Identification of long term datasets on southern hemisphere baleen whales with potential utility in climate change research

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Introduction

Datasets that are valuable for studying the effects of climate change in ecological systems must be more than long term. Although the overall duration of a study is of fundamental importance, the data must be collected at appropriate spatial and temporal scales to inform research into the impacts of a rapidly warming climate. This paper focuses on long term datasets on southern hemisphere baleen whales. We highlight datasets for estimating trends and abundance that were thoroughly described in Leaper et al. (2008). We identify a few additional datasets that reach into other areas of cetacean research, such as life history and animal health. Finally, we evaluate each dataset with respect to its potential utility in climate change research.

Dataset Characteristics Relevant to Identifying and Evaluating Climate Change Impacts

The primary characteristic of datasets relevant to climate change research is that they encompass a long time span. (Exceptions to this rule exist for highly sensitive ecosystems that undergo rapid changes due to the warming climate.) "Long term" must be defined both with respect to the life history of the organism and the temporal scale of the physical processes that shape ecological interactions and the variability therein. With respect to baleen whales, we suggest that a span of two or three decades is necessary to begin to understand the temporal variability associated with the dynamics of marine ecosystems that affect the reproduction, growth, and survival of individuals and, therefore, the trajectory of populations.

Long term is important, but not sufficient. The second characteristic of datasets that is vitally important for climate change investigations is adequate temporal resolution. Ecosystems experience background levels of variability that are not generated (but may be influenced) by trends in climate. For example, stochastic (chance) events may contribute to interannual variability. Furthermore, the El Niño Southern Oscillation (ENSO) cycle has a period of three to seven years, the Pacific Decadal Oscillation cycles over thirty to forty years, and the North Atlantic Oscillation exhibits interseasonal, interannual, and multi-

decadal variability. To disentangle stochastic or periodic changes from persistent trends in both cetacean populations and marine ecosystems, data must be available at a range of temporal resolutions, from annual to multi-decadal. This is not to say that a dataset is worthless if it lacks annual observations over a thirty-year time frame (although such a scenario would be welcome). Rather, it suggests that some long term datasets will not be valuable to climate change research because they do not have the temporal resolution to interpret variability observed in the data. In addition, it implies that, given logistical restrictions or limited funding, care should be taken when planning multi-year studies in order to achieve sufficient temporal resolution overall.

The third characteristic of datasets that is critical for addressing climate change questions is adequate spatial extent (overall area studied) and resolution (coarseness of sampling). The definition of "adequate" is relative, depending upon the organisms' movement or migration patterns, the extent of the population, and the spatial scale of the pertinent ecological processes. For example, if a population is circumpolar and sampling occurs in a solid block encompassing only 20% of potential habitat, there is considerable uncertainty associated with any inference at the population level due to large spatial gaps in sampling. In this scenario, it is not necessary for sampling to occur at every point in the Southern Ocean. Rather, sampling should be strategically positioned to occur throughout the habitat range, in patches of sufficient size to capture the pertinent smaller scale spatial heterogeneity in the environment. This could be accomplished by cooperation among researchers, institutions, and countries, if planned in advance.

Long Term Datasets for Analyzing Trends in Baleen Whale Abundance

Leaper et al. (2008) identify a collection of datasets that have been used to estimate the abundance of baleen whale populations and the trends therein. We restrict our discussion to the three datasets they identified that also satisfy our requirement for being long term, namely: 1) the IDCR/SOWER (International Decade on Cetacean Research/Southern Ocean Whale Ecosystem Research) line-transect cruises conducted by the International Whaling Commission (IWC) in the Southern Oceans; 2) the shore-based counts for abundance and trend estimation of humpback whales off East Australia, currently conducted by Mike Noad and colleagues (e.g., Paterson et al. 1994, 2001, 2004; Noad et al. 2008); and 3) the JARPA Program (Japanese Research Program in the Antarctic) conducted by the Institute of Cetacean Research (ICR). Of these three studies, only the shore-based counts of humpbacks off East Australia satisfy all three of our criteria for datasets relevant to climate change research. This study has been regularly conducted since the mid 1980s, with a total of 17 survey years (up to 2007) and inter-survey intervals ranging from one to three years. We are not aware of any climate change-related research conducted to-date using the East Australia humpback data. We suggest, however, that the Rugh et al. (2001) investigation of the timing of gray whale migration, which was associated with a regime shift in the North Pacific Ocean, could be a model for future analyses with the East Australia data. The SOWER and JARPA studies do not have consistent sampling across years at the appropriate temporal and spatial scales necessary to partition observed variability into interannual variability, short-term oscillations, and persistent trends associated with climate change. For example, each of the IWC Management Areas in the Southern Hemisphere (Donovan 1991) was surveyed once, sometimes twice, during each of the three IDCR/SOWER circumpolar surveys, which covered the period 1979 to the present (Branch and Butterworth 2001).

Long Term Datasets for Analyzing Baleen Whale Life History and Health

Two long-term studies applicable to addressing cetacean life history questions meet all of our criteria for relevance to climate change research, and both address right whale demographics and abundance: 1) studies off Peninsula Valdez, Argentina (Payne 1990; Cooke et al. 2001; Leaper et al. 2006) (covered by Rowntree et al. under Key Study 2 of the IWC Climate Change Workshop), and 2) studies off South Africa, by Peter Best and colleagues (Best et al. 2001; Best et al. 2005).

In addition, international collaborative research programs (e.g., SO-GLOBEC, CCAMLR 2000) as well as the Argentinean, Brazilian, British, Chilean, German and U.S. Antarctic survey programs have been working largely independently in the waters off the Western Antarctic Peninsula, between Elephant Island and Margueritte Bay. These programs encompass a variety of studies, including physical and biological oceanography, but many have a dedicated whale component. Therefore cetacean sighting data and biopsy samples have been collected during some of the research cruises. We do not know whether, collectively, the cetacean data from these nations would satisfy our criteria for relevance to climate change research, but we would encourage that this be investigated further.

Key Points

In summary, three critical characteristics make datasets relevant to addressing questions regarding climate change:

- **Duration**: The overall time span of the dataset should be at least twenty to thirty years long.
- **Temporal Resolution**: The dataset must capture variability ranging from interannual to multidecadal time scales. This criterion is met with annual surveys. Alternatively, this criterion could be met if the overall dataset comprises multiple blocks of time, spanning several years each, in which annual surveys were conducted.
- **Spatial Scale**: The relevant spatial scales for studying climate change range from the mesoscale (eddies, fronts, and upwelling zones) to the full extent of a population's distribution (circumpolar, for some southern hemisphere baleen whales).

Given the financial and logistical constraints of satisfying these three criteria, we recommend that collaborators from multiple institutions strategically design hierarchical or nested sampling protocols to collect data that can be used to inform research into the effects of climate change on cetaceans.

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