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Mitigation of marine mammal bycatch in U.S. fisheries since 1994

Christina K.A. Geijer [a,b], Andrew J. Read [c,*]

[a] University College London, Department of Geography, Pearson Building, Gower Street, London WC1E 6BT, UK
[b] Stockholm University, Department of Zoology, 10691 Stockholm, Sweden
[c] Division of Marine Science and Conservation, Nicholas School of the Environment, Duke University, Beaufort, NC 28516, USA

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ABSTRACT

Bycatch in fishing gear is one of the most pressing conservation issues facing marine mammals today. In the United States a formal regime to address bycatch of marine mammals was adopted in 1994 as Amendments to the Marine Mammal Protection Act (MMPA). This regime provides quantitative conservation goals and a transparent reporting system, allowing for a unique opportunity to assess the efficacy of bycatch mitigation within U.S. waters. In the present analysis, we compile bycatch estimates for each stock of U.S. marine mammals since 1994 to determine whether mitigation efforts under the Amendments have been successful in reducing bycatch. Bycatch trends were analysed on a national level, and for two regional case studies; harbor porpoises in the Gulf of Maine and common dolphins along the U.S. Pacific coast. The estimated annual marine mammal bycatch was 4356 (SE 424) and bycatch levels declined since the MMPA was amended. Harbor porpoise bycatch in the Gulf of Maine was, however, correlated with landings of cod, suggesting that effort controls in the fishery, rather than porpoise conservation measures, were responsible for initial bycatch reduction. Bycatch mitigation efforts were more successful in the Pacific, where higher levels of compliance with mitigation measures are known to occur. We conclude that the 1994 Amendments have in general been successful, but that implementation has not always translated into conservation success, as illustrated by the harbor porpoise case study. Further studies are required to determine factors that promote compliance and mitigation success within the MMPA framework.

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1. Introduction

Unintended capture in fisheries, commonly referred to as bycatch, is perhaps the most important single conservation issue facing marine mammal populations (Read et al., 2006). Bycatch is a particularly important issue for cetaceans, which have lower potential rates of population growth and are thus more susceptible to the effects of bycatch mortality than other marine mammals. The largest bycatches of marine mammals occur in gillnet fisheries (Reeves et al., 2003; Read et al., 2006; Read, 2008). Bycatch is a primary reason for the fragile conservation status of several threatened and endangered species, including: the vaquita (*Phocoena sinus*) (Rojas-Bracho et al., 2006); North Atlantic right whale (*Eubalaena glacialis*) (Kraus and Rolland, 2007); and Hector's dolphins (*Cephalorhynchus hectori*) (Slooten and Dawson, 2010).

In 1994 the United States adopted a formal regime to address the bycatch of marine mammals in commercial fisheries as Amendments to the Marine Mammal Protection Act (MMPA) (Moore et al., 2009; Read, 2008). Under this regime, each stock of marine mammals is assessed to determine whether bycatch exceeds sustainable removal levels, referred to as Potential Biological Removal (PBR) (Wade, 1998; Taylor et al., 2000). If bycatch levels exceed PBR, the MMPA requires that a Take Reduction Team (TRT) be appointed to develop a Take Reduction Plan (TRP) that will reduce bycatch to below PBR within six months of its implementation. Take Reduction Teams are comprised of representatives from federal agencies, academic and scientific organizations, environmental groups and fisheries organizations. These stakeholders work through a process of negotiated rulemaking, assisted by a federally appointed mediator, to develop a Plan. To date, 10 Take Reduction Teams have been convened; all deal with bycatch of cetaceans.

The existence of this formal regime in the United States, together with a transparent reporting system in which estimates of bycatch are made available for each stock of marine mammals, offers a unique opportunity to assess the efficacy of bycatch mitigation efforts. In the present paper, we update the analysis of Read et al. (2006) by compiling bycatch estimates for each stock of marine mammals in the United States following the Amendment of the MMPA in 1994 to assess whether bycatch has decreased on a national level. In addition, because the process is designed to work at the level of individual marine mammal stocks, we examine two case studies where bycatches of marine mammals were

* Corresponding author. Tel.: +1 252 504 7590; fax: +1 252 504 7648.
E-mail addresses: c.geijer@ucl.ac.uk (C.K.A. Geijer), aread@duke.edu (A.J. Read).

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initially large, have been monitored for a sufficient period of time, and for which long-standing Take Reduction Plans have been implemented, to determine whether the Take Reduction process has been successful: harbor porpoise (*Phocoena phocoena*) bycatch in Gulf of Maine sink gillnet fisheries, and common dolphin (*Delphinus delphis* and *Delphinus capensis*) bycatch in Pacific drift gillnet fisheries.

2. Methods

2.1. Data sources

We followed the methods of Read et al. (2006) to derive estimates of bycatch that were comparable with their findings. We reviewed published Stock Assessment Reports (SARs) (NOAA, 2011) to obtain estimates of bycatch from 141 stocks of marine mammals in U.S. waters. SARs are generated by the U.S. National Marine Fisheries Service (NMFS) and undergo peer review by three regional Scientific Review Groups before publication. Each SAR must be reviewed every three years and updated if there is significant new information, for example to warrant a change in status. For each strategic stock the SAR must be reviewed every year. For some marine mammals, it is difficult to identify the specific identity of bycaught individuals or to discriminate related species during field surveys. In such cases, two or more species from a genus may be combined into a single SAR (e.g. some species of *Mesoplodon*, *Globicephala*, *Stenella*, and *Kogia*). In these instances, we followed the SARs and included bycatch data at the genus level.

