Development and Testing of a Datalogging Device for Physiological Measurements of Deep-diving Odontocetes

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LONG-TERM GOALS

There is a dire need to determine the normal cardiovascular dive response of deep-diving odontocetes like beaked whales, and to examine how that response might be altered during exposure to anthropogenic sound. However, no one has ever recorded the electrocardiogram of a wild, free-ranging cetacean. Recent advances in the miniaturization of multi-channel datalogging devices now make it possible to conceive of remotely attaching a device to a deep-diving odontocete to record physiological variables such as heart rate and body temperature, which would then permit studies of the cardiovascular response to diving and advance many of the discussions about the susceptibility of beaked whales to gas bubble disease beyond theory and speculation.We will modify our existing technology for making physiological recordings and demonstrate its utility on beaked and pilot whales so that diving physiology studies could be conducted to further our understanding of the susceptibility of these whales to adverse physiological effects of exposure to anthropogenic sounds.

OBJECTIVES

1. Improve on our existing technology for making physiological recordings so that future studies can be conducted to understand susceptibility to adverse effects of exposure to anthropogenic sounds
   - 1.1. Modify our solid-state electrocardiogram (ECG) and dive behavior monitor for use on pilot and beaked whales and other deep diving odontocetes
   - 1.2. Deploy on pilot and/or beaked whales to prove feasibility and collect preliminary data on the physiological response to diving

APPROACH

We plan to make the necessary changes to our current physiological recording device and to conduct test deployments of the device on either pilot or beaked whales. The ECG amplification and filtering circuit we used on our initial pilot whale tests did not produce clear cardiac signals with the close

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electrode spacing that is achievable with a single "T-pole" deployment system. Therefore, we will modify the ECG circuit to increase gain while still attempting to filter out the EMG noise that is likely to be picked up from the muscles in the vicinity of the attachment sites.

We have demonstrated that it is possible to attach an ECG tag using a 2-pole system, but we need additional practice to perfect this technique. We anticipate that with additional field time, we will then be able to successfully attach our modified ECG tag, getting both of the suction cup/electrode darts to firmly attach with sufficient separation, resulting in the recording of a clear ECG.

Encounter rates with short-finned pilot whales off Hawai'i are normally quite high, e.g. during field work conducted in April and May of 2008, 41 discrete groups of pilot whales were encountered over 27 survey days (Baird et al. unpublished). Short-finned pilot whales are similar in body size to beaked whales, making them a good test surrogate morphologically, and being deep divers they will expose tags to a similar environment of cold, high pressure ocean water. This deep diving behavior of pilot whales means that they also deserve scientific attention to their diving physiology and susceptibility to gas bubble disease. Therefore, we will propose to conduct our test deployments off the island of Hawai'i where we can conduct test deployments on at least two species of beaked whales and short-finned pilot whales.

WORK COMPLETED

This project just began a few months ago and much of the work is scheduled to be completed during the next few months. We have modified our existing 8 channel archival datalogging device that we had already used to measure the electrocardiogram (ECG), breathing frequency, body temperature, 3-axes of acceleration, flipper stroking frequency, dive depth and water temperature in pinnipeds. We have built 3 different ECG amplification and filtering circuits to test variations of gain and band-pass filter limits. We have also built one set-up that incorporates a pre-amplifier directly on each electrode that incorporates a very high input impedance and a low output impedance, which we hope will improve the biopotential signal, which can be degraded due to poor contact between electrode and skin and the movement of the electrode cables. Each archival tag includes flotation for when the tag falls off the whale, and sitting on top of each float we have incorporated the usual VHF beacon as well as a very small SPOT5 location-only satellite transmitter. The addition of the satellite tag beacon should drastically improve our odds of finding the tag after it falls off the whale.

RESULTS

We believe that we have started off in a productive and positive manner. The modified archival physiological recording devices and especially the ECG amplication and filtering circuits will hopefully make it possible to successfully record the ECG of a deep-diving whale when we conduct our field deployments in Hawai'i next month (October 2011).

IMPACT/APPLICATIONS

Understanding the potential for impacts of naval activities on protected species of marine mammals and mitigating such impacts requires information on basic physiological and behavioral parameters that are currently a mystery. Demonstration of the successful operation of these physiological recording devices on free-ranging cetaceans will be a breakthrough and should lead to follow-up research on the cardiovascular dive and exercise responses of deep-diving odontocetes. Follow-on

studies could include deployments on a sufficient sample size of beaked whales in order to gather the data necessary to adequately understand the physiological mechanisms involved in the potential for gas bubble disease as a consequence of behavioral disturbance in beaked whales. .

RELATED PROJECTS

The National Oceanographic Partnership Program and ONR are supporting our project "Improving attachments of remotely-deployed dorsal fin-mounted tags: tissue structure, hydrodynamics, in situ performance, and tagged-animal follow-up." That project will also include field work this coming October in Hawai'i. The goals of that project are to improve upon our satellite tagging methodology to achieve longer, less variable attachment durations by carefully examining the factors that affect attachment success, along with follow-up studies of whales that have been tagged with a remotely-deployed dorsal fin-mounted tag to accurately quantify wound healing and the effects of tagging on whale survival, reproduction, and behavior. The National Marine Fisheries Service Pacific Islands Fisheries Science Center is supporting research on false killer whale movements in Hawaiian waters, and the Naval Postgraduate School (with funding from N45) is supporting tagging studies of a variety of species in Hawai'i. See: www.cascadiaresearch.org/hawaii/beakedwhales.htm and www.cascadiaresearch.org/hawaii/falsekillerwhale.htm .