An unusual peak in recorded mortalities of humpback whales in Western Australia: normal stochastic variability or a regional indication of carrying capacity?

Doug Coughran[1] and Nick Gales[2]

[1] Department of Environment and Conservation, Locked Bag 104, Bentley Delivery Centre, Western Australia 6983, Australia.
[2] Australian Marine Mammal Centre, Australia Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia.

Abstract
An unprecedented number of humpback whales (n=46) from Breeding Stock D (BSD) were found dead or dying on west Australian beaches in 2009. This compares to averages of only a few each year in the preceding two decades. Most of these whales were estimated to be calves of the year (44%), with 37% being juveniles/sub-adults and 19% being adults. Many of these animals appeared to be grossly underweight. There are insufficient data on which to determine causes of death. We propose three possible hypotheses to explain this peak in recorded mortalities:

1. The peak in mortalities does not represent an increase in mortality rate in BSD, but is an artefact of other features such as search effort and coastal oceanography.
2. The peak in mortalities represents a transient increase in mortality rate in BSD driven by unknown cause(s) that may be associated with processes on the feeding grounds, breeding grounds, or both.
3. The peak in mortalities represents the start of an increasing trend in mortality rates in BSD driven by unknown cause(s) that may be associated with processes on the feeding grounds, breeding grounds, or both.

We suggest that hypotheses two and three are more plausible and that extra research will be required to discriminate between them.

Introduction

Like many other global populations of great whales, the population of humpback whales that aggregate to breed along the coast of Western Australia (Breeding Stock D: BSD) were severely depleted through unsustainable whaling practices. A combination of historic catches from Western Australian coastal whaling stations and pelagic whalers, high seas whaling in the Southern Ocean and illegal, unreported whaling by the then Soviet Union (Yablokov *et al.* 1998) depleted the population to fewer than 800 animals by 1962 (Chittleborough 1965). Although there is substantial uncertainty around estimates of pre-whaling population abundance, BSD was likely to have numbered at least 20,000 animals in the early Twentieth Century, and so had been depleted to just a few percent of its original size.

The almost complete cessation of whaling on BSD post-1962 resulted in evidence of population increase by the mid-1970s and by the end of the Twentieth Century the population had reached an estimate of about 10,000 animals (Bannister and Hedley, 2001). This remarkably rapid recovery rate (>10% per annum) was also evident for the humpback whales that breed off the East coast of Australia (Noad publication). The most recent published population estimate for BSD from 2008 (Hedley *et al.* 2009) of 21,750 (95% CI =17,550-43,000) suggests that the population is likely to be at, or approaching, estimates of pre-exploitation population size.

A determination of when recovering populations of baleen whales begin to equilibrate around a carrying capacity has important ecological implications. The level at which whale population trends asymptote relative to estimates of pre-whaling abundance may provide insights into century-scale changes in Southern Ocean ecosystems. More specifically, expressions of changes in life-history and habitat-use patterns (such as reproductive rates, migratory timing and location and foraging behaviour) that accompany declines in rates of population increase may indicate the nature and extent of physical and biological forcing factors on whale populations.

Here, we present data on an unusual peak in recorded mortalities of humpback whales along the west Australian coast during the breeding season of BSD in 2009. We explore plausible explanations of the long-term trend in humpback whale mortalities, as recorded from incidents of reported beach-cast whales.

Methods

The west Australian Department of Environment and Conservation (DEC) maintains an effective regional reporting network and database of marine mammal stranding events which includes both live-stranded and dead, beach-cast cetaceans. Comprehensive records of stranding events have been maintained since 1982. Species identification are only included in the database when verified by a suitably qualified person. The west Australian stranding database was used to extract records of beach-cast humpback whales over the past two decades (1989 - 2009). Where available, data on standing data, location, animal sex, animal length and obvious cause of death were recorded. Post-mortem examination and scientific sampling is not a regular feature of stranding response.

Results

Humpback whales have been recorded to strand, dead or alive on the west Australian coast 105 times since 1989. On 27 occasions the whales were found on the beach alive. Thirteen of these whales died soon after being found alive, nine were euthanased, three were refloated, but died later, and three were refloated but were not seen again. For the purpose of this paper these last three whales were assumed to have died. Of the remaining 78 events when a dead, beach-cast whale was encountered at least 46% had been dead for an extended period (advanced decomposition) and may have died on the beach or at sea.