Estimates of bycatch, stratified by year and fishery, are provided in the section of the SARs entitled *Annual Human Caused Mortality and Serious Injury*. Most estimates of bycatch in the SARs are derived from independent observer programs, which provide empirical observations of the number of marine mammals killed or seriously injured in observed fishing trips. These observations are then extrapolated to the entire fishery using some metric of fishing effort, such as numbert of hauls, trips, or landings. To determine the magnitude of bycatch we extracted the total Estimated Mortality from this section of each SAR.

In some cases, no estimate of total mortality was available. For these stocks we resorted to other data presented in the SARs; we used the number of observed mortality or serious injuries, which are negatively biased, because only a small portion of total fishing effort is observed. For a few other stocks, we included data on bycatch obtained through self reporting and logbooks, although these, too, are likely to be negatively biased. Stranding programs vary in their ability to diagnose evidence of trauma caused by entanglements, so we did not include stranding data attributed to fisheries interactions. Taken as a whole, therefore, the data presented here underestimate the true magnitude of marine mammal bycatch to an unknown degree.

Because of variation in reporting procedures, it was not possible to estimate a total variance for each marine mammal taxonomic group, fishery type, or region. Thus, the measures of variance we present (standard errors) underestimate the true level of uncertainty in the estimates of total bycatch.

2.2. Analysis

We extracted and compiled the annual estimates on bycatch for each stock from 1999 to 2006. Many SARs do not include estimates of bycatch for years after 2006, so it was not possible to derive comprehensive estimates for more recent years. To provide a longer historical perspective, we included annual estimates from 1994 to 1999 generated by Read et al. (2006), who used methods identical to those described here. We combined bycatch estimates for each stock of marine mammals into three categories of fishing gear: gillnets, trawls, and other (e.g. longlines and purse seines). We further stratified the data by three geographical regions: Atlantic (including the Gulf of Mexico), Pacific (including Hawaii), and Alaska.

With the exception of the bycatch of pelagic dolphins in the purse seine fishery for yellowfin tuna (*Thunnus albacares*) in the Eastern Tropical Pacific (e.g. Gerrodette and Forcada, 2005), most formal attempts to reduce marine mammal bycatch in U.S. fisheries began after the MMPA was amended in 1994 (Bache, 2001; Young, 2001; Read, 2005). Therefore, we examined temporal trends in the magnitude of bycatch from 1994 to 2006 to test the hypothesis that total bycatch has been reduced incrementally after these Amendments were implemented. We conducted linear regressions of bycatch against year for: (a) cetaceans; (b) pinnipeds; and (c) all marine mammals.

To further understand the effects of the Amendments and to determine whether there are regional differences in their implementation and effectiveness, we conducted a more in-depth analysis of two regional case studies. We selected these case studies using the following criteria: (1) initial bycatches were large, providing sufficient statistical power to detect an effect of mitigation strategies; (2) a Take Reduction Plan had been implemented; and (3) bycatch had been monitored for a sufficient period following implementation of the Plan.

The first case study we selected was the bycatch of harbor porpoises in the Gulf of Maine. Porpoises from this stock are taken as bycatch in a sink (bottom-set) gillnet fishery for mixed groundfish in New England and in other gillnet fisheries in the Mid-Atlantic and the Bay of Fundy in Canada (Read et al., 2006). SARs of this harbor porpoise stock were available until 2008, so we extracted mortality estimates of the New England sink gillnet fisheries between 1994 and 2008.

We conducted linear regressions to detect potential trends in bycatch mortality following the implementation of a Take Reduction Plan in 1998 that included a series of mitigation measures in the Gulf of Maine, including a requirement to use acoustic alarms, or pingers (Palka et al., 2008), and time-area restrictions on fishing effort (e.g. Young, 2001; Read, 2010). We further performed an independent t-test to establish if there was a significant difference in the annual estimated means of harbor porpoise bycatch before and after implementation of the TRP in 1998.

Many conservation measures have been implemented in the New England sink gillnet fishery to address overfishing of target groundfish species, so we also examined temporal trends in landings of a key target species, Atlantic cod (*Gadus morhua*), from this fishery. We examined correlations between cod landings and harbor porpoise bycatch from 1990 to 2007, the last year for which landings data were available for this fishery. To tease apart the effects of variation in fishing effort and those of the TRP, we further examined correlations between landings and bycatch before and after the TRP was introduced in 1998. Landings are used as a metric of effort in the Gulf of Maine groundfish gillnet fishery because data on the quantity of gear fished (i.e. the number of sets or meters of nets fished per unit time) are not reported consistently by commercial gillnet fishermen in their vessel logbooks (Waring et al., 2011).

In the second case study, we analysed bycatch rates of common dolphins in the Pacific drift gillnet fishery for swordfish (*Xiphias gladius*) and thresher sharks (*Alopias* spp.). The California longbeaked (*D. capensis*) and California/Oregon/Washington shortbeaked (*D. delphis*) common dolphin stocks are both taken as bycatch in this driftnet fishery. SARs for these two stocks were available until 2008 and therefore we analysed annual bycatch from 1994 to 2008. A Take Reduction Plan was implemented in 1997 requiring the use of pingers and modifications to fishing gear, so

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