Ecological Indicators 60 (2016) 987–995

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Bycatch and strandings programs as ecological indicators for data-limited cetaceans

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ARTICLE INFO

Article history:
Received 13 February 2015
Received in revised form 28 August 2015
Accepted 31 August 2015

Keywords:
Bycatch
Strandings
Cetaceans
Dolphins
Whales

ABSTRACT

An integrated approach of using strandings and bycatch data may provide an indicator of long-term trends for data-limited cetaceans. Strandings programs can give a faithful representation of the species composition of cetacean assemblages, while standardised bycatch rates can provide a measure of relative abundance. Comparing the two datasets may also facilitate managing impacts by understanding which species, sex or sizes are the most vulnerable to interactions with fisheries gear. Here we apply this approach to two long-term datasets in East Australia, bycatch in the Queensland Shark Control Program (QSCP, 1992–2012) and strandings in the Queensland Marine Wildlife Strandings and Mortality Program (StrandNet, 1996–2012). Short-beaked common dolphins, *Delphinus delphis*, were markedly more frequent in bycatch than in the strandings dataset, suggesting that they are more prone to being incidentally caught than other cetacean species in the region. The reverse was true for humpback whales, *Megaptera novaeangliae*, bottlenose dolphins, *Tursiops* spp.; and species predominantly found in offshore waters. QSCP bycatch was strongly skewed towards females for short-beaked common dolphins, and towards smaller sizes for Australian humpback dolphins, *Sousa sahulensis*. Overall, both datasets demonstrated similar seasonality and a similar long-term increase from 1996 until 2008. Analysis on a species-by-species basis was then used to explore potential explanations for long-term trends, which ranged from a recovering stock (humpback whales) to a shift in habitat use (short-beaked common dolphins).

1. Introduction

A fundamental issue in conservation management of cetaceans is obtaining accurate data on population structure and abundance for species that are characteristically highly mobile over vast areas or that are rarely encountered (Magera et al., 2013). Monitoring abundance over time scales that are meaningful for species with long generation times can also be prohibitively expensive, especially when approaches such as mark-recapture or distance sampling are required. Consequently, species or stocks may be categorised as data deficient and may not be afforded an appropriate level of protection.

In recent years, it has been increasingly realised that critical demographic (Mannocci et al., 2012), genetic (Bilgmann et al., 2011) and species diversity information (Pyenson, 2010, 2011) can be obtained from relatively inexpensive strandings networks, particularly if they encompass a large area and are collected over long time periods. Strandings records also provide information on species that are rarely observed in the wild (Thompson et al., 2013) and the frequency of occurrence of species within an area (Maldini et al., 2005). However, the relationship between strandings records and population trends in live assemblages can be confounded by a range of factors such as unusual stranding events (e.g. epizootics or mass strandings), environmental variation (Meager and Limpus, 2014), carcass drift (Peltier et al., 2012) or reporting effort. It is also arguable whether strandings records represent the demographics of living communities, because the risks of mortality or morbidity characteristically vary with ontogeny (Perrin et al., 2002).

Incidental take in fisheries, or bycatch, is another source of data often collected for cetaceans. In cases where the data are reliable, such as when they are overseen by an observer program, and when gear-related effects are accounted for, standardised bycatch may provide an index of population abundance over time (Maunder and Punt, 2004). This approach has underpinned many analyses of recovery trends and hindcasts of historical population sizes of marine mammals (e.g. Baker and Clapham, 2004; Marsh et al., 2005; Christensen, 2006; Magera et al., 2013). Yet, there are many examples of known biases from using standardised bycatch as an

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http://dx.doi.org/10.1016/j.ecolind.2015.08.052
1470-160X/

ecological indicator, for example, if extrinsic factors make animals more likely to interact with fishing gear during certain time periods (Harley et al., 2001). Comparing bycatch rates with strandings records may alleviate some of these concerns by providing fisheries-independent reference points.

Monitoring bycatch is also important in its own right, because incidental catch in some fisheries poses a significant global threat to many cetacean species (Lewison et al., 2004; Read et al., 2006; Leeney et al., 2008). An important step towards mitigating bycatch is in understanding which species, sexes, ages or individuals are vulnerable to capture. To this end, much can be ascertained by comparing catch rates between gear types, or better still, against independent data such as that provided by dedicated surveys or strandings programs.

Here we analyse two long-term datasets in eastern Australia, the Queensland Shark Control Program (QSCP) and the Queensland Marine Wildlife Strandings and Mortality Program (StrandNet). Specifically, we examine long term and seasonal trends in cetacean bycatch and strandings, and explore the usefulness of this comparative approach as an ecological indicator for data-limited species across a subtropical-tropical coastline spanning more than 2000 km. We also compare the species, size and sex composition of cetaceans between gear and datasets to investigate gear selectivity and dataset biases.

