Marine Mammal Health Map: Goals and implementation through a pilot study using data from California stranding responders

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ABSTRACT

Marine mammal health can serve as an indicator for the health of the marine ecosystem and effects of climate change. However, there are no readily accessible consistent long-term data to track spatial and temporal changes in marine mammal health, or their associations with environmental factors. The Marine Mammal Health Map will be a unified reporting system for tracking heath data obtained from marine mammal strandings, Unusual Mortality Events, and health assessments during live capture-and-release programs and harvests. A pilot study using data from stranding responders from a variety of institutions (federal, academic, NGO) in California was created to categorize causes of death for animals from 2005-2010 and identify hurdles and issues in developing a web-based mapping tool. These data were integrated into a regional Integrated Ocean Observing System (IOOS) data portal. Investment in data management, data sharing and communication will enhance understanding of marine mammal health and the role of marine mammals as sentinels of ecosystem changes that impact health (harmful algal blooms, contaminants, pathogen spread, water temperature changes). The ultimate goal of the Marine Mammal Health Map is to share marine mammal health and disease information on a national and international scale and link this to ecosystem changes.

INTRODUCTION

An increase in the reporting of diseases in marine organisms has raised concerns among scientists, politicians, managers, and the public that ocean health is deteriorating (Harvell *et al.* 2004, Gulland and Hall 2007) Diseases, especially those that cause die-offs on a large scale, can alter marine mammal population distribution and abundance, which may precipitate species' extinctions, and can cause major regime changes within marine communities (Kim *et al.* 2005). However, whether the increase in reports represents a real and widespread degeneration in marine mammal health remains unclear (Lafferty *et al.* 2004). This uncertainty is due to a lack of information on the true incidence of marine mammal diseases and few long-term datasets, as well as a lack of data integration (Kim *et al.* 2005). Although marine mammals can function as ecosystem indicators, there are few readily accessible data on marine mammal health, and currently no readily accessible national or international dataset for tracking marine mammal disease trends (Gulland *et al.* 2012)

Most infectious diseases of humans are highly contingent on ecological processes that affect one or more elements of their host-vector relationship. One survey reports that 60% of marine animal emerging diseases are zoonotic, with 72% originating in wildlife (Burek *et al*. 2008). Despite this knowledge, there has been limited integration of marine mammal health and environmental data that would help elucidate host-vector relationships and better inform public health risks. In addition to infectious disease, non-infectious diseases such as toxicoses associated with exposure to harmful algal blooms or pollutants can affect both marine mammal and human health. Detection and identification of changes in marine mammal health can thus contribute to reducing public health risks and monitoring the efficacy of sustained use of ocean and coastal resources and coastal ecosystem restoration. The concept of “One Health”, that human and animal health are intimately associated and affected by environmental changes, is becoming widely accepted and needs to be extended from the terrestrial realm to the marine environment (Patz *et al.* 2011).

A number of marine mammals have been described as sentinels of marine ecosystems (Bossart 2011). Southern sea otter (*Enhydra lutris nereis*) health reflects pathogen pollution; bottlenose dolphin (*Tursiops truncatus*) tissues reflect contaminant distribution, and gray whale (*Eschrichtius robustus*) body condition and mortality may reflect habitat alterations associated with climate change (Wells 2004, Moore and Huntingdon 2008, Jessup and Miller 2012). Significant marine mammal mortality events have drawn attention to environmental changes. High pinniped mortality due to prey shifts have been recognized as early indicators of El Niño Southern Oscillation (ENSO) events along the west coasts of South and North America (Trillmich and Ono 1991). Sea lion mortality in California has focused attention on harmful algal blooms that produce domoic acid, allowing better understanding of both the acute and long term chronic effects of domoic acid exposure on marine mammals (Scholin *et al.* 2000). Because many marine mammal species are long-lived, can be long-term coastal residents, feed at a high trophic level, have fat stores that may accumulate anthropogenic toxins, and are often highly visible, marine mammals can be used to reflect the health of an ecosystem.

