Shifting baselines in scientific publications: A case study using cetacean research

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Abstract

The marine sciences have undergone a sequence of historical changes related to new methodologies, approaches and challenges. Most recently, deteriorating natural ecosystems and threatened component species have prompted a renewed change in the focus of scientific research on the marine environment. This study analyzes the scientific literature on cetaceans during the period 2005-2008 to demonstrate that a key focus of modern research is on conservation-related topics, and then compares it to the period 1970-1973 to demonstrate that this new focus represents a shift from basic biological and ecological issues. On average, approximately 46% of papers published on whales, dolphins and porpoises in 2005-2008 were categorized as conservation oriented versus focused on biology or ecology. This contrasts to approximately 10% in 1970-1973. This shift parallels that of other marine research subjects such as benthic communities, coral reefs or sea turtles and reflects a general paradigm shift in marine research toward anthropogenic impacts. This is important guidance for institutions and organizations that wish to base their agendas and decisions on state-of-the-art scientific priorities.

Introduction

The approach to gaining knowledge about the marine environment has undergone a series of changes. From an historical perspective, four eras of marine research have been distinguished: that of seafarers, of oceanographic expeditions, of marine stations, and of field research (Riedl, 1980). This has brought scientists ever closer to the object of their studies, ultimately in the form of scientists using SCUBA and other technology (such as manned and unmanned submersibles, underwater cameras, hydrophones, and ever more sophisticated tags) for in situ observation and experimentation.

A new, fifth era was recently identified, one that focuses on deteriorating ecosystems and the repercussions of their dysfunction (Stachowitsch, 2003). Accordingly, in response to a deteriorating environment, research efforts have increasingly focused on topics related to describing, preserving, restoring and managing damaged ecosystems and their inhabitants. This new era differs from earlier ones in its underlying aims, the narrower range of topics studied, the reduced validity of its conclusions, and the increased urgency for collecting the relevant data. These differences are also reflected in criteria for the selection and funding of research projects (see e.g., Pew Charitable Trusts 2010).

Bibliometric analysis (quantification of publications) has increasingly been used to investigate the proportion of published research that belongs to a specific field of study (Kochin & Levin, 2004), or to evaluate environmental trends (Bini et al., 2005). For example, Ward and Lafferty (2004) evaluated trends in marine disease prevalence using rates of publications as a proxy. On the marine habitat level, Knowlton (2006) used bibliometric analysis to investigate the evolution of research on coral reefs. From this, she distinguished three overlapping phases in the recent history of coral reef research, namely research on basic scientific questions, on the decline of corals and the nature of human impacts, and on determining how to conserve and restore coral reefs. The most recent phase or era is intimately related to management, whereby explicit recommendations for management measures are being sought and proffered.

This study echoes the work of Knowlton (2006), but examines research trends on a taxonomic (i.e., cetaceans) rather than habitat level. Whales, dolphins and porpoises were chosen for a case study primarily because of their role as keystone, or flagship, species for the marine environment. The hypothesis is that a considerable body of research is available on such species and that, due to the known major declines in many species (e.g., Clapham et al., 1999), a conservation-related focus in the recent scientific literature will be recognizable for this group.

This issue is of eminent practical interest, especially for the orientation of institutions and organizations that deal with these organisms, their respective animal communities and their habitats. A case in point with regard to cetaceans is the International Whaling Commission (IWC), the internationally recognized body responsible for the conservation and management of large whales. The IWC has a Scientific Committee, whose annual research and computing budget is allocated and approved according to priorities set by the national delegations. There is

debate among the delegations on the emphasis that should be placed on conservation-related issues versus more traditional management (e.g., quota-setting for hunts). The IWC strives to set its agenda and make its decisions based on sound scientific advice (see IWC, 1993). This calls for determining the current focus of cetacean research and for adjusting agendas and decisions to reflect these scientific priorities.