2. Materials and methods

2.1. Queensland Shark Control Program (QSCP)

The QSCP uses surface-set nets and baited hooks (drumlines) to remove potentially dangerous sharks from the vicinity of popular bathing areas in the state of Queensland, in Australia's north east, and has been in place since 1962. While it is not a commercial fishery, it uses fisheries gear to catch target species, and non-target bycatch species such as other elasmobranches, teleost fishes, marine turtles and marine mammals are caught in the process (Sumpton et al., 2011). For the purposes of this study, we define 'bycatch' as non-target animals that have become hooked or entangled on QSCP drumlines or nets, that were either dead or that required human intervention to release alive. Cases of brief entanglement, where the animal freed itself, or where damage to gear occurred for unknown reasons were not included.

Cetacean bycatch in the QSCP has been routinely recorded since 1974, but dolphins were rarely identified to species prior to 1992 (Gribble et al., 1998). From 1992, a number of initiatives including trained observers, covert surveillance and training in species identification were undertaken to improve the quality of the bycatch data. Here we analyse data from 1992 to 2012, when nets and drumlines were set at Cairns, Mackay, Rainbow Beach, the Sunshine Coast and the Gold Coast; and drumlines were set at an additional five regions (Fig. 1).

Data were first screened for data entry or misidentification errors, based on knowledge of the geographic range of species and whether other confirming data such as photos and genetic samples were available. Where there was considerable uncertainty, discussions were then held with the relevant fisheries contractor. Cases were changed to 'unidentified' where identification could not be resolved.

Operational aspects of gear deployment in the QSCP were described in detail by Sumpton et al. (2011). Briefly, nets are constructed of 1.6 mm diameter polypropylene mesh with a stretched-mesh size of 50 cm, a drop of 6 m and a total length of 186 m. Drumlines consist of a single 14/0 shark hook baited with fresh sea mullet (*Mugil cephalus*) or shark flesh suspended from a buoy at least 2 m from the seafloor at low tide. Drumlines and nets are anchored to the seafloor and set parallel to the shore in water between 6 and 12 m deep, approximately 600 m from the shore, although this distance varies depending on local topography. Nets and drumlines are checked and rebaited (in the case of drumlines) 15–20 days per month by contracted fishers. Each day the gear is checked, the contractors record details of the shark catch and bycatch, including species, sex, total length and the state of each animal (alive or dead).

No major changes in gear placement, deployment or configuration occurred in the time period and regions analysed, with the exception of the incremental introduction of acoustic pingers. Whale pingers (fundamental frequencies from 2.7 to 5 kHz) were tested on the Gold Coast during the whale migration seasons of 1992 and 1993 (Gribble et al., 1998). They were subsequently used during the whale migration season on the Gold Coast nets (since 1994) and on the Sunshine Coast (since 1997) (Lien et al., 1996). Dolphin pingers (Fumunda F10 or similar 10 kHz pingers) were incrementally deployed from 1994 to 1995 (Gribble et al., 1998). Fumunda F70 dolphin pingers (70 kHz) have also been trialled since 2012.

2.2. The Queensland Marine Wildlife Strandings and Mortality Program (StrandNet)

Stranded cetaceans are recorded in the StrandNet database for the state of Queensland (Meager and Limpus, 2014). For the purposes of the current study, we use the term 'strandings' for cetaceans that were reported to be in ill health, injured, incapacitated or dead, whether beach cast or observed at sea. Records are obtained from government departments, environmental organisations and the general public, and include information such as location, date, sex, body-size measurements, and carcass condition. All records are verified by trained staff or species experts. The probable cause of death is established through examination of carcasses by trained staff, necropsies by veterinarians or, in some cases, through photos and/or case histories.

Cetacean strandings have been systematically recorded along the east coast of Queensland, Australia from Cairns to the Queensland–New South Wales border since 1996. Cetacean strandings attract significant attention from the public and there are few locations along the coastline where beach-washed cetaceans are not reported. The proportion of carcasses or debilitated animals that reach the shoreline is unknown, and is likely to depend on factors such as currents, wind and carcass buoyancy, and losses to scavengers (Peltier et al., 2012). Cetaceans are also reported floating dead or debilitated at sea. Coverage at sea is the most comprehensive in areas of high vessel traffic or where regular patrols are conducted.

Data for the time period from January 1996 to December 2012 were first filtered to remove records associated with QSCP bycatch (which are also recorded in StrandNet). Records known to be associated with entanglement or incidental capture in recreational or commercial fisheries, or entanglement in discarded fishing gear were then removed (10% of records). This increased the independence of the strandings dataset from QSCP bycatch because species that interact with QSCP gear could reasonably be expected to interact with recreational and commercial fisheries gear. The coordinates of each stranding event were then used to assign data to QSCP regions (Fig. 1), and data outside of QSCP regions were excluded (18% of records). Finally, we filtered the data for spatial–temporal clusters that could confound the interpretation of the strandings record as an ecological indicator, using a space–time permutation scan test in the program SatScan (Kulldorff et al., 2005; following Norman et al., 2012). This analysis detected one significant cluster of four unidentified small whales on 10/08/2002 (test statistic = 12.7; $p = 0.001$). These cases were excluded from further