
Minke Whale


Gray Whale

ecosystems, even after we account for the considerable uncertainties associated with our estimates. Humans thus represent a kind of specialized "superconsumer" and as such may destabilize marine food web structures through overexploitation.

Consequently, there is little evidence for the notion that the great whales or any marine mammal species are to blame for current fisheries problems. Conversely, the "fishing down" of marine food webs demonstrated by others (Pauly et al. 1998b) and the rapid expansion of ocean areas where fisheries dominate marine ecosystems as top consumers shown here suggests that we, ourselves, are at the root of most fisheries-related problems. By extension, the solution to declining fisheries catches lies with the management of these fisheries and not in the culling of already reduced great whale populations.

[1] See Kaschner et al., 2006, SC/58/E3 for more details.

[2] See Kaschner et al., 2006, SC/58/E3 for list of species.

[3] Note that the results presented here were generated using a model version which ignored seasonal difference in occurrence when linking marine mammal food consumption estimates to annual average species distributions. Feeding of great whales is much more concentrated in the summer feeding grounds located in polar waters of both hemispheres than suggested by our maps, and consumption rates in these areas may thus be higher in reality. However, results from an improved model that does take these seasonal aspects into account can be viewed in SC/58/E3. The results presented in this paper show the concentration of food intake in higher latitudes but also illustrate the robustness of the patterns of dominance of fisheries as top consumers in the more temperate latitudes.

[4] The exception may be Antarctic waters, where crabeater seals potentially have taken over the role as the top consumer. However, abundance estimates and consequently the estimated food consumption of this species are highly uncertain (Mori and Butterworth 2005). Moreover, this species almost exclusively feeds on krill—a prey type currently hardly utilized by humans.

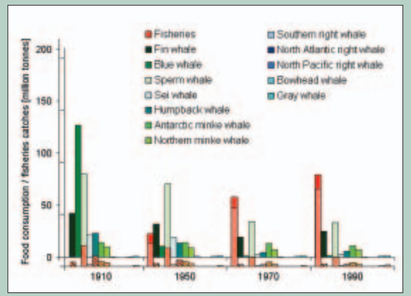

Figure 1. *Estimates of mean total food consumption of 12 great whale species and fisheries catches during different decades of the last century. Prey types primarily targeted by commercial fisheries—consisting of benthic invertebrates, small pelagics, and a diverse group of miscellaneous ground and large pelagic fishes—are represented by the hatched portions of each bar. Fisheries likely surpassed all great whale species in terms of total consumption in the 1970s and in terms of extraction of commercially important prey types as early as the 1950s. Note the comparatively small amounts consumed by the abundant but relatively small minke whale species often mentioned in the context of competition for food resources.*

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References

Christensen, L. B. in prep. *Reconstructing historical biomasses of marine mammals at the global scale: Stochastic stock reduction analysis*. M.Sc., University of British Columbia, Vancouver.

Kaschner, K. 2004. *Modelling and mapping of resource overlap between marine mammals and fisheries on a global scale*. Ph.D., University of British Columbia, Vancouver, Canada.

Kaschner, K., Watson, R., Trites, A. W., and Pauly, D. in press. *Mapping worldwide distributions of marine mammals using a Relative Environmental Suitability (RES) model*. Marine Ecology Progress Series.

Mori, M., and Butterworth, D. S. 2005. Modelling the predator-prey interactions of krill, baleen whales and seals in the Antarctic (SC/57/O21). *In International Whaling Commission—Scientific Committee Meeting*. Korea. (Unpublished).

Pauly, D., Trites, A. W., Capuli, E., and Christensen, V. 1998a. Diet composition and trophic levels of marine mammals. *ICES Journal of Marine Science*, 55: 467–481.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., and Torres, F. J. 1998b. Fishing down marine food webs. *Science*, 279: 860–863.

Watson, R., Kitchingman, A., Gelchu, A., and Pauly, D. 2004. Mapping global fisheries: Sharpening our focus. *Fish and Fisheries*, 5: 168–177.


