



Research activities at Hawaiian Islands Humpback Whale National Marine Sanctuary during the 2021-22 whale season

Prepared by Marc Lammers, Eden Zang, and Anke Kügler

Sept. 10, 2022

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 the whales' distribution and abundance, studying their behavior while in sanctuary waters, and monitoring potential human impacts. The HIHWNMS research team is composed of Dr. Marc Lammers, Research Ecologist, HIHWNMS; Eden Zang, Research Specialist, HIHWNMS; Anke Kügler, Graduate Assistant, University of Hawai'i (UH) at Mānoa and Dani Kleinhenz, Data Analyst, National Marine Sanctuary Foundation. Below is a summary of the team's activities and accomplishments during the 2021-22 field season (October 2021 – May 2022).

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 whales can be used to track the relative presence of whales in an area, revealing the timing of their arrival, their peak abundance, and their departure. The abundance of song can also be used to compare the relative occurrence of whales 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, which includes 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 are funded in part through the



Diver placing an acoustic recorder on the ocean floor. Photo: Jason Sturgis

[SanctSound Project](#), an Office of National Marine Sanctuaries endeavor to characterize the soundscapes in seven national marine sanctuaries and one marine national monument.

Accomplishments: Beginning in October 2021, five Ecological Acoustic Recorders (EARs) were deployed in waters around Maui Nui (Maui, Molokaʻi, Lānaʻi, and Kahoʻolawe) and Oʻahu at locations ranging in depth between 49 and 656 feet (15-200 meters). Several 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 whale chorusing levels. In addition to the EARs, four SoundTrap recorders were deployed in sanctuary waters off Maui (Olowalu), Oʻahu (Makapuʻu Point), Kauaʻi (north shore) and Hawaiʻi Island (Kohala Coast) as an extension of the SanctSound Project, which officially ended in April 2022. The SoundTrap deployed off Hawaiʻi Island was deployed in partnership with the Hawaiʻi Marine Mammal Consortium (HMMC) as part of a new acoustic collaboration between the sanctuary and HMMC. Two SoundTrap recorders were also deployed at Middle Bank and French Frigate Shoals in Papahānaumokuākea Marine National Monument (PMNM) as part of the SanctSound Project in September 2021. The EARs and SoundTraps in HIHWNMS were recovered in May and June. The two PMNM recorders will be recovered during a research cruise in August 2022. Figure 1 in Appendix A shows preliminary results from the shallow-water EAR deployed off Olowalu. In December 2021 a paper was published in the journal *Frontiers in Marine Science* titled “Male humpback whale chorusing in Hawaiʻi and its relationship with whale abundance and density” that combined results from the acoustic monitoring efforts described above and data obtained through visual surveys (see below) to allow abundance estimates to be derived solely from recorded chorusing levels. In addition, in April 2022 the [SanctSound web portal](#) was publicly released providing access to all data and data products generated by the project over the past four years. Finally, in June 2022 PBS South Florida releases an episode of the Changing Seas documentary series titled Vanishing Whales that featured the sanctuary’s acoustic monitoring work. The documentary can be viewed [here](#).



Humpback whale carrying a CATS tag. Photo: Marc Lammers/NOAA. NOAA permit #19655.

Tagging humpback whales to understand their behavior

Background: Although humpback whales have been studied in Hawaiʻi for decades, much of their behavior remains a mystery. For example, not much is known about what whales do at night and whether their activities differ from those observed during the day. Very little is also still known about how whales respond to acoustic disturbances, such as vessel traffic and other sources of human-generated noise. Animal-borne sensor tags can dramatically expand our understanding of

animal behavior. When placed on humpback whales, these tags can provide insights into the lives of whales that are otherwise impossible to obtain through observations from the surface. These tags that are placed on whales using suction cups measure sound, dive behavior, the whales’ three-dimensional movements using tri-axial accelerometers and magnetometers, and in some case 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 activity levels. Over the past four years, HIHWNMS has

increased its involvement in this type of research through partnerships, the acquisition of tools, and expanded analytical capabilities, and now leads and collaborates in efforts to examine some of the open questions about whale behavior using tags.