Material and Methods

The present bibliometric analysis evaluated two separate literature databases. For 2005-2008, we used a database maintained by author DJ at the Natural History Museum of Los Angeles County (NHMLAC). For 2005, the NHMLAC database contained 1023 document records, for 2006 1500, for 2007 1389 and for 2008 2310; these included books, theses, technical reports, and articles from over 300 peer-reviewed journals. These document records covered a wide range of topics on marine mammal (and marine mammal-related) biology, evolution, ecology, habitat, conservation, and policy. This appears to be a reasonably inclusive database for peer-reviewed and technical publications on marine mammal-related topics in the literature; for example, searching 'Google Scholar' using the search term 'cetaceans' and '2005' yielded 1,830 hits, but many of these listings were abstracts from conference proceedings, popular science articles, web articles, obituaries, or otherwise not appropriate to include in the current analysis. We randomly selected approximately two dozen hits (of peer-reviewed articles only) from this Google Scholar search – all were present in the NHMLAC database. Thus, the peer-reviewed articles identified by Google Scholar were, by and large, contained in the NHMLAC database as well, while the NHMLAC database contained only a fraction of the non-peer-reviewed records listed in the Google Scholar search.

For the period 1970 to 1973, we conducted a key word search of the BIOSIS database. Key words used were: cetacean, Cetacea, whale, dolphin, porpoise, marine mammal, marine conservation, marine pollution, marine policy, marine ecology, and marine habitat. The BIOSIS database contained 145 cetacean or cetacean-related document records for 1970, 157 for 1971, 133 for 1972, and 107 for 1973. The BIOSIS database may have underrepresented documents from sources other than peer-reviewed journals (i.e., books, theses, and technical reports); nevertheless, more than 200 journals, books, reviews, and report series were represented. No abstracts were available for the BIOSIS documents, so categorization was based entirely on the title of the document and/or the journal/publication. This may have led to an underestimation of studies that addressed cetacean conservation issues, as documents on topics such as marine pollution that did not specifically mention cetaceans in the title were deleted. However, the number of such document records was very small for each year, making the effect of this on the final result minimal.

The databases were examined, document by document, according to a decision flowchart (Fig. 1). The primary analysis was done by author NAR. For both databases, all records that focused on pinnipeds or other marine animals – or on aspects of marine organisms, habitats or ecosystems not immediately relevant to cetaceans – were deleted. The analysis involved almost exclusively primary literature in peer-reviewed journals; thus, book reviews, letters-to-the-editor and similar publications (*e.g.*, short news pieces) were not considered (however, invited papers in conference proceedings were retained for analysis). The remaining records were then classified into two categories as follows:

- B ('basic biology'): Primary focus on basic biology (*e.g.*, evolution, behavior, physiology, anatomy, or taxonomy), ecology (*e.g.*, distribution, habitat preference, habitat partitioning, or stock structure), or new research methods

- C ('conservation'): Primary focus on environmental threats, conservation, management, or policy

For many records in the NHMLAC database (and all of those in the BIOSIS database), this decision was made based on title alone. For the remainder, the abstract was reviewed.