The mean number of whales ashore between 1989 and 2007 was between 2 and 3 humpbacks per annum (range 0 – 5). Fifty seven percent of the total strandings occurred in 2008 and 2009, with 2009 being by far the peak year with 46 humpback whale strandings (42% of the total) (Figure 1). Almost all strandings occurred in the second half of each calendar year, with numbers trending up to peak in November (Figure 2).

Stranded humpback whale length ranged from 3.25 – 15m (Figure 3). Mean length was 8.0 ± 3.3m (mean ± sd). Determining age cohort by length is difficult as there is substantial overlap between calves of the year, juveniles/sub-adults and adults. However, if we assume that adults include all animals greater than 12m, juveniles/sub-adults include animals 7-12m and calves of the year include all animals less than 7m, then 44% of strandings were of calves of the year, 37% were of juveniles/sub-adults and 19% were of adults.

Formal body condition measurements were not taken, although many were noted to look grossly underweight. There was insufficient data to provide any quantification of nutritional status.

Strandings occurred throughout the expected range of humpback migratory and breeding habitat along the coast of Western Australia (Figure 4). Highest densities in recorded stranding events were in the lower mid-west coast of Western Australia.

Discussion

As populations of whales which migrate past populated coastlines increase in size it is reasonable to expect an increase in recorded mortality events. When trends in these mortalities vary from recorded population trends it is reasonable to consider what the underlying forcing mechanisms may be.

In the case of humpback whales from Breeding Stock D it is clear that 2009 represented a year of unusually high recorded mortality events, preceded as it was by a smaller elevation in events in 2008. Whether these mortality peaks represent the start of an increasing trend, or are just an unusual, and perhaps unexplainable, peak remains to be seen through the collection of data in future seasons.

At this stage we are able to draw the following conclusions:

- The temporal pattern of mortalities shows no significant trend prior to 2008, after which there are two years of substantially higher, and increasing recorded events.
- Mortalities are primarily restricted to sub-adult age classes (>80%), with over half of these likely being from the calves of the year.
- There is a bias in mortality events towards the latter half of the winter breeding season, with most occurring during the southern migration.

- The spatial distribution pattern of stranding events includes nearly all Western Australian coastal habitats, with differential densities more likely reflecting human population distribution (search effort) rather than real mortality event distribution.
- In a qualitative sense many of the animals were noted to look very skinny, but there were insufficient data to quantify this.
- The actual number of recorded mortalities represents a very small proportion of the total population of BSD.
- The current estimate of population size of BSD is close to, and perhaps even greater than, estimates of population size prior to industrial whaling.

The winter migratory and breeding season of humpback whales is associated with a period of physiological and energetic stress associated with extended fasting and the demands of travel and reproduction. This almost certainly leads to seasonal peaks in mortality which will be disproportionately recorded at coastal locations near human populations. The record we present here, which runs for over two decades, must to some degree include biases associated with variable search effort, as well as variability in oceanography and sea conditions that affects the likelihood of sick or dead whales appearing on the beach. Nevertheless, the beaching of a humpback whale of any size represents an obvious and persistent event that is likely to eventually be reported by one of the huge population of west Australians who utilise almost all of the coastline for recreation or industry. Consequently, we propose that the increase in mortality we report most likely represents a real spike in mortality in the sub-adult age classes in BSD in 2008 and 2009.

We propose the following hypotheses as possible explanations:

1. The peak in mortalities does not represent an increase in mortality rate in BSD, but is an artefact of other features such as search effort and coastal oceanography.
2. The peak in mortalities represents a transient increase in mortality rate in BSD driven by unknown cause(s) that may be associated with processes on the feeding grounds, breeding grounds, or both.
3. The peak in mortalities represents the start of an increasing trend in mortality rates in BSD driven by unknown cause(s) that may be associated with processes on the feeding grounds, breeding grounds, or both.

As discussed above we believe hypothesis 1 to be the least plausible, particularly given the scale of change in records over such a short timeframe.