Sperm Whales

Funding for this report provided by

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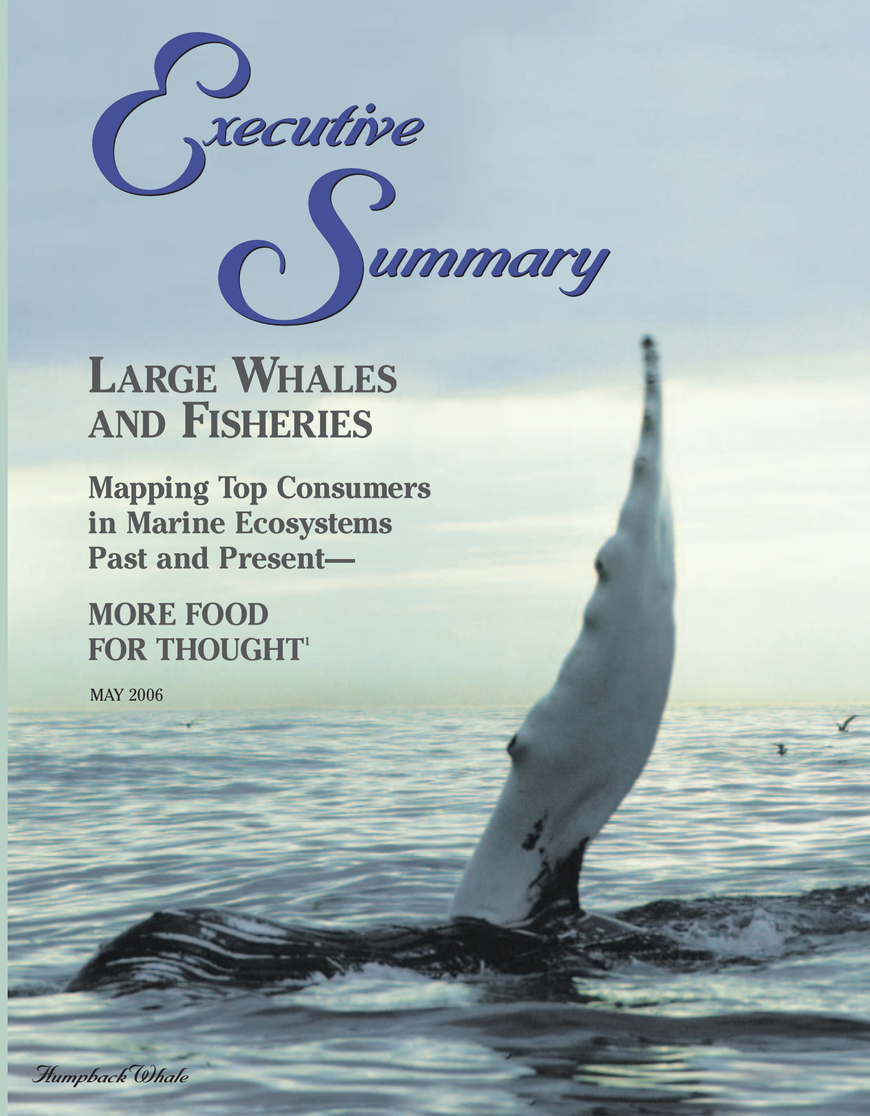
Executive Summary

LARGE WHALES AND FISHERIES

Mapping Top Consumers in Marine Ecosystems Past and Present—

MORE FOOD FOR THOUGHT[1]

MAY 2006


Humpback Whale

IN RECENT YEARS, THERE HAS BEEN AN ONGOING AND heated debate in several international fora about the extent to which marine mammals and particularly whales might be competing with humans for available—and increasingly more limited—marine food resources. In this context, a simplistic argument has been promoted that more food would become available for human consumption if we were to reduce the number of marine mammals. Here, we show that, over the past 50 years, fisheries have replaced marine mammals as top consumers in almost all areas where they co-occur. Given the much more dominant role that fisheries currently play in marine ecosystems, it seems highly unlikely that we could increase fishing capacity by removing marine mammal predators.

Scientifically, it is difficult to unequivocally demonstrate to what extent competition between marine mammals and fisheries occurs due to the complexity of trophic interactions in marine ecosystems and the difficulties in obtaining reliable information about the various parameters that would need to be considered. Instead of investigating competition, we therefore studied the changes in the roles that the great whales and fisheries have played as top consumers in marine ecosystems during the last century to provide some perspective about the chances of further increasing global fisheries production by lowering whale abundance.

