Tag-based Heart Rate Measurements of Harbor Porpoises During Normal and Noise-exposed Dives to Study Stress Responses

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LONG-TERM GOALS

Marine mammals face potentially dramatic changes in the environment, as well as continued disturbances of their ocean habitat from shipping, sonar, fisheries, oil exploration and other ocean activities. To predict and quantify how marine mammals will respond to natural and anthropogenic stressors, it is essential to understand their physiological limits, the potential plasticity of their diving physiology, and their physiological responses to stress. The typical mammalian startle or stress response to an acoustic stressor is increased heart rate, cardiac output and ventilation rate (Graham 1979), all which are contrary to the typical marine mammal dive response (Scholander 1940). Information on the acute stress response during diving is essential to predict how potential stressors effect oxygen and nitrogen management and can provide information on the level of stress the animals routinely experience. Here we propose to examine the dive heart rate, ventilation rate and activity in both captive and wild porpoise to better understand the dive response and how it may be overruled by noise exposure. We will access the acute stress response to an acoustic stressor by comparing heart rate, ventilation rate, and activity between control and exposure dives.

OBJECTIVES

This study will use modified Dtag3 data loggers to record diving electrocardiograms, acceleration, orientation, pressure and acoustic data in captive and wild harbor porpoises. The specific objectives are: 1) Quantify the physiological (heart and ventilation rates) and behavioral response (activity) to acoustic stimuli in captive porpoises by examining differences between the control and controlled noise exposure trials; and 2) study the dive heart rate, activity and ventilation rate of wild porpoises and opportunistically examine the physiological and behavioral responses to absolute noise levels that they may be exposed to during routine behaviors. Using harbor porpoises as model species, this study will provide novel information on the capability to use non-invasive, multi-sensor tags to quantify the impact of potential stressors such as sound on physiological systems in cetaceans in the wild.

APPROACH

Objective one: Physiological and behavioral response to acoustic stressors

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Dive heart rate and behavioral response to acoustic stimuli will be examined in three harbor porpoises housed in net pens (size: 35 x 10 x 5 m (L × W × D)) at the Fjord and Bælt center using two protocols: 1) experimental and 2) opportunistic. For the experimental protocol porpoises will be trained to perform stationary and prey capture dives in a range of dive durations while instrumented with an ECG Dtag3 data logger. Experimental sessions will consist of a block of approximately 10 dives of the same dive category (stationary or prey capture) and duration (30, 60, or 120 s). During 50% of the dives porpoises will be exposed to an acoustic stimulus (sonar or shipping noise) at a predetermined point during the dive. Additionally, we will collect the same data in between training sessions. We will opportunistically obtain data for both control dives (no acoustic stimuli) and noise exposure dives using passing boats to which the porpoises display strong and stereotyped behavioral startle responses. We will determine a) diving heart rate, b) maximum heart rate during a dive, c) minimum heart rate, d) heart rate variability, and e) rate of initial heart rate decline. In addition we will examine the change in heart rate by analyzing pre-exposure, exposure, and post-exposure heart rate. We will compare heart rate profiles, ventilation rate and activity in dives of similar duration between control and noise exposure trials.

Drs. Peter Madsen and Birgitte McDonald will be responsible for data collection and analysis. Mark Johnson will provide assistance with the data logger and analysis. The animals are housed at the Fjord and Baelt center under the care of head trainer Jakob Christiansen.

Objective two: Dive heart rate in wild porpoises
Porpoises accidentally caught in pound nets will be instrumented with an ECG Dtag3 data logger upon release. The tags will be deployed with four suction cups programmed to release after 48 hours. Recovery from small boats is aided by built in VHF and Argos antennas following establish procedures (Soto et al. 2008). This technique was recently used to successfully collect data from four wild harbor porpoises. In 2014 and 2015, we will tag approximately 5 animals. We will obtain the first diving heart rate data from a wild porpoise and be able to relate this to dive duration, depth, activity and ventilation rates. Additionally, due to the acoustic data collection capabilities of the data loggers we will opportunistically be able to examine the heart rate response to acoustic stimuli while at sea.

Drs. Peter Madsen and Birgitte McDonald will be responsible for data collection and analysis. Mark Johnson will provide assistance with the data logger and analysis. Captures will be conducted in collaboration with a research group led by Jonas Teilman (Marine Mammal Research, Institute of Bioscience, Aarhus University).

WORK COMPLETED

We are in the initial phase of this project. Data collection will begin in October 2014. Animals are being trained for the study protocol. Baseline data collected in a previous study using a prototype ECG Dtag3 is currently being analyzed for comparison to the noise exposure protocol.

RESULTS

We have no results at this time.

IMPACT/APPLICATIONS

This study directly addresses two of the ONR Marine Biology Program thrusts: Diving physiology and stress physiology. We will obtain important diving physiology data for the harbor porpoise using a combination of field and laboratory studies. Due to their small size and ability to be studied in captivity and in the wild, harbor porpoises are a good model species to develop and validate new techniques for studying diving physiology and the stress response in a wild cetacean that can then be used in future studies of larger toothed whales, such as beaked whales. We will investigate the relationship between dive behavior and the heart rate response in harbor porpoises and for the first time document the level of bradycardia in a wild cetacean. This information is critical to understanding not only how cetaceans manage oxygen and nitrogen during routine activities, but also how plastic their oxygen store management is, which is key to understanding their ability to adapt to a changing environment. The controlled and opportunistic noise exposure study will provide information on how the stress response may influence the ability for cetaceans to manage oxygen and nitrogen during diving. This data is essential for use by the Navy in estimating the impact of naval exercises (i.e. mid-frequency sonar) on marine mammals.

RELATED PROJECTS

This project is building on an ongoing project investigating diving physiology of harbor porpoises ("Field energetics and diving physiology of a small cetacean, the harbor porpoise", NSF International Postdoctoral Fellowship awarded to Birgitte McDonald, Award #: 1159123). In the above study we are investigating the dive heart response in captive harbor porpoises. In the ONR funded project we will use a similar study protocol to build upon our finding by investigating how an acoutic stressor impacts the 'natural' dive response'.

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