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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For the last five months, 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. Dr. Gough has begun work on each of these goals and will continue to solicit input from Navy personnel as objectives evolve throughout his fellowship.

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Abstract:

For the last five months, 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. Dr. Gough has begun work on each of these goals and will continue to solicit input from Navy personnel as objectives evolve throughout his fellowship.

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., In press). 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 six-month review of progress on this project.

Primary Goals and Progress on this project:

The primary expertise of Dr. Will Gough is in using triaxial accelerometer Customized Animal Telemetry tags (CATS) 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. Working with PI's Drs Lars Bejder and Aude Pacini, Dr. Gough has made a strong start since joining the MMRP at the University of Hawaii (UH) at Manoa. The following update has been developed by Dr. Gough and provides a brief overview of his progress since joining the MMRP through the support of the US Pacific Fleet Environmental Readiness Division.

Over the last ~five months, Dr. Gough has been using his expertise to begin 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; and

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 each goal including the ways in which Dr. Gough has started organizing for the next few years.

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, a small hard drive tower for local backup of datasets, and a dedicated staging area for field expeditions. He has also implemented a cloud-based storage account (Google Drive) that can be accessed by members of the lab to maintain their data in case of a local failure or emergency (fire, flood, etc.). Moving forward, the MMRP is raising funds for a larger hard drive tower (Synology) that will be maintained offsite at another location at the Hawaiian Institute of Marine Biology (HIMB) and will be used to store large quantities of lab data into the future. In the lab, Dr. Gough has started to work with members of the MMRP to develop more accurate calibration and data processing procedures for the data collected from our range of biologging devices. These procedures and infrastructural purchases will be outlined for other research groups to copy as they see fit.

2) Over the past ~five months, Dr. Gough has assisted on two field expeditions: 1) a 10-day field expedition to Lanai in November 2022 and, 2) a 12-day field expedition to Maui in February 2023. His work on Lanai helped produce a marathon ~50 hour deployment on a short-finned pilot whale and gave the team an opportunity to track a tagged animal as well as work out logistics to successfully recover a biologging tag >50 nautical miles from shore. This deployment was also a successful test of a prototype CATS tag that can be deployed on deep-diving animals (up to 2000 m) and includes headlights that can illuminate foraging events and body movements at depth. His work on Maui produced 10 tag deployments, including nine on humpback whales (five non-neonate calves, three mothers, one male escort) and one on a false killer whale, one of the first times this species has been tagged with an accelerometer tag.

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 1st year PhD student in the MMRP lab who is studying false killer whale movement and foraging behavior. **Brijonnay Madrigal** is a 3rd year MMRP PhD graduate student who is focusing on acoustic behavior of false killer whales and pilot whales. The data recovered from the pilot whale and false killer whale deployments (accelerometer, camera, audio) will be invaluable to their research goals. In particular, they will work with Dr. Gough to pull out foraging events using both accelerometer and acoustic signatures, then build up a model of foraging energetics based around energetic costs of movement and frequency of foraging events. **Kirby Parnell** is a 4th year MMRP PhD graduate student who is studying the vocal behavior, and the movement and foraging behavior of Hawaiian monk seals using accelerometry and acoustics. In the coming months, Dr. Gough will be assisting her to calibrate a new set of CATS tags designed specifically for her study species as well as process and analyze the data that we recover from any successful tag deployments. Similar to our procedures with the false killer whales, Dr. Gough and Kirby will use accelerometer and acoustic signatures to determine foraging events and build up towards an energetics model based on movement costs and the frequency of foraging events. **Gussie Hollers** is a 1st year MMRP PhD graduate student who is studying the suckling and cooperative behaviors of humpbacks migrating between Hawaii and southeastern Alaska. Dr. Gough has been helping her transition our backlog of raw tag data into processed and calibrated data packets known as PRH (pitch-roll-heading) files. These files are ready for further analysis and will contribute

directly to Gussie's PhD work as well as the work of future students and researchers. Over the next two years, Dr. Gough will be helping Gussie to develop protocols for controlled exposure of vessel noise to tagged cetaceans.

4) Dr. Gough has started preliminary development on two short-form classes that are intended to be available to UH Manoa students and virtually to reach a broader audience. The first would focus on biomechanical adaptations of vertebrates within the marine environment. He would cover areas such as locomotion and maneuverability, prey capture, and reproduction in detail. The second course would focus on biologging and biotelemetry and will be modeled after a similar course taught by Dr. Goldbogen at Stanford University's Hopkins Marine Station. The course would cover 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. Subsequently, he would discuss the use cases for biologging data and how processed biologging data can be analyzed to answer specific questions. He is envisioning that the biomechanics course would be primarily geared towards undergraduate students, while the biologging course could include collaborators or anyone else who would like to learn how to work with biologging data. To supplement this course, Will would plan to run a series of workshops similar to the CATS data processing workshop run by Dr. Cade and himself in 2020. Much of the curricula and materials for this endeavor are already in place and could be used again with some changes based on recent updates to the CATS hardware and user interface. Finally, Dr. Gough will explore ways to implement a high school internship program similar to one that he co-led at Hopkins Marine Station. This program brought students from a local underserved school district into the marine station to work directly with graduate students and post-doctoral fellows on research projects.

5) For his own research, 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 for large whales ranging from minke to blue. He is currently finalizing the fourth chapter of his dissertation and preparing it for publication. This paper will bring together the most recent energetic estimates and propose a theoretical model of annual energy-use for large migrating whale species. This model will be directly applicable to the work of MMRP PhD graduate student Martin van Aswegen, who is using UAS drones to calculate the annual changes in body condition of humpback whales that migrate between Hawaii and SE Alaska.

Working together with Alaska Whale Foundation, Dr. Gough has also been involved 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. Understanding the foraging and energetic intake of these whales on their foraging grounds can give us insight into their health and reproductive potential on the breeding grounds of Hawaii.

Next steps

Over the next six months, Dr. Gough will continue to make progress on each of these goals. In particular, he will 1) finish setting up infrastructural elements at the MMRP lab, 2) work to process the tag data collected on recent field expeditions, 3) continue to train MMRP lab members and help them develop their research agendas, 4) create a plan to implement each of the proposed classes, and 5) continue working on the personal research projects outlined above. Dr. Gough will also begin working with PIFSC to help them advance their CATS tagging capabilities on Hawaiian monk seals. He will also seek input from ONR, FLEET, and PIFSC as to their further interests and how he can tailor his time and efforts to best address their needs.

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