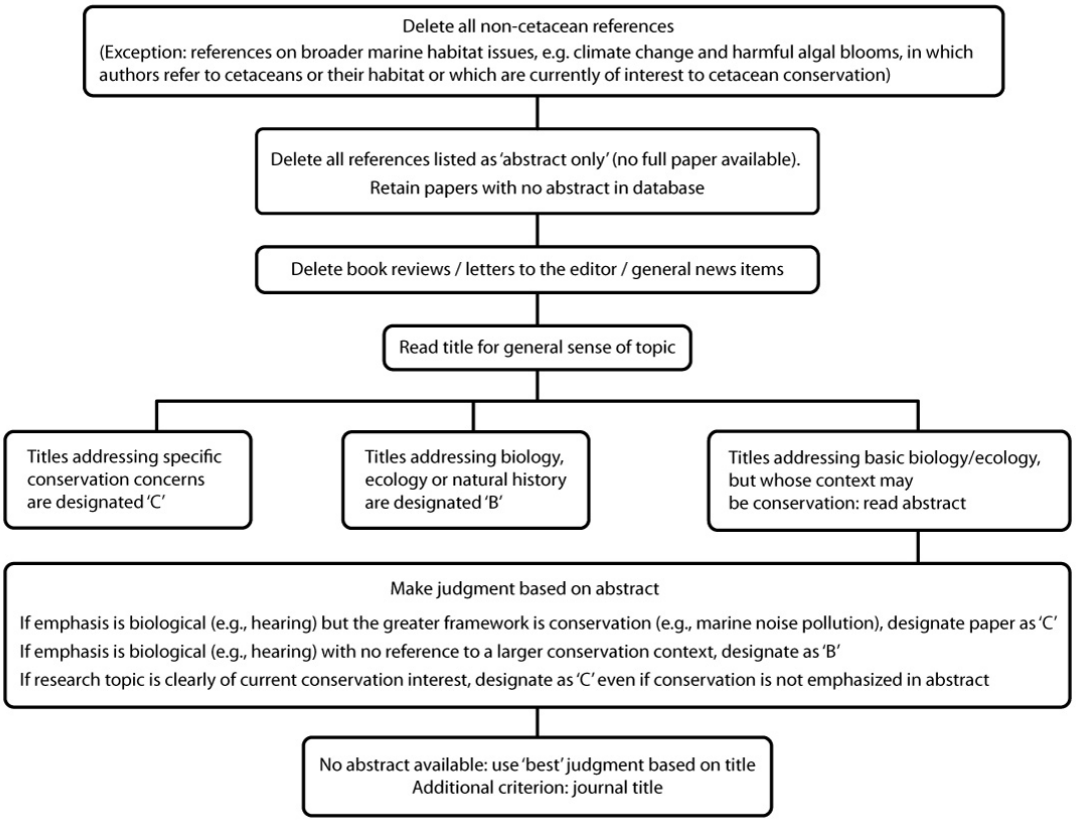


Figure 1: Decision-making flowchart for designating cetacean research papers into 'biology' (B) versus 'conservation' (C) categories for the Natural History Museum of Los Angeles County database on marine mammal publications. The BIOSIS database did not contain abstracts.

If an abstract did not generally refer to any larger conservation context, then the paper was designated 'B.' Studies that presented basic biological or ecological information on a species and included a mention of management implications only as a 'general framework' were also typically categorized as 'basic biology.' If management or conservation implications were the primary motivation for undertaking a study (even if the study treated basic aspects of cetacean biology or ecology), however, then the paper was generally categorized as 'conservation.' This designation was also given if the research topic was clearly of current conservation interest, even if this interest was not emphasized in the abstract.

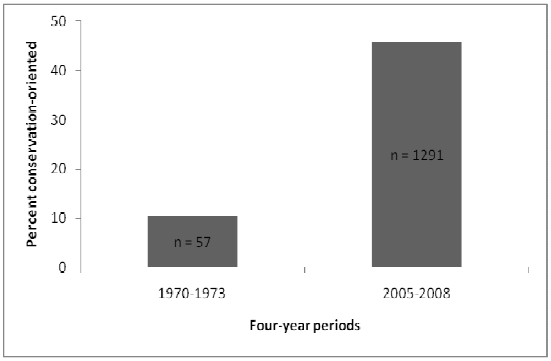
Most decisions were clear-cut. Those that presented more difficulty can be illustrated using hearing in cetaceans as an example. Studies with a purely physiological/anatomical focus were typically designated 'B'. Research on hearing in beaked whales, however, which are the most commonly affected species in sonar-related strandings, was generally classified 'C'. If the emphasis was biological, but the motivation for the study was management or conservation (*e.g.*, marine noise pollution), the designation was also 'C'.

Results

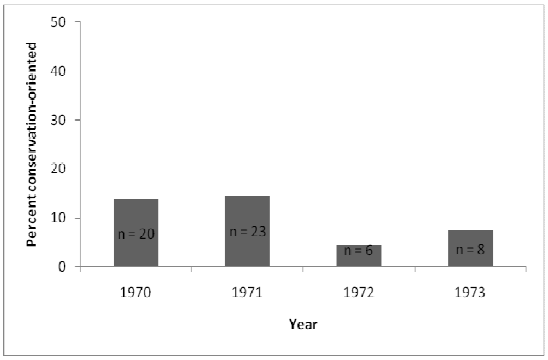
Of the total number of cetacean-related document records examined for 2005-2008, 54.1% (n = 1521) was focused on basic biology and 45.9% (n = 1291) on conservation. For 1970-1973, the distribution was 89.5% (n =485) and 10.5% (n = 57), respectively (Fig. 2a). The proportion of the BIOSIS database categorized as 'conservation' ranged from 4.5% to 14.6% (Fig. 2b). For 2005-2008, the proportion increased slightly over the four year period (Fig. 2c), from 43.6% to 50.4%.