Accomplishments: A total of 20 tagging missions were undertaken during the 2022 field season, resulting in 33 successful tag deployments on humpback whales, doubling the number of tag deployments made over the previous three years at HIHWNMS and providing novel and groundbreaking data on whale behavior. Collaborators from Syracuse University and the University of Hawai'i at Hilo participated in several missions throughout the season. The data collected are being used in a variety of projects, including by Julia Zeh, a Ph.D. student at Syracuse University, to examine the development of singing behavior in juvenile male humpback whales and by HIHWNMS staff to quantify behavioral activity cycles throughout the 24-hour day. This season also marked the successful deployment of 20 Customized Animal Tracking Solutions (CATS) video tags by HIHWNMS, which yielded over 86 hours of “whale cam” video (e.g. Appendix A Figure 2). The CATS tag video data were analyzed by Cameron Larmer, a NOAA Hollings Scholar hosted by HIHWNMS who quantified the behavior seen in the videos using an ethogram. HIHWNMS staff and colleagues presented results from the tagging work at the 7th International Bio-Logging Symposium (Oct. 18-22, 2021) and at the 24th Biennial Conference on the Biology of Marine Mammals (Aug. 1-4, 2022). In August 2022 a paper titled “Comparing the social signaling behavior of humpback whales in three group types on the Hawaiian breeding grounds using acoustic tags” was accepted for publication in the journal *Frontiers in Remote Acoustic Sensing*. This paper is based on the data collected from HIHWNMS tagging efforts and is part of the Masters work of Jessica Carvalho, a student at the University of the Algarve in Portugal.



HIHWNMS staff conducting a vessel-based whale survey aboard the R/V *Koholā*. Photo: Martin van Aswegen

Vessel surveys to quantify whale abundance

Background: The abundance of whales in the Hawaiian Islands has been fluctuating 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 efforts are providing an estimate of whale presence in Hawai'i based on the singing activity of males, but it is not clear how well this captures trends in the population overall, including non-singing males, females, and calves. To measure whale abundance

more accurately in Maui Nui and to relate whale numbers to recorded levels of song chorusing (see above), vessel-based surveys are conducted each season in a focal study area off west Maui. Vessel surveys using the R/V *Koholā* record whale sightings along a systematic transect line that covers the same area monitored by several bottom-moored acoustic recorders. The use of distance sampling methods during vessel surveys allows the estimation of absolute whale densities in the study area. The data are then used to create time series of whale abundance off west Maui within and between seasons.

Accomplishments: Nine vessel surveys were conducted between December 14, 2021 and April 6, 2022. The data obtained were processed using distance sampling methods to compare with whale abundance trends obtained in previous years and to relate whale song chorusing levels measured in decibels to metrics of whale density measured visually. Initial results indicate that song chorusing is currently able to predict whale density with approximately $\pm 15\text{-}20\%$ accuracy. Continued visual and acoustic data collection will help improve the estimates. Whale density trends calculated from vessel surveys conducted over the past four seasons are shown in Figure 3 of Appendix A. Finally, the HIHWNMS team submitted a manuscript in July 2021 to the journal *Frontiers in Marine Science* titled "Male humpback whale chorusing in Hawai'i and its relationship with whale abundance and density" that describes the effort to relate acoustic monitoring data to visual survey efforts.

Collaboration to monitor Maui Nui's spinner dolphins

Background: Hawaiian spinner dolphins are resident to Maui Nui waters and occupy the near shore waters off Maui and Lāna'i to socialize and rest during the day. In late 2020, a consortium of organizations began a collaboration to use acoustic monitoring to study and better protect spinner dolphins that use the Honolua Bay (Maui) and Mānele-Hulopo'e (Lāna'i) Marine Life Conservation Districts (MLCDs). This consortium includes The Nature Conservancy, HIHWNMS, State Department of Land and Natural Resources Division of Aquatic Resources, Oceanwide Science Institute, Hawai'i Association for Marine Education and Research, Ultimate Whale Watch and Pūlama Lāna'i. The objective of this effort is to acoustically monitor three known spinner dolphin resting areas in these MLCDs for one year to better understand how dolphins respond to human use changes as the economy of Hawai'i reopens following COVID-related shutdowns.



