Diversity

Mass Cetacean Strandings—a Plea for Empiricism

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The recent series of mass cetacean strandings in the stranding-prone regions of Australia and New Zealand (BBC News 2004) and the ensuing speculation regarding their cause demonstrate that debates surrounding this phenomenon continue to be of issue. As most interested in these debates are aware, hypotheses addressing their causes range from the more biologically plausible—including climate and oceanographic variation (Mignucci-Giannoni et al. 2000; Evans et al. 2005), navigational errors arising from particular magnetic configurations (Walker et al. 1992; Brabyn & Frew 1994) or bathymetric and ocean current features (Brabyn & McLean 1992), and anthropogenic noise and sonar interference (Balcomb & Claridge 2001; Madsen et al. 2002)—to the less-supported, including sensory stimulation (Mawson 1978), distraction (Wood 1979), regression to instinctive behaviors (Cordes 1982), and even the suggestion that earthquakes are responsible (ABC News 2004).

Rather than supplying more fuel for conjecture in light of severe shortages of convincing data, we believe it is more constructive to provide a scientific framework for testing hypotheses that seek to explain the patterns observed and mechanisms responsible for strandings. The most reliable and long-term data are the time series of stranding events. Recently, our research group, in collaboration with a large multidisciplinary team, examined the periodicity of these events in the southeastern region of Australia, including one of the world's stranding hotspots—the southern island state of Tasmania (Evans et al. 2005). Substantial records of strandings are available in this region from the 1920s, and in some years there were >20 mass-stranding events recorded involving sometimes >300 individuals per event. Our analyses showed that not only were there clear cycles in the number of stranding events of approximately 12–14 years' periodicity, but that these pulses were related to measurable changes in climate patterns. We found that increases in zonal and meridional winds resulting in colder and presumably nutrient-rich waters moving closer to southern Australian landmasses were good predictors of increases in stranding frequency.

The model derived in our analysis forecasted that the austral summer of 2004–2005 would be a peak year for cetacean strandings in southern Australia and, indeed, many strandings occurred. Approximately 20 stranding events were recorded in the southeastern state of Victoria prior to Christmas 2004, and 8 more strandings occurred on beaches in the following week. This high stranding rate continued throughout January and February, with an average of one new animal found stranded every 4 days, resulting in a total number of stranding events recorded across this period almost equivalent to the total recorded for the entire previous year.

Admittedly, this finding does not provide a mechanistic resolution. However, researchers are much closer to understanding why whales strand themselves because they now have a solid basis from which to generate and test new hypotheses. Variability in the distribution and availability of food resources dictates patterns in animal migration, survival, fecundity, and, ultimately, population size. Broad changes in the distribution of cetacean food sources as a function of variation in oceanography should therefore be a prime area of study. If nutrient-rich water incursions are responsible for bringing cetaceans closer to land, then the probability of stranding at those times should also be higher. Oceanographic and climatological analyses with respect to cetacean distribution, foraging behavior, and migration are therefore the most fruitful avenues of research and should be encouraged.

There is also some, although in many cases equivocal, evidence that certain features of ocean basins such as magnetic variation, current patterns, and bathymetric topography are correlated spatially to stranding hotspots (Brabyn & McLean 1992; Walker et al. 1992; Brabyn &

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Frew 1994). However, these are not causes in themselves; rather, they are analogous to the relationship between strandings and climate in that they indicate where (as opposed to when) strandings are more likely to occur.

In the absence of the basis to generate and test new hypotheses, speculation as to why cetaceans strand themselves has flourished. Without doubt, the thorniest of issues in this debate involve hypotheses linking noise pollution originating from human activities in and on the water to disorientation and physical trauma of exposed individuals. The passion and vitriol associated with the argument that operations such as military sonar, seismic surveying, shipping traffic, and even recreational vehicles are responsible for startling cetaceans or disrupting their sensitive navigational systems are well documented (Frantzis 1998; Balcomb & Claridge 2001; Malakoff 2001). Although there are suggestions that some species of whales, particularly those of the beaked whale (Ziphiidae) family, may be particularly sensitive to military sonar activities (Frantzis 1998; Simmonds & Lopez-Jurado 1991; U.S. Department of Commerce & Navy 2001), much of the so-called evidence describes coincidental strandings in the few cases where localized sonar activity was contemporaneous (but not necessarily nearby). More specifically, the stranding-prone regions of the world such as southern Australia cannot be used to support the noise-pollution hypothesis because military and other sources of sonar noise pollution are relatively uncommon there.

The recent discoveries that stranded-whale remains from some deep-diving species show signs of osteonecrosis (Moore & Early 2004) and perhaps gas-bubble lesions (Jepson et al. 2003; Piantadosi & Thalmann 2003), pathologies that may be associated with decompression sickness, are interesting because they suggest that cetaceans may not be completely immune to the rigors of a marine existence. However, the suggestion that these symptoms result from an escape response to military sonar is unsupported. If deep-diving cetacean species are prone to bone trauma under "normal" conditions (indeed, bone trauma was described in sperm whales as early as 1868), how is it possible to distinguish normal attrition and damage resulting from flight responses to anthropogenic noise? Perhaps if researchers could measure aspects of the diving behavior of a number of different species (such as diving ascent rates and periods of subsurface activity) and relate these to incidences of osteonecrosis, they might be able to make some inferences, but the difficulty of experimentation linking diving behavior to tissue pathology in individuals currently precludes this approach.

However, the technological means to undertake classic impact studies involving detailed and replicated approaches in which individuals are monitored prior to and following a particular disturbance (Underwood 1994) during times when climatological models forecast higher stranding frequencies are available. For example, researchers could track enough individuals known to migrate through a particularly susceptible area and then initiate a series of high-intensity noise disturbances (with the appropriate spatial and temporal controls). Changes in post-disturbance behavior, such as variation in ascent and descent rates, body articulations, and sounds produced by the animal, could then be recorded (e.g., Miller et al. 2004) and the biological significance of such behavioral responses assessed. In light of the substantial investment in marine mammal research, perhaps a coordinated effort to achieve such an experiment is possible. However, the strong ethical restrictions imposed on manipulative experiments that involve charismatic taxa such as cetaceans are likely to prevent proposals for such an impact study to be taken seriously.

Even after so long contemplating why cetaceans strand themselves at all, is the issue closer to being resolved? Researchers are beginning to piece together a probabilistic framework for the spatial and temporal variation in the propensity to strand, but little insight exists into the real mechanisms driving the behavior at the time immediately before stranding. However, given that cetacean strandings have been recorded for as long as humans have kept records, these animals are probably as prone to stranding as certain other species are to hazards they must face in their particular environments, such as falling from cliffs (Andersen & Linnell 1998) or drowning due to flooding (Webb et al. 1983). By virtue of their generally large size (sperm whales can weigh >25 tons), the observation that many species demonstrate high group cohesion (Connor 2002) and that, like any other species, cetacean behavior will be dictated to a large degree by the search for food, mass strandings should not come as a great surprise. Climatic and other predictive models can provide broad-scale mechanisms for stranding propensity, although the specific, proximate mechanisms for individual stranding events are likely to vary widely. As scientists, however, let us stand up to unsupported conjecture with well-planned and well-analyzed approaches to understanding, predicting, and possibly even reducing the number of cetacean strandings.

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