To confirm the objectivity of the decision-making process, 100 of the 785 records analyzed in 2007 were randomly chosen, using a random numbers table, and independently evaluated by authors NAR, ECMP, and MS. This independent categorization showed a very high degree of agreement in the absolute number of records designated as 'conservation' (37/37/38 out of 100). There was, however, some disagreement over which

individual records constituted that category, with some co-authors designating documents as 'C' that others did not and vice- versa. This means that, overall, an even greater number of records were deemed conservation-related by the authors as a group. The categorization of document records in the databases for both periods of this study was therefore conservative and was unlikely to have over-represented the level of conservation-related research.



(a)



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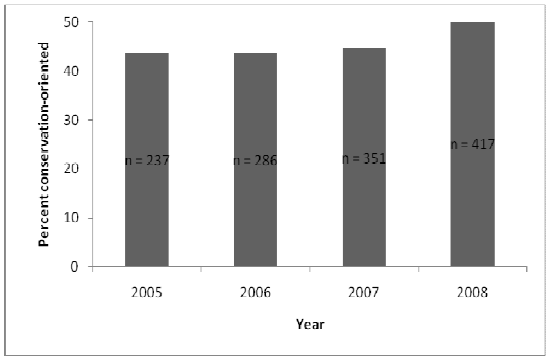

(c)

Figure 2: a) Comparison of the total percent of records categorized as conservation oriented for each four-year period; percent of records categorized as conservation oriented in b) the BIOSIS database for each year 1970-1973 and c) the NHMLAC database for each year 2005-2008.

For 1970-1973, the total number of cetacean papers fluctuated, from 145 in 1970 to 107 in 1973, peaking at 157 in 1971. The number of conservation-oriented papers also fluctuated, with a low of 6 in 1972 and a high of 23 in 1971 (Fig. 2b). The total number of papers addressing cetacean issues increased from 544 in 2005 to 828 in 2008. In parallel, the number of conservation papers increased from 237 to 417 during this period (Fig. 2c). The steady increase in absolute numbers of documents in the 2005-2008 period is probably as much a reflection of increased search effort by author DJ (the NHMLAC database manager) as it was an increase in research effort by the scientific community over those years: he has augmented the key words used and the number of journals searched over the past decade.

Discussion

Scientific knowledge is subject to highly dynamic processes that have led to explosive increases in information, constantly shifting priorities and paradigms within individual disciplines, and ever new fields of inquiry. This evolution can be driven by new technologies and analytical processes (e.g., Loscalszo, 2003) or by the recognition of new challenges. This clearly also pertains to the biological sciences and, in the present case, to marine sciences. In marine biology and ecology, the trends have been governed not only by the general accumulation of data inherent in scientific inquiry and increasingly sophisticated technology, but also by the rapid, anthropogenically driven changes that the systems are undergoing: all the data and methods of analysis point to drastic and increasingly rapid degradation of marine ecosystems due to the synergistic effects of

overfishing, biological, toxic, noise and nutrient pollution, habitat loss, and global climate change (see Jackson, 2008, for a synthesis).

Over the last decades, research in the field of marine sciences has therefore undergone a corresponding paradigm shift (Stachowitsch, 2003; Knowlton, 2006; this study). In response to a deteriorating environment, research efforts have increasingly focused on topics related to describing, preserving, restoring and managing damaged ecosystems and their inhabitants. Our analysis shows that this development is also valid for cetacean research. Almost half of all publications on cetacean biology and ecology today have a direct conservation focus. This is in contrast to 35-40 years ago, when research was almost entirely focused on basic questions of biology and ecology (see Fig. 2a), in the then relatively new science of cetology (Forestell, 2009). Moreover, the bibliometric analysis from 2005-2008 probably underestimates the number of studies undertaken to inform cetacean management or conservation policies, given our generally conservative criteria for categorizing papers: some papers designated as 'basic biology,' were no doubt inspired by on-going conservation or policy debates and could arguably be considered part of this paradigm shift.

Organizations and institutions that wish their actions to remain in synch with new research priorities need to fully consider this trend. In the case of cetaceans, a key body – the International Whaling Commission – is highly divided as to the relative amount of effort it should devote to the two parts of its mandate, to wit: "to provide for *the proper conservation of whale stocks* and thus make possible *the orderly development of the whaling industry*" (ICRW, 1946; emphasis added). Over the years, environmental issues have gained increasing importance at the IWC. This was reflected in the establishment of a Standing Working Group on Environmental Concerns in the Scientific Committee in 1992. This group identified five core issues that merit IWC attention: habitat degradation (which includes fisheries interactions, marine debris, and ship strikes), noise impacts, chemical pollution, climate change, and disease and mortality events.

