

Progress Update: Department of the Navy – US Pacific Fleet Environmental Readiness Division

Project

Advancing monitoring capacity in Hawaii through non-invasive triaxial accelerometry tags to evaluate fine-scale responses of marine mammals to disturbance

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Abstract:

For the period of funding, Dr. Will Gough has been working at the Marine Mammal Research Program (MMRP) on a number of goals that will build capacity within Hawaii and advance the Navy's goals related to the long-term health of protected marine mammal species. These goals relate to Dr. Gough's expertise working with accelerometry-based biologging tags and include: setting up infrastructure at the MMRP to maintain large quantities of tag data, collecting novel data and expanding existing datasets through field efforts, training members of the Navy and MMRP to work effectively with accelerometry data and biologging devices, develop training materials and short-form workshops to disseminate knowledge of accelerometry data processing and analysis more broadly within the Hawaiian community, and use new and existing datasets to answer questions of relevance to the Navy and other organizations tasked with monitoring and management of protected species.

Background:

The Navy has expressed interest in obtaining information from marine mammals in the Hawaiian Island region to explore the potential consequences of Navy training on the long-term health of these species, particularly those that are listed under the Endangered Species Act (ESA). The Navy's Hawaii Range Complex overlaps with the habitat of >30 species of protected whales, dolphins and one phocid species, the endangered Hawaiian monk seal (*Neomonachus schauinslandi*). It is, therefore, crucial to ensure a strong and locally-based science team to monitor the potential impacts of anthropogenic activities on these species.

The Navy's marine mammal monitoring efforts in the Western Pacific region have focused mainly on the use of satellite telemetry, photo-identification, and passive acoustic monitoring to provide broad-scale response metrics to military acoustic exposure. However, these methods do not currently offer the resolution needed to measure immediate short-term responses and effects on exposed animals. Fortunately, non-invasive archival tags now have the capacity to integrate several synchronized data streams (including high-resolution triaxial accelerometry, video and acoustic data) in odontocete, mysticete, and pinniped species. These tags provide an opportunity to measure fine-scale baseline data (Bejder et al., 2019) as well as short-term behavioral and physiological response metrics associated with a stressor (Mikkelsen et al. 2019, Elmegard et al., 2021, Czapanskiy et al., 2021). These baseline and acute response data are important to quantify effects of disturbance and to inform predictive models such as the Population Consequences of Disturbance framework (PCoD) (Booth et al. 2020, Pirotta et al., 2021).

Using the mysticetes tag-analysis toolkit developed by Stanford University, tag deployments on a range of mysticete and odontocete cetacean species have begun to yield crucial results at the interface of ecology, behavior, biomechanics, kinematics and physiology (e.g., Cade et al., 2016; Goldbogen et al., 2017; Goldbogen et al., 2019a,b; Gough et al., 2019; Czapanskiy

et al., 2021). This toolkit was made available as an open resource in 2020 with a formal week-long training led by Dr. David Cade and Dr. Will Gough.

With tag development evolving rapidly, it is important to continue the foundational work to generate an analysis platform that can be expanded to new tags, species and regions. Because of its current effort and existing capacity, the Marine Mammal Research Program (MMRP) can ground truth, expedite, and disseminate the tools that will be derived from this project to other researchers working on Navy's priorities and marine mammal conservation.

In light of this background, funding was provided to employ Dr. Will Gough as a post-doctoral researcher through a Cooperative Agreement titled: "*Advancing monitoring capacity in Hawaii through non-invasive triaxial accelerometry tags to evaluate fine-scale responses of marine mammals to disturbance*". This effort is co-funded by National Marine Fisheries Service and the Office of Naval Research. Below is a review of progress on this project.

Primary Goals and Progress on this Project:

The primary expertise of Dr. Will Gough is the use of triaxial accelerometer Customized Animal Tracking Solutions (CATS) tags and other biologging devices to obtain biomechanical and energetic data that can be used to inform biological baselines for various marine mammal species of interest to policymakers and the general public. The following update has been developed by Dr. Gough and provides an overview of his progress since joining the MMRP through the support of the US Pacific Fleet Environmental Readiness Division.

