews joined the team, further amplifying awareness of this promising restoration method.

This two-year initiative continues to demonstrate the sanctuary's role as a key partner in developing sound-based strategies to enhance coral settlement and reef recovery. This season's field trials represent one of the largest applications of acoustic enrichment for coral restoration to date, with results expected to provide critical insights for scaling the method across Hawai‘i and beyond.

Interns help advance HIHWNMS science



Left to right: Lizzy Glazer in the field using a stop watch to time the length of a tagged whale's dive. Photo: L. Beato/NOAA; Alex Holm in the field, ready to collect photo-identification images during a tagging mission. Photo: L. Beato/NOAA; Danielle Moffat excited for a field day on the R/V Koholā. Photo: M. Schonwald/NOAA

Background: HIHWNMS staff have limited resources to collect and analyze data from multiple field efforts. As a result, each year HIHWNMS recruits student interns who can provide assistance with field operations and data analysis, in return offering aspiring scientists hands-on training in whale research. These internships give young professionals the opportunity to participate in ongoing sanctuary projects, developing their skills and experience, and providing mentorship that prepares them for future careers in marine science and conservation. HIHWNMS benefits by leveraging the interns' enthusiasm and donated time to advance

research priorities.

Accomplishments: This year, HIHWNMS benefited from the contributions of three exceptional interns whose projects advanced our understanding of humpback whale behavior, acoustics, and human impacts, while also strengthening our field capacity. They are:

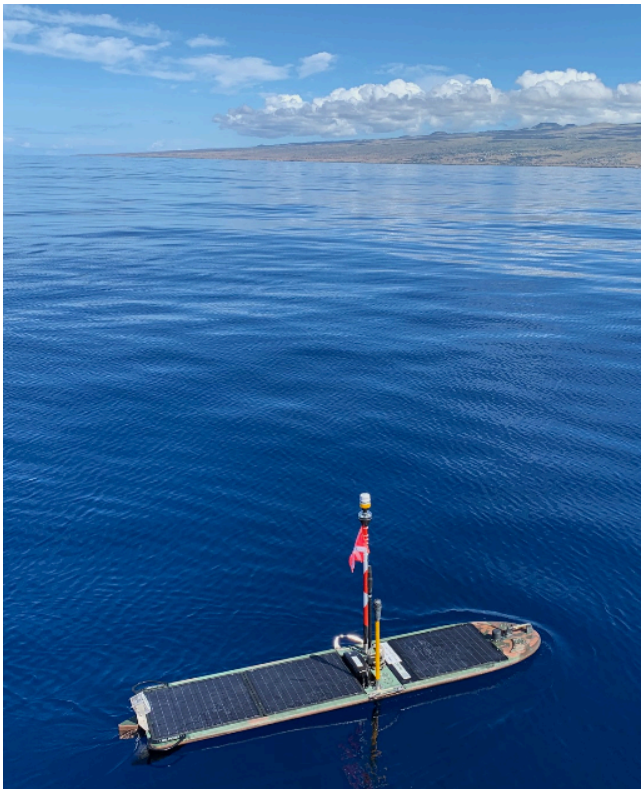
Lizzy Glazer: Lizzy is a NOAA Hollings Scholar from Duke University who spent nine weeks with HIHWNMS conducting an independent project titled *Silencing the Singers: How Anthropogenic Noise Disrupts Humpback Whale Song and Alters Behavior*. Working closely with Dr. Marc Lammers and Maura Schonwald, Lizzy analyzed data from 46 humpback whale tag deployments collected between 2018 and 2025 to examine how vessel noise influences humpback whale behavior. She manually reviewed spectrograms to mark and categorize vessel noise, then integrated these acoustic records with tag-derived dive behavior. Her analysis focused on singers and stationary whales, including mothers with calves and dyads. Preliminary results showed that vessel noise was present in every deployment and audible, on average, during 25% of daylight hours. In several cases, whales altered diving behavior or stopped singing in response to high-level vessel noise, sometimes surfacing abruptly or expending additional energy—raising concerns about heightened strike risk.

