

## **Cetacean Community Ecology in the Waters of Sri Lanka and the Bay of Bengal**

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### **LONG-TERM GOALS**

The Indian Ocean contains arguably the highest diversity of cetaceans in the world's oceans, yet research in this region is extremely limited. The strong environmental variability imposed on the northern Indian Ocean by the seasonal monsoons likely causes a wide variety of niches in both space and time that support the observed diversity of cetaceans. In addition to shelf, slope, and oceanic habitats, there are regions dominated by the input of fresh water (e.g., Bay of Bengal), by evaporation and low river runoff (e.g., Arabian Sea), as well as coastal currents, eddy activity, and large-scale oceanic currents. Moreover, the Arabian Sea and Bay of Bengal have well-developed oxygen minimum zones (mesopelagic regions with O<sub>2</sub> concentrations <0.5 ml l<sup>-1</sup>) that likely have a significant influence on the behavior and distribution of cetacean prey.

Our long-term goal is to understand the physical and biological oceanographic processes that influence the distribution and occurrence of tropical and subtropical cetaceans. We believe the northern Indian Ocean is particularly well suited for investigating these processes because of the large spatial and temporal variability in environmental conditions imposed by the monsoons. However, very little is known of the distribution, abundance, or behavior of cetaceans in the oceanic waters of the Bay of Bengal. What little research has been done in the region has focused on the river dolphins and near-shore porpoises (e.g., Smith et al. 2008). Indo-Pacific humpback dolphins and spinner dolphins are endemic to the coastal waters of the Bay of Bengal (de Boer et al. 2002), while a wide variety of oceanic dolphins, "blackfish" (pilot, melon-headed, and false killer whales), sperm whales, beaked whales, pygmy and dwarf sperm whales, and several baleen whale species occur over the continental slope and abyssal plain of the oceanic Bay (Leatherwood et al. 1984, Ballance and Pittman 1998, de Boer et al. 2002). Among all the cetaceans, the presence of baleen whales in this low-latitude habitat, including blue, humpback, fin, minke, and Bryde's whales (de Boer et al. 2002), is perhaps most interesting. Some baleen whale species visit the tropics only during breeding and/or calving seasons, but there is evidence that a sub-population of blue whales in the waters of Sri Lanka (Alling et al.

1991, Branch et al. 2007) may be year-round residents (Stafford et al. 2010), as are humpbacks in the Arabian Sea (Mikhalev 1997). These observations suggest that there are ample year-round food resources available for baleen whales in the region (e.g., mesopelagic fish; Gjøsaeter 1984), perhaps unlike in the tropical regions of the Atlantic and Pacific Oceans.

## **OBJECTIVES**

We hypothesize that the cetacean community of the oceanic Bay of Bengal and the waters of Sri Lanka varies with seasonal changes in water masses and circulation associated with the monsoons. During the summer and the following autumnal inter-monsoon period, the cetacean community of Sri Lanka will be dominated by oceanic species endemic to the Arabian Sea, whereas during the winter and vernal inter-monsoon period, the cetacean community should be dominated by neritic species and species endemic to the Bay of Bengal. In the oceanic Bay of Bengal, we hypothesize that cetacean community composition will exhibit significant seasonal variability associated with strong monsoonal forcing of the upper ocean, and that the spatial distribution of cetaceans will be influenced by the depth of the oxygen minimum layer (which, in turn, influences the availability of prey in the upper ocean). To address these hypotheses, we will take advantage of an extraordinary opportunity to participate in a physical oceanographic field program to characterize (1) the cetacean community in the waters around Sri Lanka and in the oceanic Bay of Bengal during the fall and spring inter-monsoon periods, (2) the relationship between cetacean spatial distribution and mesoscale oceanographic features, and (3) the relationship between cetacean community composition and variability in seasonal oceanographic conditions associated with the periods immediately following the southwest and northeast monsoons.

## **APPROACH**

We are participating in the Air-Sea Interactions in the Northern Indian Ocean (ASIRI) project sponsored by the ONR Physical Oceanography program and the Naval Research Laboratory (NRL). This program is providing us with the opportunity to combine marine mammal observations with intensive physical oceanographic measurements in a region where environmental variability likely has a strong influence on cetacean distribution, occurrence, and community composition. We will participate in ASIRI cruises when feasible (i.e., when scheduled during fair weather seasons that allow for effective marine mammal sighting surveys), and we will use ASIRI-related travel and meeting opportunities to build scientific collaborations with Indian and Sri Lankan scientists interested in marine mammal research. Within the framework of these collaborative relationships, we hope to expand our observing capability to include sighting surveys on foreign vessels and passive acoustic monitoring.

## **WORK COMPLETED**

### Relationship building

During December 2014, Drs. Stafford and Baumgartner traveled to India to teach a short course on bioacoustics at the Indian National Centre for Biological Sciences (NCBS) in Bangalore and to attend an ASIRI meeting in Mahabalipuram outside Chennai. The 3-day short course was held December 10-12 for over 20 students and postdocs in the NCBS Program in Wildlife Biology and Conservation (Figure 1). The students worked on a wide variety of taxa, including bats, birds, elephants and marine mammals.

