

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_2 concentrations $<0.5 \text{ ml l}^{-1}$) 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; Gjøsæter 1984), perhaps unlike in the tropical regions of the Atlantic and Pacific Oceans.

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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 will 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 will participate 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 will provide us with an exceptional 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 conduct cetacean sighting surveys aboard the R/V *Roger Revelle* during cruises to the central Bay of Bengal planned for fall 2013, spring 2014, fall 2014, and spring 2015 (Figure 1). We will participate in the survey legs only, during which time the ship will conduct a broadscale survey in the international waters of the Bay of Bengal (Figure 1). While steaming the ~3900 km survey track, Dr. Tom Farrar (WHOI) will profile an underway conductivity-temperature-depth (UCTD) instrument from the surface to 400 m every 15 minutes, which will provide fine-scale (3-4 km) observations of the structure of the upper ocean. At a coarser resolution (50 km), stations will be occupied during which an instrument package consisting of a CTD and oxygen sensor will be profiled to 300 m. We will conduct visual surveys along the survey transect with an observer corps of 7 scientists (4 U.S., 1 Sri Lankan, and 2 Indian scientists) using 25×150 “big eye” binoculars, 7×50 hand-held binoculars, and the naked eye. Sighting data will be collected using standard survey software (e.g., Wincruz) interfaced to a global positioning system (GPS) receiver. All observers will receive training before and during the cruise from the sighting team leader, Ms. Suzanne Yin, a professional marine mammal observer with experience identifying tropical and sub-tropical cetacean species.

The cruise will provide us an opportunity to collaborate with Sri Lankan and Indian scientists, and we hope that this international cooperation will lead to follow-on collaborative studies that will involve other cetacean research methods, such as passive acoustic monitoring or tagging.

WORK COMPLETED

To date, we have participated in two planning meetings for the first ASIRI cruise (to be held in November and December of 2013). The first meeting was in Boston, Massachusetts on March 3-4, 2013, and the second meeting was in La Jolla, California on June 26-27, 2013. We have also collected all of the equipment required for the cruise (including big-eye binoculars borrowed from the NOAA Southwest Fisheries Science Center), packed it, and shipped it to Sri Lanka via container ship. Two contract observers have committed to participating in the cruise: Ms. Suzanne Yin and Mr. Ernesto Vázquez. We have also been working with both Sri Lankan and Indian scientists to arrange for their participation in the project, and to visit their respective institutions both before and after the November-December cruise to discuss marine mammal research priorities and future plans.

RESULTS

No scientific results are available at this time, as no fieldwork has been conducted as yet.

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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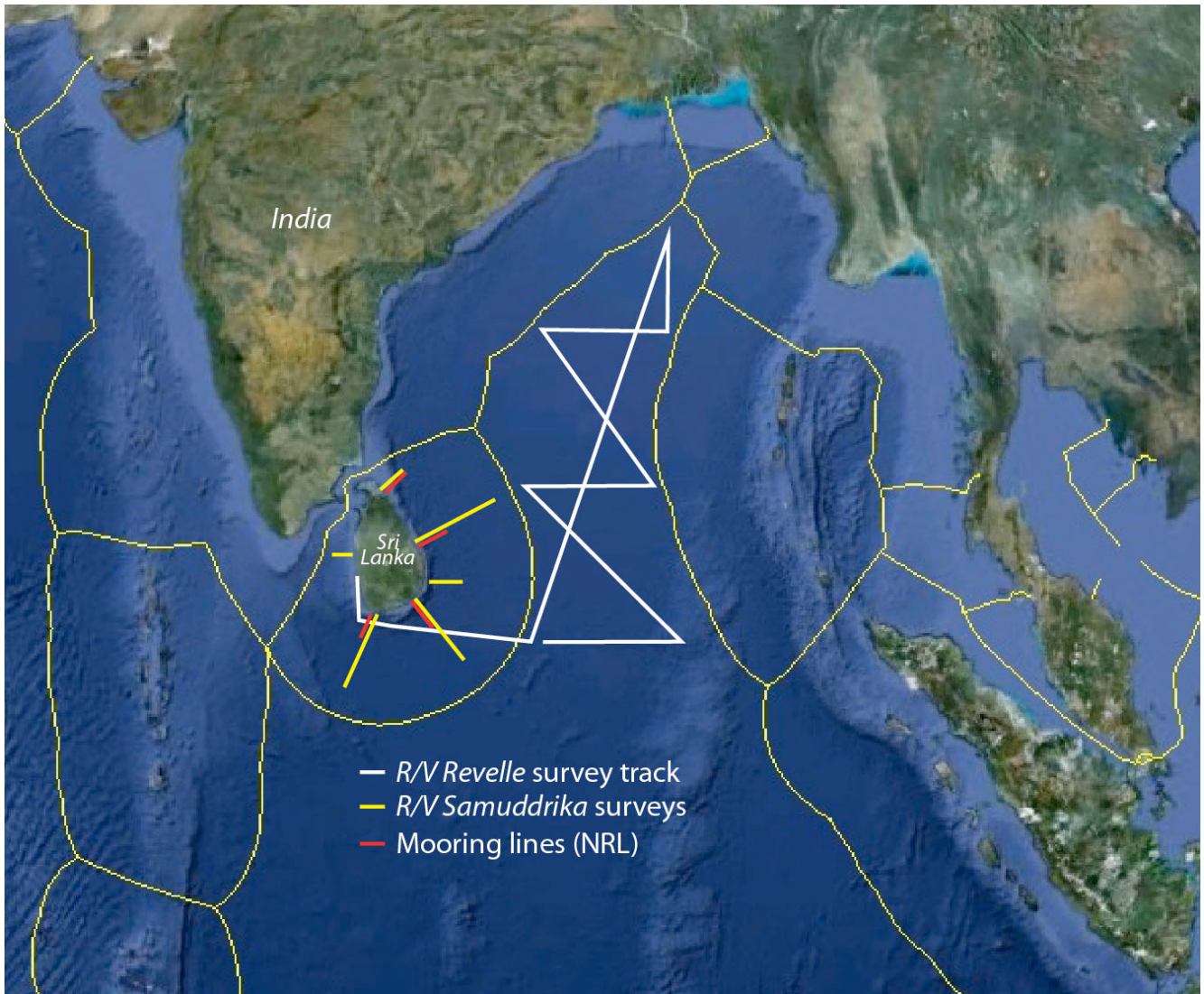


Figure 1. Map of study area in the central Bay of Bengal and the waters of Sri Lanka, including ASIRI cruise transects and mooring lines. Light yellow lines indicate national EEZs.