Danielle Moffat: Dani joined the sanctuary team for a four-month internship from James Cook University in Australia, where she recently completed her Master's degree in Marine Biology with distinction. During her internship, she focused on a long-term behavioral study examining the relationship between whale acoustics and behavioral states. Her research emphasized the analysis of overnight acoustic tag data to investigate diel (day vs. night) patterns in social sound production and movement metrics such as depth and acceleration. Dani is continuing this analysis with the guidance of Dr. Marc Lammers and Maura Schonwald, with the goal of publishing her findings in 2026.

Alex Holm: Alex is a master's student from the University of St. Andrews in Scotland who joined HIHWNMS for the 2024–25 academic year to fulfill part of his degree requirements. Alex is studying the communicative functions of humpback whale social calls on the Hawaiian breeding grounds. While humpback whales are best known for their elaborate songs, they also produce a wide variety of non-song vocalizations, or social calls, that are not well documented. Alex's project leveraged synchronized video and acoustic data from 19 video-enabled biologging tag deployments collected over three breeding seasons in Maui. Before the advent of these tags, how humpback whales use social calls was largely a mystery. By linking social call production to observed behaviors such as swim speed, surface activity, grouping, and physical contact, he created one of the first catalogs of humpback whale social calls for Hawai'i. Preliminary results show that whales are more likely to produce higher frequency calls with increasing swim speeds, following a general trend in animal communication. He also found that social grouping influences call production. These findings reveal that humpback whale social calls follow patterns shaped by arousal levels and social context, underscoring their distinct communicative functions. He was jointly advised by Dr. Marc Lammers and his University of St. Andrews mentor, Dr. Julie Oswald.

Examining humpback whale population structure

Background: Recent studies have indicated that the waters of Papahānaumokuākea National Marine Sanctuary (PNMS) are an important part of the winter breeding habitat of North Pacific humpback whales. Past acoustic surveys using an autonomous Wave Glider have revealed that the distribution of whales across PNMS may be more structured than previously known, raising the possibility of two sub-populations inhabiting the Hawaiian archipelago; one tied to the main Hawaiian Islands (MHI) and another more restricted to the northwestern end of PNMS (Lammers et al, 2023). Currently, no empirical evidence exists to validate or refute this possibility, largely due to the logistical challenges associated with obtaining survey data from PNMS during winter and spring months when whales are present. To overcome this challenge, HIHWNMS staff have been leveraging existing data from past passive acoustic monitoring efforts to examine the structure of humpback whale song recorded at various locations in PNMS and compare it to songs recorded in the MHI. Because distinct breeding populations of humpback whales typically exhibit divergence in the structure of their song, such an analysis may help to determine whether two sub-populations are present in the archipelago.



The Wave Glider “Europa” that was used to survey PNMS in 2020. Photo: Marc Lammers/NOAA

Management Implications: Determining whether two sub-populations share the Hawaiian archipelago is important because, if confirmed, it could require that they be managed differently based on their population status.

Accomplishments: HIHWNMS staff processed an extensive archive of Ecological Acoustic Recorders (EAR) from Kānemilohaʻi (French Frigate Shoals), spanning 12/16/2017–04/16/2018, totaling 2,928 hours of continuous data. Within this period, five days featured well-developed song structure, representing at least six individual whales and 24 complete songs. Each of these songs was sectioned and annotated, and is being compared to dipping hydrophone recordings collected from six whales in the Maui Nui region in March 2018, and to one tagged whale that produced more than 10 consecutive songs. Analyses are ongoing, but once completed, these comparisons will provide valuable insight into the connection between whales using Kānemilohaʻi and those in the MHI.

The Wave Glider deployment in early 2020 added another important dimension to this work. Covering 01/08/2020–03/14/2020, it captured approximately 1,587 hours of continuous recordings across PNMS. From these data, high-quality songs were identified at several sites: three from Middle Bank, three from Moku Manu (Nihoa), three from Papaʻāpoho (Lisianski), two from an unnamed seamount near Papaʻāpoho, and two from Raita Bank. Figure 4 in the appendix shows the locations where songs were successfully isolated. Like the Kānemilohaʻi dataset, these songs were sectioned and annotated, and are being compared across PNMS sites and with two tagged whales from Maui. Together, these ongoing analyses may help reveal how humpback whale song is shared, and potentially differentiated, across the archipelago. This will help shed light on whether two sub-populations potentially share the archipelago.