To identify the top consumer species, i.e., the species that actually utilizes the most of the marine food resources, we compared the food consumption of 14 species (including most of the great whales and some pinniped species[2]) with fisheries catches over the course of the past five decades. We first estimated historic trends in global marine mammal abundance and the corresponding mean annual food consumption of each species for different decades using a stock reduction analysis model (Christensen in prep.) combined with a simple food consumption model and published information (Kaschner 2004). We then incorporated diet compositions (Pauly et al. 1998a) and the geographic distribution of each species (Kaschner et al. in press) and compared spatially explicit food intake rates of marine mammal species and matching fisheries catch rates expressed with the same spatial and temporal resolution (Watson et al. 2004). The results of this analysis approach illustrate the importance of considering—in the context of assessing competition between marine mammals and fisheries—not only how much is being consumed by whom but also what type of food is being taken and where it is being eaten or caught.

A direct comparison of trends in food consumption/catches on a species-by-species basis indicated that humans surpassed all the great whale species in terms of total extraction of food resources as early as the 1970s (Fig. 1). In addition, since at least the 1950s, fisheries have probably been the primary consumers of those prey types that are of highest commercial importance, represented by hatched portions of each bar in Fig. 1. These prey types make up around 90 percent of all catch and consist mostly of benthic invertebrates such as mussels and shrimps, small pelagic fishes such as herring and anchovies, and a diverse group of miscellaneous demersal, bathypelagic, and large pelagic fishes such as cod, pollock, and small tunas.

Linking food consumption to the geographic areas where the food was probably consumed[3] or caught, we estimated that, in the 1990s, combined food intake rates of baleen whales in most of the world's oceans represent only a fraction of the amounts consumed by these species before most stocks were depleted through whaling activities (Fig. 2). In the North Atlantic, whale consumption has decreased to a lesser extent than elsewhere, but in this ocean basin fin whales, a species feeding predominantly on krill, consume the majority of all food (Fig. 3A). In contrast to these—largely downward—marine mammal trends, fisheries catch rates in most areas have exceeded even the combined maximum consumption rates of whales from the onset of available data in the 1950s and continue to increase.

When we compared food extraction rates for all species, including humans, in different geographic regions, our analysis showed that humans have increasingly replaced the large whales as top consumers in marine ecosystems in many areas of the world over the course of the past 50 years[4] (Figs. 3A and 4A). Moreover, areas with extremely high fisheries catch rates, particularly of commercially important groups, have been spreading rapidly over the same time period (Figs. 3B and 4B). Our findings indicate that in some of these areas humans have been and are extracting food resources from the oceans at rates that are likely up to 100 times higher than those of any other mammal species in marine

Figure 2. *Maps of fisheries catch rates (A) and total food consumption rates of great whales combined for different time periods (B). Whale consumption rates have decreased continuously over the past century and, in the 1990s, were estimated to be lower by at least an order of magnitude than around the turn of the last century due to the extreme depletion of most of the large whale species. In contrast, fisheries catch rates have consistently increased since the onset of available spatially disaggregated catch data, i.e., the 1950s. Note the open-ended scale of the legend: In areas of high concentration of fisheries such as along the continental shelves of the northern hemisphere, fishing rates can exceed more than 150 tonnes per year per km², i.e., more than a 100 times higher than top consumption rates of all whales combined.*

Figure 3. *Maps of top consumer species in each cell (A) and normalized extraction rates relative to top marine mammal consumption rates (B) in terms of total consumption/catches. Areas where humans have replaced marine mammal species as top consumers are highlighted in red in (B) and have been spreading consistently since the 1950s. Geographic regions where humans represent a kind of superconsumer are highlighted in different reds in (B). In terms of total extraction, fishing rates can be up to 10 times higher than top consumer rates of any whale or pinniped consumer species included in this analysis. Note that fisheries data was unavailable prior to the 1950s. The 1910s maps are based exclusively on marine mammal data and thus represent a baseline for comparison.*

Figure 4. *Maps of top consumer species in each cell (A) and normalized extraction rates relative to top marine mammal consumption rates (B) in terms of consumption/catches of a prey type consisting of a large group of commercially important fishes (demersal, bathypelagic, and large pelagic). Areas where humans have replaced marine mammal species as top consumers with respect to this prey type are highlighted in red in (A) and are even larger than those shown in Figure 3. Similarly, geographic regions where fisheries represent a superconsumer for this prey type—highlighted in different reds in (B)—are much larger and have been increasing rapidly over the past 50 years. In these areas, fisheries are and have been extracting resources at rates that can be up to 1,000 times higher than top consumption rates of any whale or pinniped consumer species included in this analysis. Note that fisheries data was unavailable prior to the 1950s. The 1910s maps are based exclusively on marine mammal data and thus represent a baseline for comparison.*