A review of the status of marine mammal research in 2003 concluded that a more coherent and comprehensive infrastructure was needed to investigate marine mammal health in a systematic and holistic manner (Reeves and Ragen 2004). Despite the lack of long-term, nationally collected health data, there is considerable interest in marine mammal health, and there are long-term existing regional sampling and response programs. Marine mammal mortality events attract high levels of attention and concern from the public. Climate change will likely have both direct and indirect effects on marine mammal diseases and coastal health by changing pathogen survival and transmission rates, host and pathogen distributions, and host susceptibility. Detection of these changes will require baseline data and a coordinated health tracking program (Burek *et al*. 2008). It is crucial to re-evaluate how data on marine mammal health are collected and integrated, so a true understanding of health changes can be developed, and these changes used to detect ecosystem changes, and minimize risks to public health and food safety.

Thus, the goal of the Marine Mammal Health Map project is to develop a web-based marine mammal health and disease mapping system that will allow managers, scientists, policy makers and the public to track spatiotemporal trends in marine mammal health. This platform also will provide a centralized location for stranding network participants to disseminate their collective data. The maps can be used to determine marine mammal health status relative to other components of the ocean ecosystem, and guide future health studies.

METHODS/RESULTS

The Marine Mammal Health Map is a collaboration among many groups, including the National Marine Fisheries Service (NMFS) Marine Mammal Health and Stranding Response Program (MMHSRP) and National Marine Mammal Stranding Network (NMMSN), the Marine Mammal Commission, the Integrated Ocean Observing System (IOOS), the National Wildlife Health Center, NGOs, academics, and State agencies. The first objective of the Health Map was to conduct a small-scale pilot study using stranding data from California NMMSN responders collected from January 2005 to December 2010. Contributors reported at least two years of data within the timeframe. Deceased animals were assigned to at least one health category based on the reported cause of death. Assignment of multiple categories was acceptable, but only if the cause was significant enough to contribute directly to stranding or death. Categories included: infectious disease – known pathogen; infectious disease – non-specific; biotoxin; trauma – other; trauma – human interaction; neoplasia; malnutrition; other; and unknown. When available, more specific information about disease processes also was reported. Additional data about each animal included genus and species, date of stranding location of stranding (county and coordinates), and confidence in health category assignment (diagnosed or suspected). Data were integrated onto the Central and Northern California Ocean Observing System (CeNCOOS) data portal. Figure 1 depicts causes of death for stranded marine mammals included in this pilot project, broken down by county along the California coast. The size of the symbol corresponds to the number of animals per county. For example, the smallest symbol in Sacramento County is indicative of only 1 stranding in that county. Monterey County, in contrast, has the largest symbol size with 636 total cases during the study period.

Figure 1. Causes of death for stranded marine mammals along the California coast between 2005-2010, grouped by county.