Acknowledgments: The efforts described here would not be possible without the dedicated help of many individuals who contributed in various ways. These include (in alphabetical order): Shannon Atkinson, Amy Apprill, Nadège Aoki, Elizabeth Beato, Oceane Boulais, Hunter Brendel, William Carrier, Elise Chassman, Helena Colletta, Patrick Conley, Luke Evancoe, Adam Frankel, Chris Gabrielle, Beth Goodwin, Ted Gruppenhoff, Maria Harvey, Jessie Hoffman, Kim Hum, Lee James, Chris Keller, Iain Kerr, Dani Kleinhenz, Anke Kügler, Jason Leonard, Ed Lyman, Stephen Manley, Megan McElligott, Aran Mooney, Jason Moore, Carolin Nieder, Sofia Nuri, Erin Oleson, Adam Pack, Susan Parks, Valeria Perez, Meredith (Molly) Reeve, Shelly Rofrits, Jeannine Rossa, Audrey Sarin, Alex Shorter, Adam Smith, Russell Sparks, Alison Stimpert, Kristi Stone, Grant Thompson, Julia Wente, Sarah Wilkin, Chris Zadra, Eden Zang, and Julia Zeh.

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APPENDIX – Preliminary Results

NOTE: The figures below are preliminary and unpublished. Please do not publish or post on social media. Contact Dr. Marc Lammers (marc.lammers@noaa.gov) before disseminating.

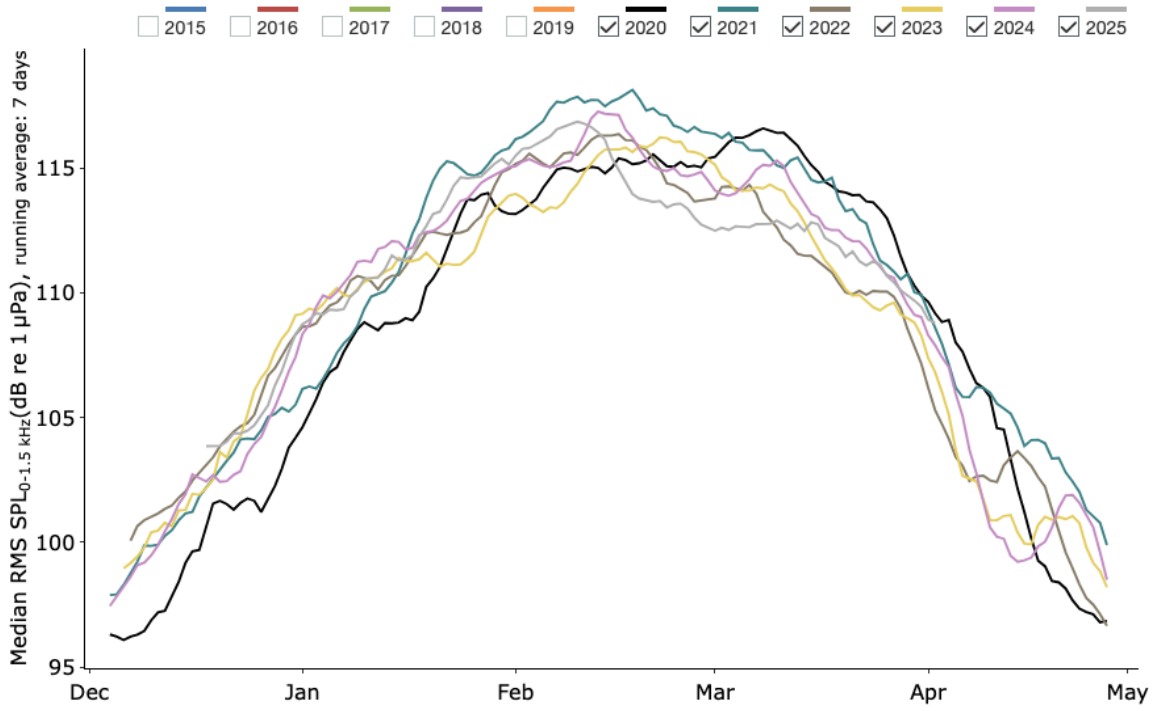

Figure 1 – Humpback whale song chorusing levels in decibels measured by an Ecological Acoustic Recorder (EAR) deployed off Olowalu between 2020 and 2025.