Hawaiian spinner dolphins. Photo: Kawika Singson

Accomplishments: Beginning in December 2020, HIHWNMS staff assembled and helped deploy three EARs at Honolua Bay, Hulopo'e and Mānele Bay. These were refurbished approximately every four months until May 2022. Megan McElligott, a University of Hawai'i at Mānoa PhD student working under the supervision of Dr. Marc Lammers, has been analyzing the data obtained, thanks to financial support provided by The Nature Conservancy. The analyses are quantifying the presence of spinner dolphins at each monitored location to allow for comparisons with pre-Covid baseline periods.

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): William Carrier, Peter Colombo, Patrick Conley, Mark Deakos, Luke Evancoe, Emily Fielding, Adam Frankel, Chris Gabrielle, Beth Goodwin, Michelle Graham, Ted Gruppenhoff, Leila Hatch, Lee James, Kimberly Jeffries, Jessie Kittel, Jen Kogan, Jason Leonard, Ed Lyman, Kiki Mann, Megan McElligott, Karlina Merkens, Mark Mohler, Jason Moore, Adam Pack, Susan Parks, Jeannine Rossa, Russell Sparks, Kristi Stone, Suzanne Yin and Julia Zeh.

APPENDIX A – 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.

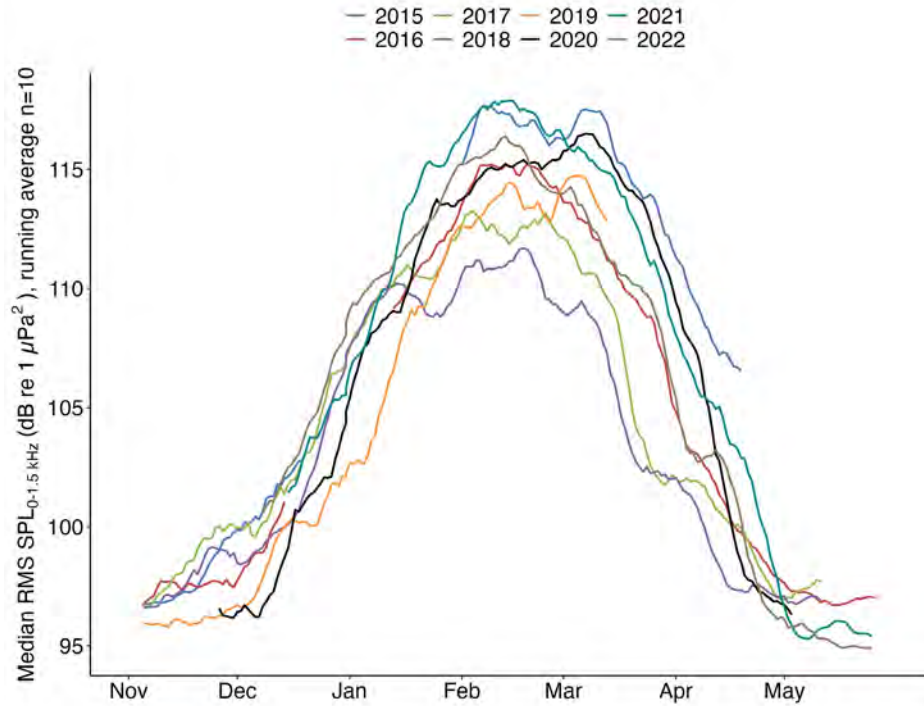


Figure 1 – Humpback whale chorusing levels in decibels measured by an Ecological Acoustic Recorder (EAR) deployed off Olowalu over the past eight years. Data gaps represent periods when the EAR did not record.



Figure 2 – View from a CATS video tag deployed on a whale in a dyad group showing the companion whale.

