

Understanding the Patterns and Causes of Variability in Distribution, Habitat Use, Abundance, Survival and Reproductive Rates of Three Species of Cetacean in the Alborán Sea, Western Mediterranean

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LONG-TERM GOALS

The question of how environmental variability affects populations of marine top predators is an important one because of their role within ecosystems and their potential to influence community structure and biodiversity (Heithaus *et al.* 2008). An understanding of the patterns of distribution and abundance and particularly the causes of that variation is critical to making informed assessments of the importance of anthropogenic activities to marine mammal populations.

This project will quantify changes in distribution, habitat use, abundance, survival and reproductive rates of three species of cetacean in the Alborán Sea (western Mediterranean) in relation to variation in the physical and biological environment and human activities, based on 18 years of data. The proposed study species, bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*) and long-finned pilot whale (*Globicephala melas*) occupy different oceanographic niches off southern Spain. The Alborán Sea is a highly productive and distinct ecosystem that plays an important role in the oceanography of the Mediterranean basin, and has experienced marked changes in climatic and oceanographic conditions.

We will attempt to relate features of a species' biology to environmental change, particularly climate change, focusing on distribution, abundance and estimated reproductive and survival rates. The two last ones provide information on the mechanisms that cause distribution and abundance to change. Knowledge of these relationships will help us to predict the future impacts of environmental change in a way that studies of distribution and abundance alone cannot.

This project will do this using a two decade dataset on bottlenose and common dolphin and pilot whale in the Alborán Sea and the time series of environmental changes generated by IMEDEA (Mediterranean Institute for Advanced Studies) and by NOAA OceanWatch. Once established, these relationships will be used in conjunction with the simulations of environmental change generated by IMEDEA to predict the effects of further change on these species over the next 40 years. The existing dataset available for these species covers 18 years. Data on human activities (e.g. fisheries, maritime traffic) are also needed to explore how they interact with the environmental changes and with the species parameters changes.

OBJECTIVES

The primary goals of the research in this Grant are:

- (1) Quantify relationships between measures of cetacean population ecology, dynamics and status (distribution, habitat use, abundance, survival and reproductive rates) and variation in the marine environment (physical and biological oceanography, prey distribution and relative abundance) for the three focal species over the last 18 years in the Alborán Sea;
- (2) Test the hypothesis that environmental changes have had a greater effect on cetacean species that feed at lower trophic levels;
- (3) Explore the relative contribution of environmental variation and anthropogenic activities on cetacean population changes;
- (4) Quantify the effect of moving the Cabo de Gata TSS (the source of major noise pollution) on the distribution and abundance of the three focal species;
- (5) Predict responses of the three focal species to future environmental change under a range of scenarios;
- (6) Assess how well cetaceans can serve as indicators of environmental change in the marine environment and of “ocean health” generally.

APPROACH

To achieve the objectives of this project, the following steps will be taken:

- (1) existing data on the focal cetacean species (line transect sampling and photo-identification), human activities and environmental variables will be compiled and organized into appropriate strata at appropriate resolution and spatial and temporal scales;
- (2) some new data will be collected (summers 2010 and 2011) and, if sample sizes are large enough, they will be organized in the same way as the existing data to complete a 20 year dataset;
- (3) available information on changes in the marine environment over the last two decades (through collaboration with IEO and IMEDEA) will be organized to allow joint analysis with the cetacean and human activities data described above;
- (4) density surface modeling (spatial modeling) of line transect data will be used to relate changes in distribution, habitat use and abundance of the focal species to changes in the environment, including data on oceanography and human activities as explanatory covariates;
- (5) mark-recapture analysis of photo-identification data will be used to relate changes in survival and reproductive rate to changes in the environment again using oceanographic and human activities data as covariates;

- (6) models that are developed that relate changes in cetacean biological/ecological characteristics to changes in the environment will be combined with the output of environmental simulation models developed by IMEDEA to predict impacts up to 40 years into the future (through collaboration with IMEDEA).

WORK COMPLETED

The funding for Fiscal Year 2011 arrived on 21st July 2011, and field work for Grant N00014-09-1-0536 occurred between 15 August and 9 September 2011 (data also used for this project). Therefore, very little time was left before the end of 2011 Fiscal Year and delivery of this report to work on the present Grant. Nevertheless, some advances have been made:

Step 1.

Existing survey data on the focal cetacean species from 1992 to 2010 and *in situ* data on human activities from 1998 to 2009 has been compiled and organized into effort and sightings files, both in the format for Distance sampling analysis (to estimate the detection function) and for spatial modeling. Environmental variables, namely sea surface temperature, chlorophyll concentration, sea surface height anomaly and primary productivity have been downloaded from NOAA Ocean Watch (http://las.pfeg.noaa.gov/oceanWatch/oceanwatch_safari.php), in all cases both monthly and 8-day averages for every month of every year.

Step 2.

Data was collected through line-transect surveys at sea during summers of 2010 and 2011 (under GRANT N00014-09-1-0536), and added to the existing data, yielding a 20 year time series of data for the three focal cetacean species in the Alborán Sea. These surveys in 2010 and 2011 continued using the protocols developed over previous years (Cañadas & Hammond 2006; 2008). Photo-identification data for estimating survival and reproductive rates were collected during the same surveys and similarly added to existing data to create a 20 year dataset.

Step 3.

A meeting with Dr. Tintoré (IMEDEA) has been scheduled for October 2011 to discuss the best way of putting together their data on environmental change in the Alborán Sea with our data on cetaceans. Dr. Tintoré also informed that they have greatly improved their projection system for environmental change into the next 40 years. The application of this projection to the results from the cetacean data analysis will be discussed at this meeting too. The results of this meeting will dictate in large part the resolution and format in which the cetacean data will be organized and stratified for this project.

Step 5.

Photo-identification data for the years 2004 to 2010 for bottlenose dolphins has been organized into a catalogue in a database in Access 2007 during 2010, with a matching process including 18,654 photographs resulting in 367 individuals in this catalogue. This work was done by student Monica Arso and is incorporated in this project. Processing, matching and cataloguing of photographs from 1992 to 2003 for this species will be done during 2012.

RESULTS

No results can be reported as yet as the project has just started 2 months before the submission of this report.

REFERENCES

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