Research activities at Hawaiian Islands Humpback Whale National Marine Sanctuary during the 2020-21 whale season

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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 the whales' distribution and abundance, studying their behavior while in sanctuary waters, and monitoring potential human impacts. The HIHWNMS research team is composed of Research Ecologist Dr. Marc Lammers, Research Specialist Eden Zang, University of Hawai'i (UH) at Mānoa Graduate Assistant Anke Kügler, and National Marine Sanctuary Foundation Data Analyst Jessie Kittel. Due to limitations associated with COVID-19 safety protocols, field activities were more limited in scope and breadth than in previous years. Below is a summary of the team's activities and accomplishments during the 2020-21 field season (October 2020 – May 2021).

Acoustic monitoring of whale singing activity

Singing male humpback whale in Maui waters. Photo: Ed Lyman/NOAA

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, including in relation to the current global COVID-19 pandemic. Acoustic monitoring efforts are led by HIHWNMS in partnership with Oceanwide Science Institute, Scripps Institution of Oceanography (SIO), and

Greenridge Sciences, Inc., and with funding support from the 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 of 2020, seven ecological acoustic recorders (EARs) were deployed in waters around Maui Nui (Maui, Molokaʻi, Lānaʻi, and Kahoʻolawe) and Oahu at locations ranging in depth between 15 m and 200 m. 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, five SoundTrap recorders were deployed in sanctuary waters off Maui (Olowalu), Molokaʻi (Penguin Bank), Oahu (Makapuʻu Point), Kauaʻi (north shore), and Hawaiʻi Island (Kohala Coast) as part of the SanctSound Project. 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 2020. Finally, on February 21 three directional autonomous seafloor acoustic recorders (DASARs) were deployed as part of a project led by SIO and Greenridge Sciences, Inc. to localize and count the number of humpback whales singing at any given time in the sanctuary's focal study area off west Maui, representing the second year of this collaborative project with HIHWNMS. The EARs and SoundTraps in HIHWNMS were recovered in May and June. The two PMNM recorders will be recovered during a research cruise in July 2021. The three DASARs were recovered on June 24, 2021. Figure 1 in Appendix A shows preliminary results from the shallow water EAR deployed off Olowalu. A more comprehensive summary of acoustic monitoring results from the past several years was published in December 2020 in the journal *Endangered Species Research* with the following citation: Kügler, A., Lammers, M.O., Zang, E.J., Kaplan, M.B. and Mooney, T.A. (2020) "Fluctuations in Hawaii's humpback whale *Megaptera novaeangliae* population inferred from male song chorusing off Maui." *Endangered Species Research* 43:421-434. Visit the link for the full text.

Tagging humpback whales to understand their behavior

HIHWNMS researchers deploy an acoustic tag on a whale using a long pole. Photo: Marc Lammers/NOAA, under NOAA permit #19655

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 have the ability to 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, and the whales' three-dimensional movements using tri-axial accelerometers and magnetometers. In some

cases, they also obtain video. The data generated provide unique insights into what whales do when they slip under the surface and out of view, allowing us to examine questions about their communication, movements, and activity levels. Over the past three years, HIHWNMS has increased its involvement in this type of research through partnerships, the acquisition of tools, and expanded analytical capabilities. HIHWNMS now leads and collaborates in efforts to examine some of the open questions about whale behavior through the use of tags.

Accomplishments: Due to safety restrictions associated with the COVID-19 pandemic, participation in field activities during the 2021 season was limited to core NOAA staff. As a result, inclusion of established partners and volunteers in field operations was not possible this season. Nonetheless, ongoing tagging collaborations with colleagues at the University of Hawai‘i at Hilo, Syracuse University, Stanford University, and University of Algarve (Portugal) continued. A total of 15 tagging missions were undertaken during the 2021 field season, resulting in 14 successful tag deployments on humpback whales. These included our longest tag deployment to date, which remained on the whale 46.5 hours! The data collected are being used in a variety of projects, including by a Ph.D. student (Julia Zeh) to examine the development of singing behavior in juvenile male humpback whales, by a Masters student (Jessica Carvalho) to examine acoustic signaling in different social roles, and by HIHWNMS staff to quantify behavioral activity cycles throughout the 24-hour day. This season also marked the first successful deployment of a Customized Animal Tracking Solutions (CATS) video tag by HIHWNMS, which yielded over nine hours of stunning “whale cam” video (e.g., Appendix A Figure 2). Unfortunately, the CATS tag developed a problem following this deployment and had to be returned to the manufacturer for repair. HIHWNMS staff and colleagues have submitted two abstracts to present their work at the 7th International Bio-Logging Symposium (October 18-22) and at the 24th Biennial Conference on the Biology of Marine Mammals (December 13-17).

Vessel surveys to quantify whale abundance

HIHWNMS staff conducting a vessel-based whale survey aboard the R/V *Koholā*. Photo: Jessie Kittel

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 more accurately measure whale abundance 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: Ten vessel surveys were conducted between December 15, 2020 and April 13, 2021. 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. Whale density trends calculated from vessel surveys conducted over the past three seasons are shown in Figure 3 of Appendix A. In addition, 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 residents 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 Hawaii's economy reopens following COVID-related shutdowns.


A spinner dolphin leaps out of the water. Photo: Marc Lammers/NOAA

Accomplishments: Beginning in December 2020, HIHWNMS staff assembled and helped deploy three EARs at Honolua Bay, Hulopo‘e, and Mānele Bay. These will be refurbished approximately every four months. In addition, UH Mānoa Ph.D. student Megan McElligott and Dr. Marc Lammers submitted a manuscript in June 2021 to the journal *Frontiers in Marine Science* titled "Investigating Spinner Dolphins (*Stenella longirostris*) Occurrence and Acoustic Activity in the Maui Nui Region" describing a previous acoustic monitoring effort.