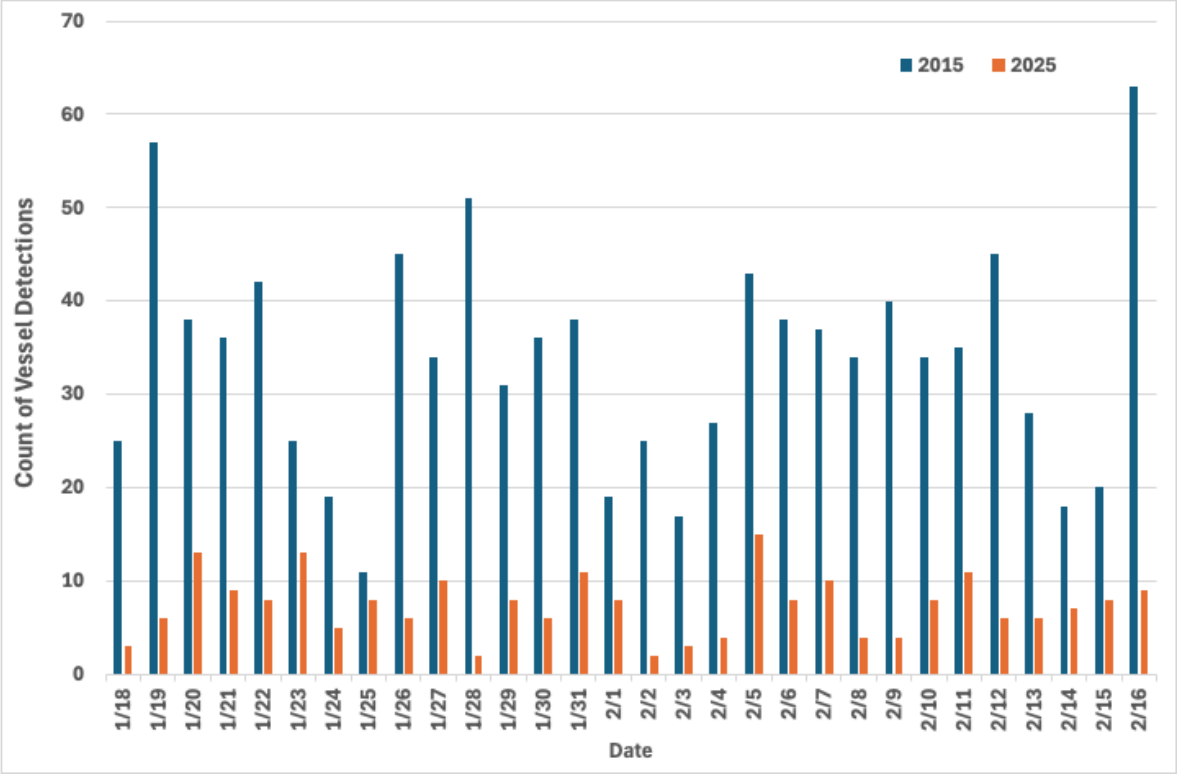

Figure 2 – Count of vessels detected acoustically in the ʻAu'au channel between Maui and Lānaʻi from January 18 to February 16 in 2015 and in 2025 showing a decrease in vessel traffic resulting from the destruction of Lahaina harbor by the 2023 Maui wildfires.