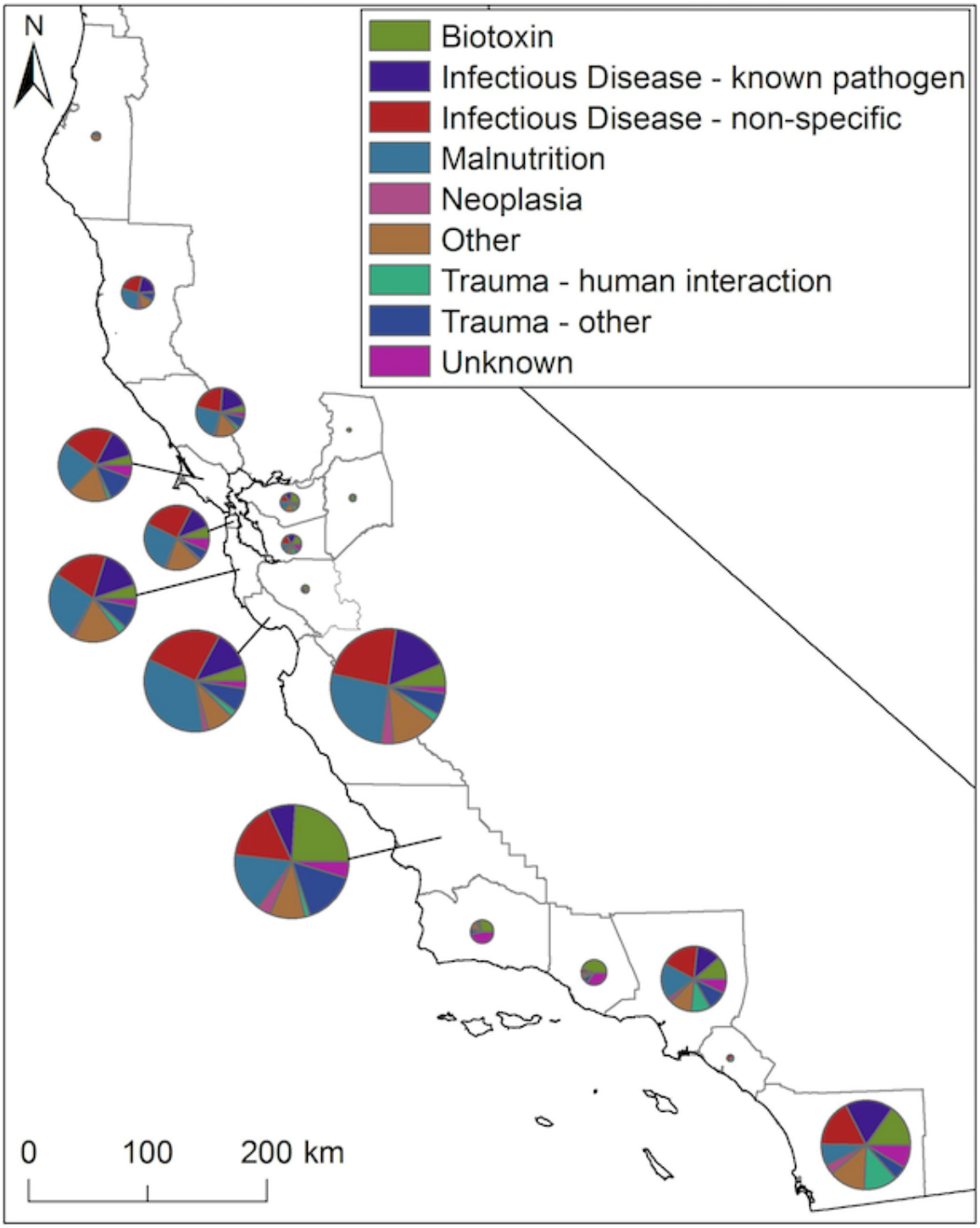
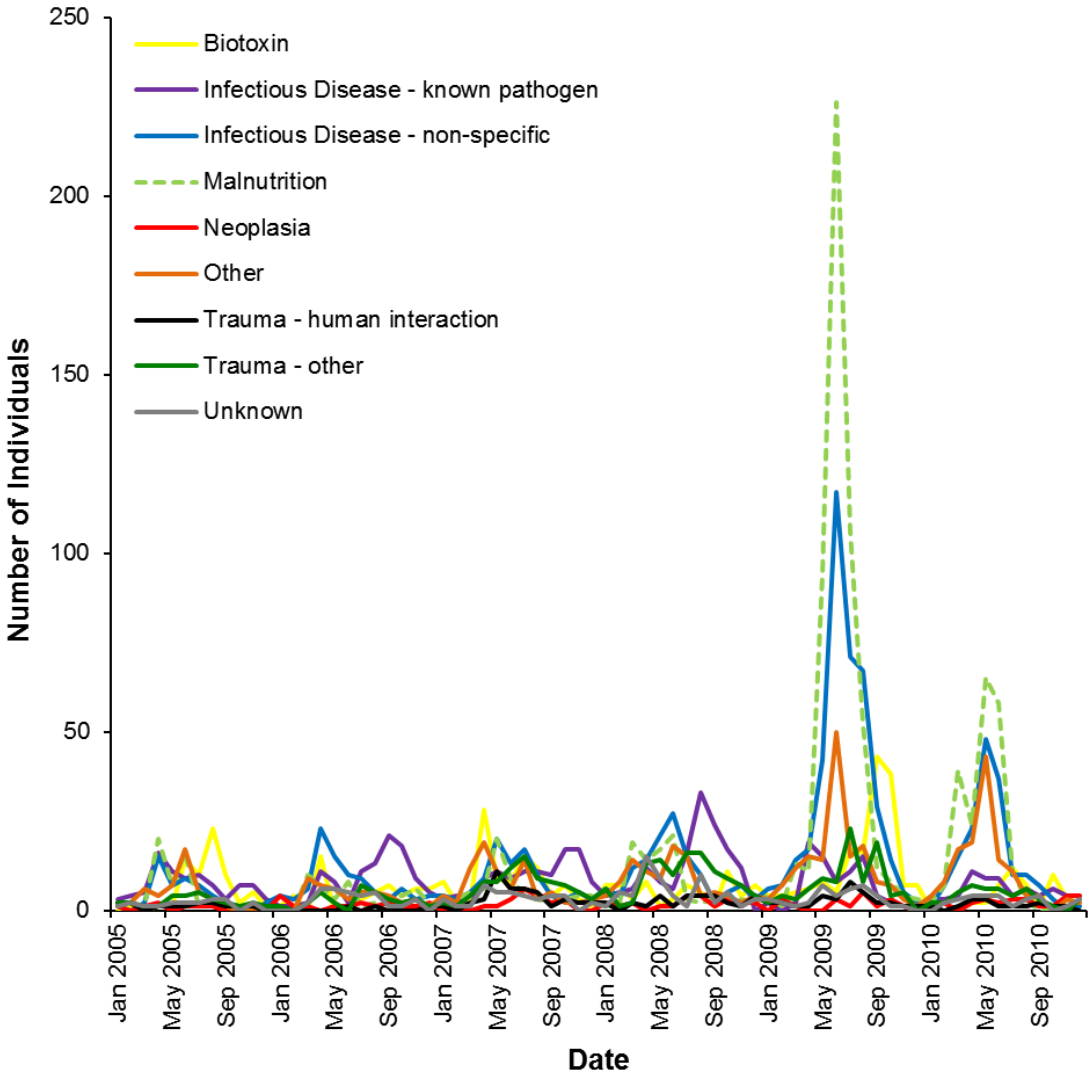