Over the last ~18 months, Dr. Gough has been using his expertise to work on five goals:

- 1) Setting up infrastructure elements so the members of the MMRP can safely maintain large datasets in perpetuity.
- 2) Collecting CATS tag data in the field.
- 3) Training members of the MMRP to work effectively with biologging devices in the field and the lab.
- 4) Developing workshops and short-form classes to train the wider scientific community (and the public) in biologging methodology and data processing.
- 5) Continuing to use our biologging datasets to answer questions related to the physiology and behavior of various marine mammal species.

To give some additional information, here is a brief outline of how Dr. Gough has progressed towards each of these goals:

- 1) Since arriving at the MMRP, Dr. Gough has established a section of the lab devoted to tag setup, calibration, diagnostics, and data processing. This area includes two desktop computers with a full suite of relevant software and a dedicated staging area for field expeditions. He has also spearheaded the purchase and setup of a Synology NAS (network-attached storage) drive with ample storage to 1) maintain all MMRP datasets in perpetuity, 2) allow lab members to house stable backups for all of their current and near-future analyses, and 3) allow lab members and collaborators to access and share MMRP data while they are traveling or in the field.

- 2) Over the past 18 months, Dr. Gough has acted as the primary support personnel for five field seasons in Hawaiian waters (November 2022 in Lanai, February 2023 in Maui, November 2023 in Lanai, February 2024 on the Big Island, April 2024 in Lanai) aimed at collecting biologging data from various cetacean species. This included maintenance and preparation of biologging devices prior to field expeditions, small-boat operations for deployment and recovery of biologging devices, and processing of recovered data for subsequent analyses. Field seasons resulted in multiple successful deployments (n = 80 for humpback whales, n = 8 for short-finned pilot whales, n = 2 for false killer whales), including the first recording of a prey capture in a false killer whale and one of the first recordings of sexual contact in a humpback whale. In addition to cetacean tagging operations, during the reporting period, Dr. Gough also traveled to the Okinawa Churaumi Aquarium in Motobu, Japan to assist MMRP graduate student Jens Currie with his dissertation work. This work involved the collection of 3-D body scans and the short-term deployment of CATS tags on the collection of false killer whales housed in the facility. In addition to these field/travel opportunities, Dr. Gough assisted NOAA PIFSC and MMRP graduate student Kirby Parnell with the preparation of CATS tags, resulting in a successful Hawaiian monk seal deployment (n = 1).

- 3) As part of this data collection and processing effort, Dr. Gough has been working closely with multiple MMRP PhD graduate students. **Jens Currie** is the chief scientist at Pacific Whale Foundation and a 3rd year PhD student in the MMRP lab studying false killer whale movement and foraging behavior as it pertains to the health and energetics of the Hawaiian Islands population. Dr. Gough has assisted him with processing false killer whale deployments and subsequently extracting foraging events/dives and estimates of daily energetic expenditure. **Brijonnay Madrigal** is a 5th year MMRP PhD graduate student focused on acoustic behavior of false killer whales and pilot whales. Dr. Gough has helped her to extract foraging acoustics (e.g., clicks, buzzes) and align them with accelerometer signatures and behavioral states. **Kirby Parnell** is a 6th year MMRP PhD graduate student studying the vocal behavior, movement, and foraging behavior of Hawaiian monk seals using accelerometry and acoustics. Dr. Gough has helped her to calibrate and successfully deploy a CATS tag, as well as validate the resultant data. **Augusta Hollers** is a 3rd year MMRP PhD graduate student studying the behavioral energetics of humpbacks migrating between Hawaii and southeastern Alaska. Dr. Gough has helped her to process the backlog of raw tag data into processed and calibrated data packets known as PRH (pitch-roll-heading) files. He has also taught her field skills related to the successful setup and deployment of CATS tags, with the goal of preparing her to successfully lead a field season on her own. Finally, Dr. Gough has helped her to analyze the collection of humpback whale data to extract behavioral states and estimates of energetic expenditure for mothers and calves in Hawaii. **Martin van Aswegen** is a 6th year MMRP PhD student using UAS (unmanned aerial

system) morphometrics to quantify the body condition and related energetics of humpback whales throughout the year. **Lewis Evans** is a 1st year MMRP Masters student using UAS to quantify body condition and energetic metrics for humpback males on the breeding ground. Dr. Gough has provided both Martin and Lewis with peripheral support as well as energetic insights gleaned from tag data. In addition to graduate students, Dr. Gough has been working with a UH undergraduate student, **Cameron Nemeth**, on a project focused on the turning performance of humpback whales. This work is being prepared for publication in the next ~3 months and will be presented at the 25th Biennial Conference on the Biology of Marine Mammals. Dr. Gough has also indirectly assisted and/or provided support for multiple undergraduate interns that have spent time at the MMRP lab throughout the period of funding.