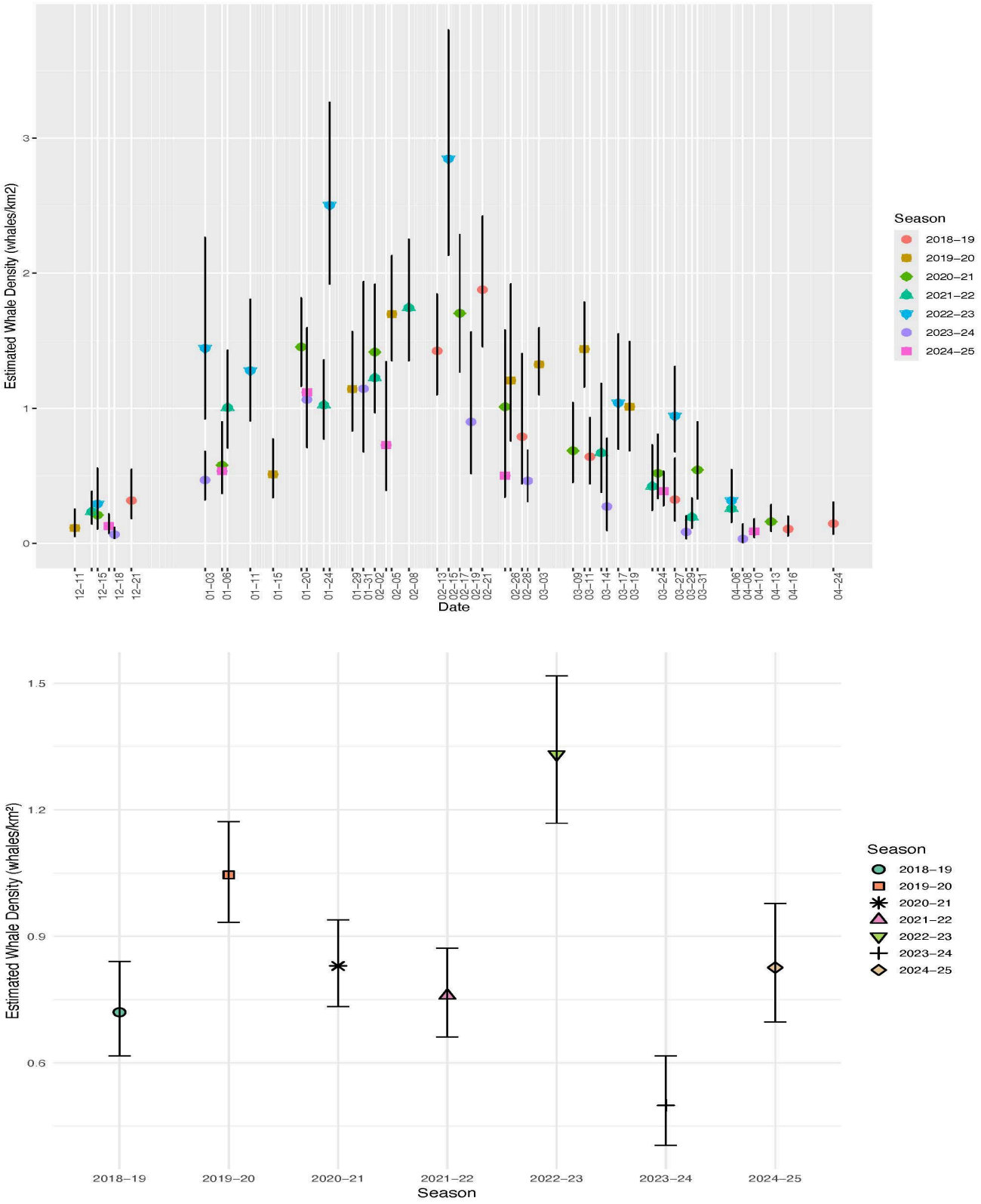

Figure 3 - The mean and standard deviation of humpback whale density off West Maui observed for each survey day (top graph) and averaged for each season (bottom graph).