We are unable to discriminate plausibility between hypotheses 2 & 3 without several more years of data. It is important to reflect however that the ecological significance of the two is very different. If hypothesis 3 is correct then it may signify a threshold change in carrying capacity for this population of humpback whales in the Southern Ocean. While the fact that BSD is approaching estimates of pristine population size lends some support to this hypothesis, it remains the case that we have a low power to accurately predict pristine population size, and perhaps more importantly we might expect contemporary Southern Ocean ecology to be substantially different from that of a century ago.

We propose three recommendations in order to better understand the significance of the mortality pattern we report:

1. Continue with at least current levels of effort to record humpback whale mortality events in Western Australia.
2. Consider an enhancement of this effort in order to collect additional post-mortem information from fresh carcases to better inform possible causes of death.
3. Continue with long term monitoring of population trend of humpback whales in BSD.

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Figure 1. Number of live and dead humpback whales recorded on west Australian beaches between 1989 and 2010.

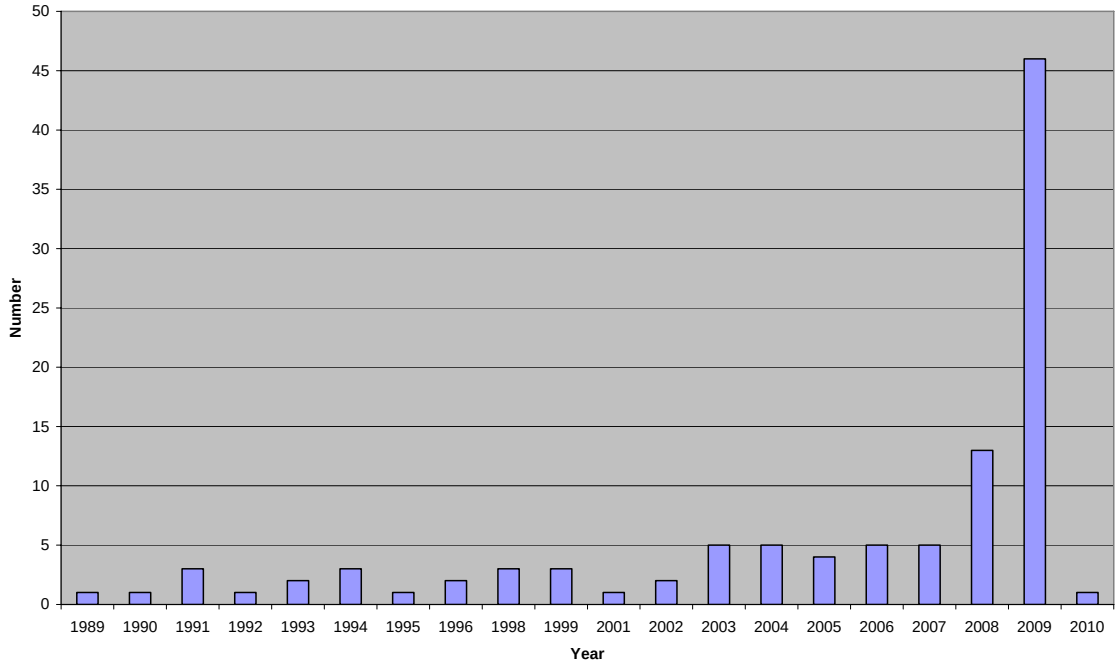

Figure 2. Number of live and dead humpback whales recorded on west Australian beaches during each month for the years 1989 – 2010.