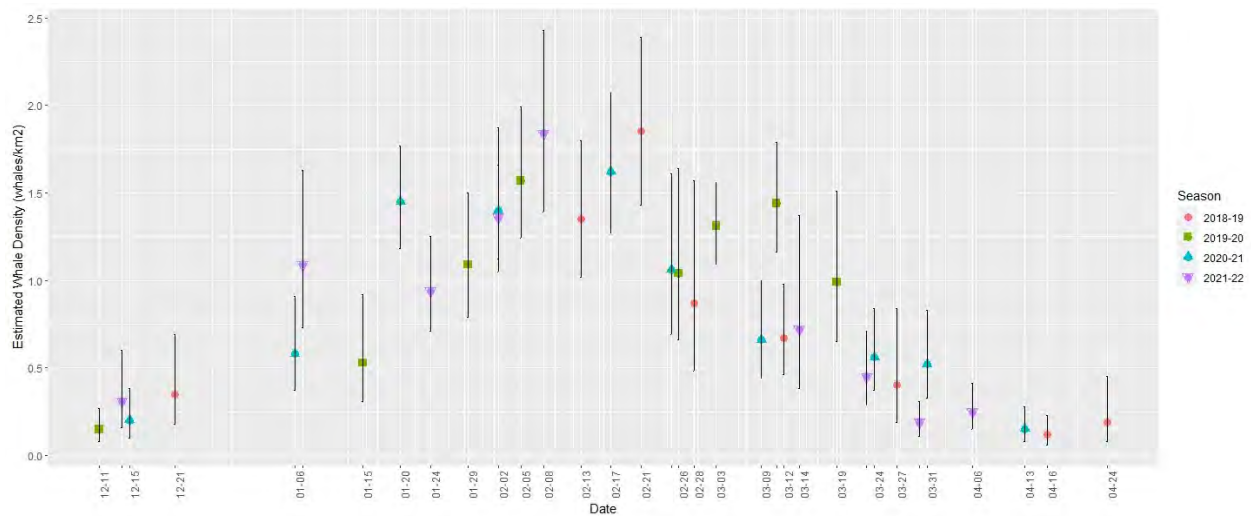


Figure 3 – Estimated density and 95% confidence intervals of whales in the west Maui area calculated from 35 vessel-transect surveys conducted during the 2018/19, 2019/20, 2020/21 and 2021/22 whale seasons.

Recent HIHWNMS publications:

- Carvalho, J., Lammers, M.O., Indeck, K., Pack, A. and Castilho, R. (2022) “Comparing the social signaling behavior of humpback whales in three group types on the Hawaiian breeding grounds using acoustic tags.” *Front. Remote Sens.* 3:910455.
- Parsons, M.J.G., Lin, T-H., Mooney, T.A., Erbe, C., Juanes, F., Lammers, M.O., Li, S., Linke, S., Looby, A., Nedelec, S.L., Van Opzeeland, I., Radford, C., Rice, A.N., Sayigh, L., Stanley, J., Urban, E. and Di Iorio, L. (2022) Sounding the Call for a Global Library of Underwater Biological Sounds. *Front. Ecol. Evol.* 10:810156.
- Tenorio-Halle, L., Thode, A.M., Lammers, M.O., Conrad, A.S. and Kim, K.H. (2022) “Multi-target 2D tracking method for singing humpback whales using vector sensors.” *J. Acoust. Soc. Am.* 151:126-137.
- Kügler, A., Lammers, M.O., Zang, E.J. and Pack, A. (2021) “Male humpback whale chorusing in Hawaii and its relationship with whale abundance and density.” *Frontiers in Marine Science.* 8:735664. doi: 10.3389/fmars.2021.735664
- Zang, E., & Lammers, M. (2021). “Estimated density and abundance of humpback whales (*Megaptera novaeangliae*) off Maui, Hawaii: Results from 2018-21 vessel-based surveys.” National Marine Sanctuaries Conservation Series ONMS-21-09.
- McElligott, M.M. and Lammers, M.O. (2021) “Investigating spinner dolphin (*Stenella longirostris*) occurrence and acoustic activity in the Maui Nui region.” *Front. Mar. Sci.* 8:703818.
- McKenna, M.F., Baumann-Pickering, S., Kok, A., Oestreich, W., Frstrup, K., Adam, J., Barkowski, J., Goldbogen, J., Joseph, J., Kim, E.B., Lammers, M.O., Margolina, T., Peavey, L.E., Rowell, T.J., Stanley, J., Stimper, A., Zang, E.J., Southall, B., Van Parijs, S., Hatch, L. (2021) “Advancing the interpretation of shallow marine soundscapes.” *Front. Mar. Sci.* 8:719258.