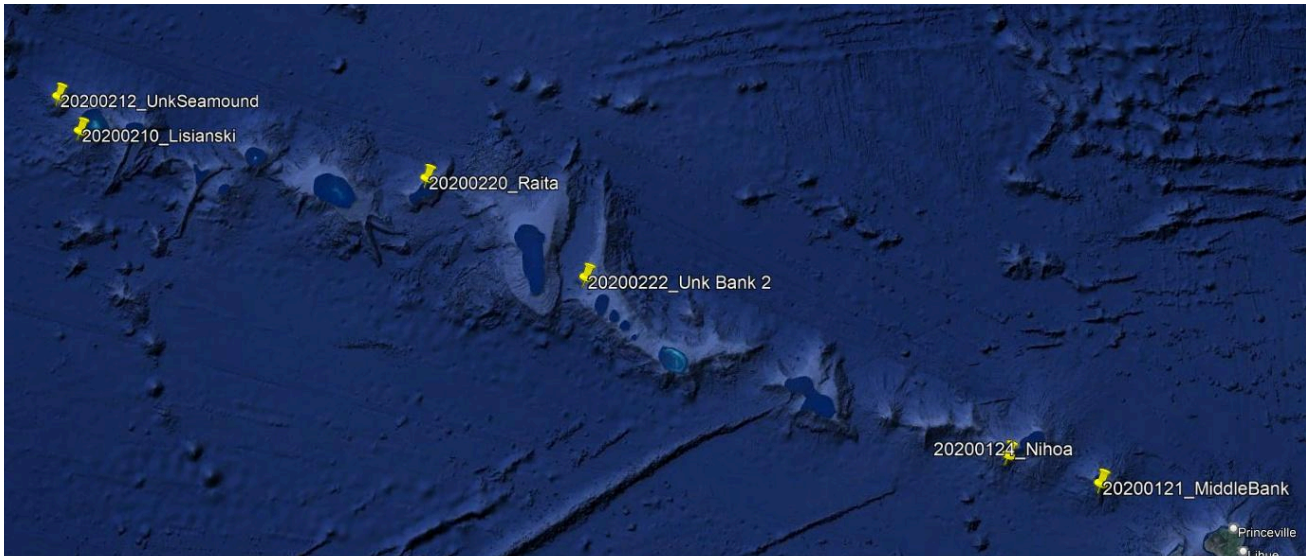

Figure 4 - Map of the Northwestern Hawaiian Islands showing the date and location where the Wave Glider collected high-quality recordings of humpback whale song.

Recent HIHWNMS publications:

Zeh, J.M., Lammers, M.O., Pack, A.A. and Parks, S.E. (2025) “Movement and sound production in yearling humpback whales: age-class comparisons.” Beh. Ecol. Sociobiol. 79:36 https://doi.org/10.1007/s00265-025-03575-7

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Cheeseman, T. and 73 other authors (2024) "Bellwethers of change: population modeling of North Pacific humpback whales from 2002 through 2021 reveals shift from recovery to climate response.” R. Soc. Open Sci. 11: 231462. https://doi.org/10.1098/rsos.231462

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https://doi.org/10.1098/rsos.230279

Lammers, M.O., Kriedler, N., Kügler, A. and Zang, E.J. (2023) “Too loud: A singing humpback whale responds to ship noise.” Proceedings of the 10th Convention of the European Acoustics Association Forum Acusticum 2023, pp. 5451-5454. doi: 10.61782/fa.2023.0932

Zang, E., Lammers, M.O., Pack, A., Hatch, L. (2023) “Impulsive sounds produced by humpback whale surface active behavior recorded on acoustic tags and bottom-moored recorders.” Mar. Mamm. Sci. 40:302–308. https://doi.org/10.1111/mms.13085

Gruden, P., Jang, J., Kügler, A., Kropfreiter, T., Tenorio-Halle, L., Lammers, M.O., Thode, A. and Meyer, F. (2023) “Automating multi-target tracking of singing humpback whales recorded with vector sensors.” J. Acoust. Soc. Am. 154:2579-2593. https://doi.org/10.1121/10.0021972

Lammers, M.O., Goodwin, B., Kügler, A., Zang, E.J., Harvey, M., Margolina, T., Martinez, J.A., Merkens, K. and Hatch, L.T. (2023) “The occurrence of humpback whales across the Hawaiian archipelago revealed by fixed and mobile acoustic monitoring.” Front. Mar. Sci. 10:1083583. doi: 10.3389/fmars.2023.1083583

America's Underwater Treasures