An increasing number of workshops have been devoted to these topics in recent years (e.g., IWC, 2006). In 2000, the Scientific Committee responded to an IWC resolution request "to provide regular up-dates to the Commission on environmental matters that affect cetaceans" (IWC, 1997) by producing a prototype State of the Cetacean Environment Report (SOCER) (Simmonds et al., 2001), which addressed the above priority issues for the world's major oceans. The IWC Commissioners then requested the Scientific Committee to produce the SOCER annually thereafter (IWC, 2000); after subsequent deliberations on format and content within the Scientific Committee (Perry & Stachowitsch, 2001), the SOCER has been produced annually since 2003 (see Stachowitsch et al., 2003; 2005).

In 1998, environmental concerns had already assumed a middle ranking of importance within the framework of the Scientific Committee's main tasks, which include developing a scientifically sound approach to setting commercial quotas (the Revised Management Procedure), setting quotas for aboriginal subsistence whaling (Aboriginal Whaling Management Procedure), addressing so-called small cetacean issues, and addressing the impacts of whale watching on whales (Fig. 3). Nonetheless, considering that several of these tasks are not recognized as being within the competence of the IWC by many member states (e.g., whale watching), the ranking of environmental concerns within the Scientific Committee was inappropriately low.

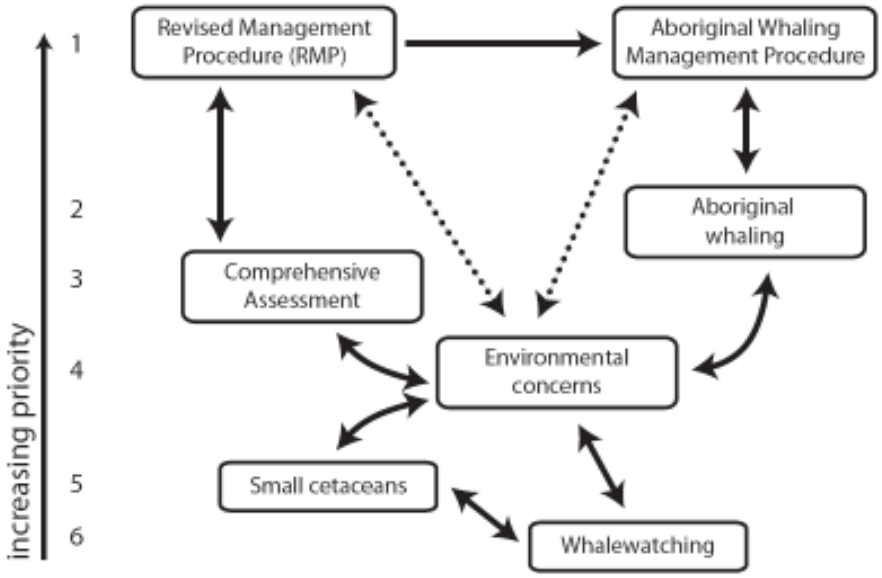

Figure 3: Schematic representation of the relative importance of environmental concerns in the IWC's Scientific Committee tasks, including perceived links (based on Fig. 1 in IWC, 1999, p. 5, used with permission).

In 2003, conservation issues reached a higher level of importance within the Commission itself, when it established the Conservation Committee, in what continues to be a contentious decision (IWC, 2008). The results of the present analysis can inform this situation by pointing out the major focus on conservation in current cetacean research. Accordingly, the IWC is accurately reflecting the current trend in scientific endeavor by dealing with environmental and conservation matters in its Scientific Committee and within the Commission itself. Recognizing and reacting in a timely manner to shifting baselines and shifting timelines in ecological status (Erlandson & Rick, 2008) are prerequisites for addressing and solving the problems facing cetaceans and the marine environment in general. The ultimate result is the generation of new concepts, changes of opinion, and political movements culminating in new agreements, treaties and conventions – fueled by dramatic changes in electronic data documentation and internationally oriented information systems (Hammer, 2003). The shift in the focus of scientific publications is an excellent mirror of this process.

Acknowledgements
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