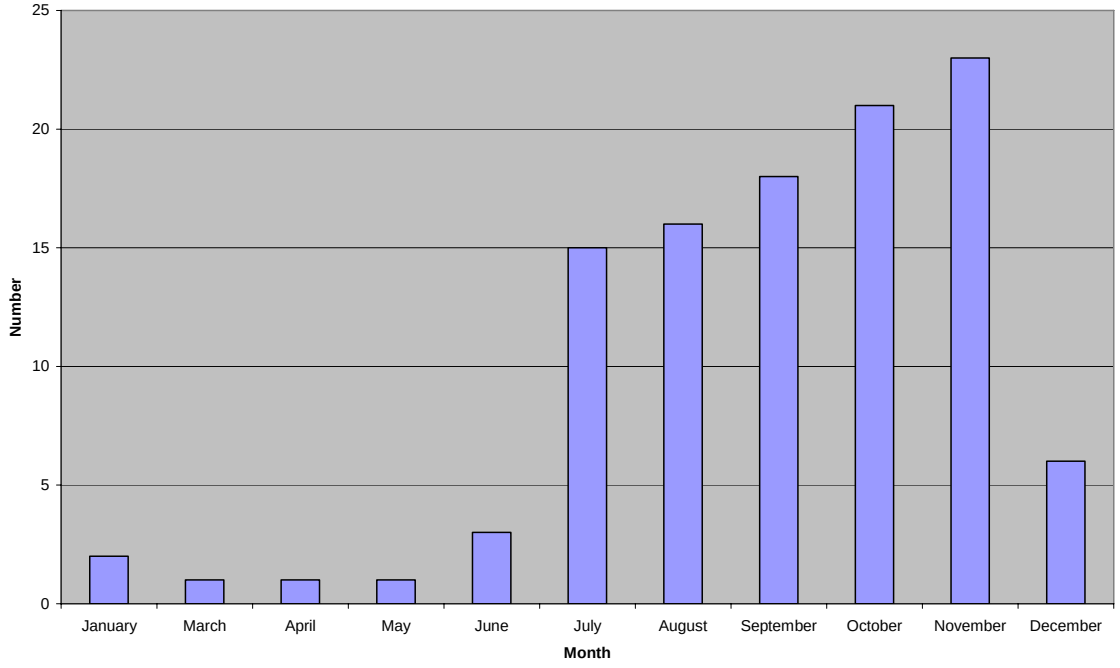

Figure 3. Length frequency distribution of live and dead humpback whales which stranded on west Australian beaches between 1989 and 2010.

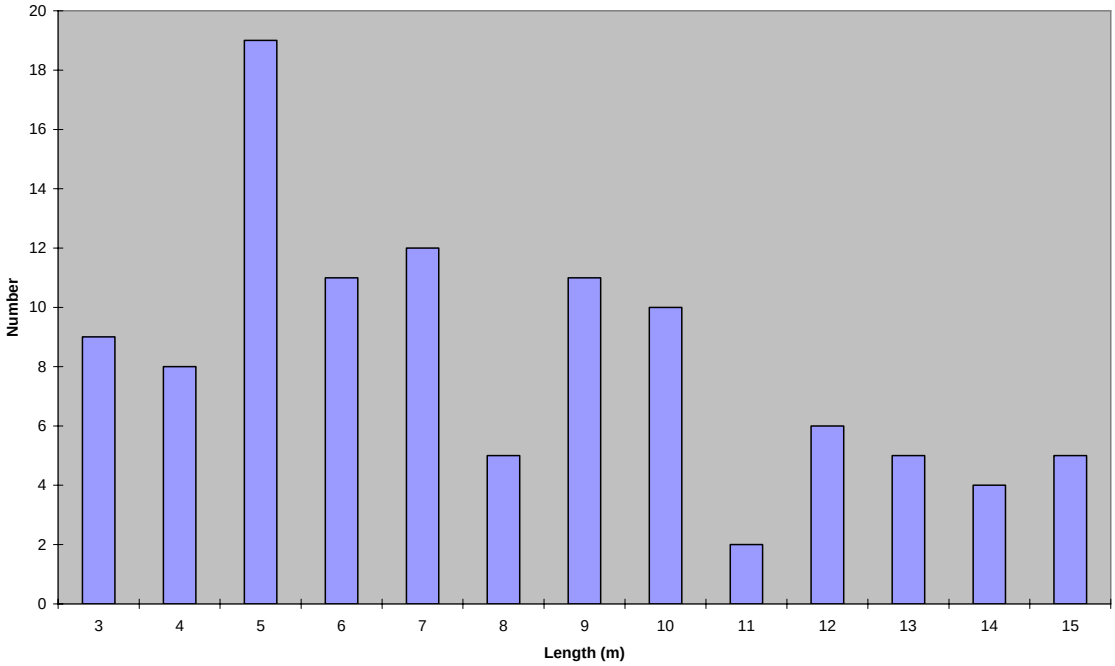

Figure 4. Distribution of humpback whale stranding events between 1989 and 2010.