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, Alex Conrad, Mark Deakos, Emily Fielding, Ted Gruppenhoff, Leila Hatch, Lee James, Jessie Kittel, Jason Leonard, Ed Lyman, Kiki Mann, Jonathan Martinez, Megan McElligott, Karlina Merkens, Jason Moore, Adam Pack, Susan Parks, Jeannine Rossa, Russell Sparks, Aaron Thode, 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.

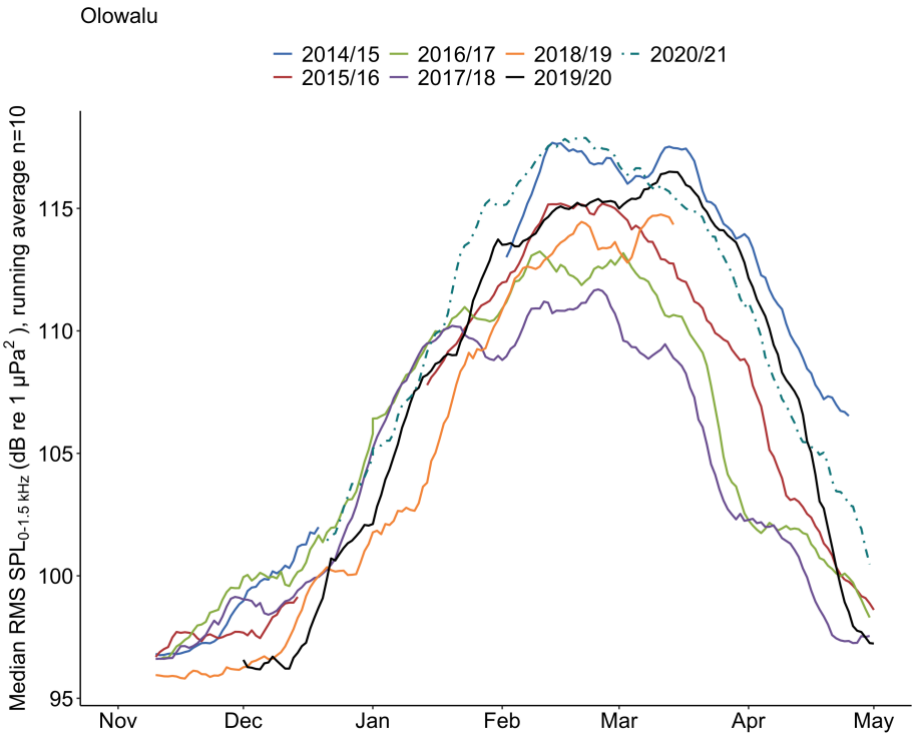

Figure 1 – Humpback whale chorusing levels in decibels measured by an ecological acoustic recorder (EAR) deployed off Olowalu over the past seven years. Data gaps represent periods when the EAR did not record.

Figure 2 – View from a CATS video tag deployed on a male escort showing a mother and calf, as well as an *Ōpelu* (mackerel scad) feeding on the whale's dead skin.

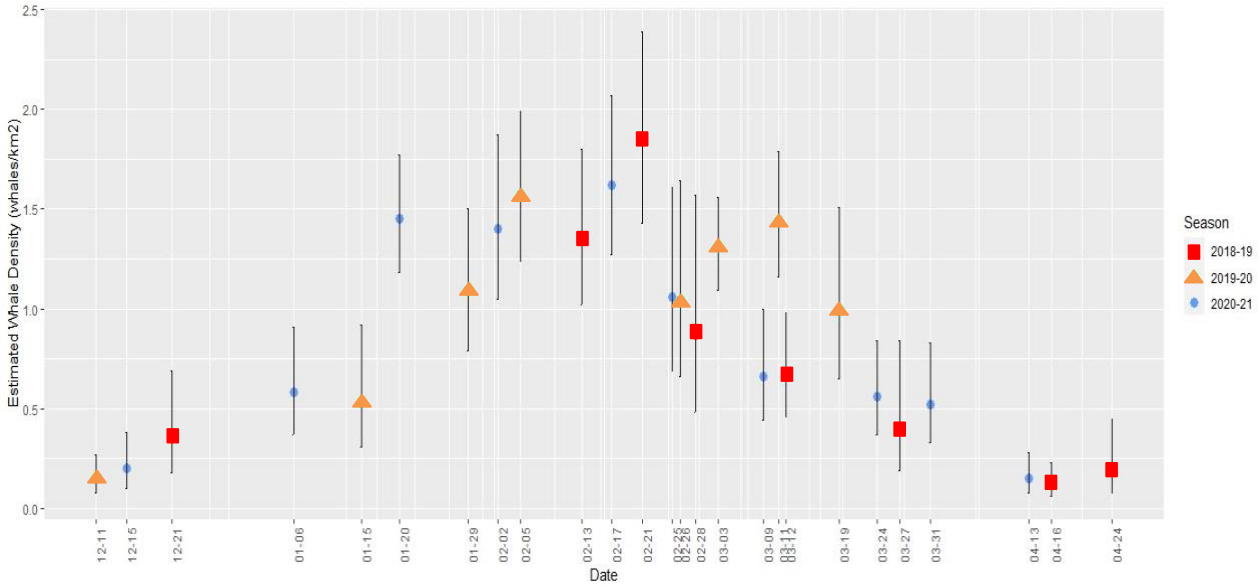

Figure 3 – Estimated density and 95% confidence intervals of whales in the west Maui area calculated from 26 vessel-transect surveys conducted during the 2018/19, 2019/20, and 2020/21 whale seasons.