4) Outside of the MMRP, Dr. Gough has continued to build capacity within the Hawaiian research community for those interested in working with accelerometer data. This has included continued engagement in training and professional development with a number of parties, including local Hawaiian high school students, non-MMRP graduates students, and staff from both NOAA PIFSC and NOAA sanctuary. These training sessions have taken the form of small group classes (<12 students) or one-on-one topics in the lab and the field. Topics in the classroom have been tailored to the age-range and expertise of the group, primarily focused on simple data types and use of tags. One-on-one training sessions in the lab have been more in-depth, with topics ranging from tag calibration and preparation to data processing methods and analysis. In the field, Dr. Gough has provided his knowledge of tag deployment and recovery as well as use of relevant equipment. In addition to these training avenues, Dr. Gough developed and ran a workshop (March/April 2024) similar to the CATS tag data processing workshop run by Dr. David Cade and himself in 2020. The format for this workshop was changed slightly, with more time provided between sessions (one meeting every other Tuesday across eight weeks) to allow for more complete uptake of information and supplemental one-on-one meetings. This workshop was targeted towards those in the Hawaiian research community who are currently working with accelerometer data or interested in working with those data in the future. The majority of participants were MMRP graduate students, with two members joining from PACFLEET. Dr. Gough covered the entire process of preparing and calibrating a biologging device, deploying it in the field, recovering and retrieving animal-borne data, and processing the data into a package that would be ready for further analysis. The materials from these training sessions have been retained and will be used again for a second workshop in April 2025.

5) Dr. Gough has long been interested in understanding how biomechanics influences energetics and behavior in the marine environment. His PhD research focused on the effects of body size scaling on the biomechanics and energetics of swimming and foraging of large whales ranging from minke to blue. He is currently preparing a manuscript for resubmission that combines energetic estimates from CATS tags and migration information from longer-duration satellite tag data to model the energetic consequences of migration and the tradeoffs that arise between migratory distance and swimming speed. Dr. Gough has also used the recently collected dataset from short-finned pilot whales to develop a manuscript (planned for submission by 11/1/2024) modeling the holistic energetic budget of short-finned pilot whales in Hawaiian waters. These energetic models and supporting methodologies have been used to inform the analyses for multiple MMRP PhD students, including Augusta Hollers, Jens Currie, Martin van Aswegen, and Lewis Evans. Working together with Alaska Whale Foundation, Dr. Gough has continued his involvement with a series of papers that employ the large biologging dataset that we have for

humpback whales foraging in southeastern Alaska - one of the primary foraging grounds for the humpback whales that breed and overwinter in Hawaii. The first of these papers, "*Solitary humpback whales manufacture bubble-nets as tools to increase prey intake*", was recently published in *Royal Society Open Science*. Understanding the foraging and energetic intake of these whales on their foraging grounds can provide insight into their health and reproductive potential on the breeding grounds of Hawaii.

Next Steps:

Over the next year, Dr. Gough will continue to make progress on each of the goals of this project. In particular, he will 1) continue to develop data-handling protocols to enhance personnel continuity and ensure that MMRP datasets are safely maintained in perpetuity with multiple on- and off-site backups, 2) collect additional tag data for species of interest, particularly humpback whales, false killer whales, and short-finned pilot whales, 3) work to analyze tag data along with member of the MMRP to develop behavioral baselines and enhance new and existing energetic models to inform management and future research endeavors, 4) continue to train MMRP lab members and other members of the Hawaiian research community in the use of tags and the analysis of accelerometry data through targeted one-on-one sessions and larger group meetings such as the planned April 2025 tag data processing workshop, and 5) continue working on personal research projects related to the behavior and energetics of pilot whales, humpback whales, and other species of interest, with the near-term goal of publishing impactful work on these species.

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