Drs. Baumgartner and Stafford presented at the 3-day ASIRI meeting (December 16-18) on their marine mammal survey work during the 2013 ASIRI pilot cruise in the Bay of Bengal. We invited our two main NCBS collaborators, Dr. Ajith Kumar and Ms. Divya Panicker (both participated in the marine mammal survey during the ASIRI pilot cruise), to accompany us to Mahabalipuram for the ASIRI meeting. The four of us met with Dr. R. Venkatesan of Indian National Institute of Ocean Technology (NIOT) and Dr. Debasis Sengupta of the Indian Institute of Science to talk over opportunities for our group to conduct visual surveys from the *Sagar Nidhi* and *Sagar Kanya*, two Indian research vessels. There was some enthusiasm for this, but they described significant bureaucratic hurdles for any foreigners participating in the cruises.

We learned at the ASIRI meeting that NIOT has an Ocean Acoustics program, and we (Baumgartner, Stafford, Kumar and Panicker) traveled to NIOT in Chennai to meet with the head of the program, Dr. G. Latha. We gave short presentations to Dr. Latha's group, and they, in turn, presented their work to us. They have impressive calibration facilities and are building much of their own equipment. They don't do any bioacoustics work aside from documenting humpback whale calls on their recording equipment, but they seemed enthusiastic to collaborate.

We also learned during our visit that WHOI and NIOT were drafting a letter of intent to collaborate on a wide variety of research activities. Dr. Latha and Baumgartner were able to insert into the letter language that promoted collaborative marine mammal research, including both visual surveys and passive acoustics. We hope that this letter will be a tool to help cut through some of the crushing Indian bureaucracy to allow us to use their ships and collaborate on passive acoustic projects.

### Training

As in 2014, Dr. Baumgartner invited Ms. Divya Panicker to participate in the annual NOAA NEFSC spring large whale cruise to the southwestern Gulf of Maine during May 2015 for additional training. Ms. Panicker is a young scientist with a masters degree who is learning new techniques in marine mammal science, and this was to be an excellent training opportunity for her to see and help in oceanographic and prey sampling, sighting surveys, short-term tagging, and the use of autonomous vehicles. Ms. Panicker was an excellent addition to the team on the cruise, and she was trained in nearly every task undertaken during the trip.

### Publications

Together with Hemantha Wijesekera (NRL) and many co-authors, we contributed to a manuscript submitted to the Bulletin of the American Meteorological Society entitled "Decrypting a mystery bay – ASIRI ocean-atmosphere initiatives on Bay of Bengal." The manuscript is currently in review.

We have been invited by Dr. R. Venkatesan (NIOT) to contribute a chapter on marine mammal monitoring to a book that will be published by Springer entitled "Observing The Oceans In Real Time – Instruments, Measurements And Experience"

## **RESULTS**

The goal of our 2015 activities were to continue to form and strengthen collaborative relationships with scientists from NCBS and NIOT to allow us to conduct sighting surveys on Indian oceanographic vessels and to conduct passive acoustic monitoring in Indian and adjacent international waters. We believe we were successful in building these collaborative relationships; however, much work remains to be done to actually begin the research. During this meeting, it became very clear to us that we (Drs.

Stafford and Baumgartner) would not be able to initiate any research given the substantial bureaucratic challenges of foreigners conducting research in Indian waters. Instead, *marine mammal research could only be accomplished if it were initiated by our NCBS colleagues, specifically Ms. Panicker and Dr. Kumar.*

To achieve this goal, we have been working closely with Ms. Panicker to establish a visual monitoring program using ferries off the west coast of India. The survey was conceived by Ms. Panicker, and she hopes it will become the foundation of a PhD thesis project at an institution in the United States. She is also pursuing permits to begin passive acoustic monitoring within the study area where the visual monitoring will be conducted. Ultimately, she hopes to conduct similar surveys in the eastern Bay of Bengal near the Andaman Islands. We believe it is only within Ms. Panicker's project that we will be able fulfill our ONR project goals of studying marine mammal occurrence and distribution in the northern Indian Ocean. We will continue to advise and support Ms. Panicker, relying on the collaborative relationship that we have built over the past 2 years, to realize our shared research goals.

## **IMPACT/APPLICATIONS**

This research will improve our understanding of the relationships between tropical/subtropical cetaceans and oceanographic conditions in an area characterized by large environmental variability. The northern Indian Ocean is a region of high strategic importance to the United States, and Naval vessels use this area regularly. Continued operational use of sonar in this region requires a better understanding of the risks to marine mammals, and a large part of the assessment of that risk requires characterization of the distribution and abundance of cetaceans and how that distribution changes with changes in the environment. Our study will also be particularly helpful in assessing the distribution and habitat of baleen whales, as their presence in the northern Indian Ocean is rather anomalous when compared to other tropical regions.

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## **PUBLICATIONS**

Stafford, K.M. and M.F. Baumgartner. 2014. Marine mammal conservation and the role of research. Current Conservation 8:18-25. [published]



***Figure 1. Participants in bioacoustics short course taught by Kate Stafford and Mark Baumgartner at the Indian National Centre for Biological Sciences December 10-12, 2014.***