Figure 2 depicts the same data on a temporal scale. Causes of death for stranded animals are reported monthly, with a notable increase in malnutrition cases in May 2009, which corresponds to a large number of emaciated young California sea lions that stranded during a moderate El Niño event. These static maps

and figures highlight overall marine mammal health trends and patterns. These data, however, are better visualized though the interactive, web-based CeNCOOS data portal, which will house the data in the future.

Figure 2. Causes of death for stranded marine mammals along the California coast, from 2005-2010, depicted by month.



CONCLUSIONS

The results of the pilot study highlighted several areas of interest for future development of the project. First, mapping health data captures trends both temporally and spatially, allowing easy identification for "hot spots" of certain health changes. If overlaid with environmental data, associations amongst strandings from specific disease categories and the factors that may be affecting health can be investigated.

Second, strict standardization of input parameters is necessary to ensure that the resulting data are meaningful. Largely due to time constraints, contributing members submitted data on differing temporal scales. Most datasets encompassed the entire five-year period, while one only reported a portion of the time period. In addition, data formatting and quality assurance were different among contributors and require

standardization. There also were some notable differences in categorization of similar disease findings. The authors are currently developing case definitions for common marine mammal diseases, to standardize categorization in the future. Moving forward on a national and even international scale, agreement on disease definitions and reporting must be standardized to ensure that results can be useful across regions.

Third, the pilot study showed that dedicated personnel to input data and maintain databases and data portal are necessary to continue this health reporting on a larger scale. Stranding members are often severely resource-limited, and reporting is unlikely to become routine unless supported with both additional funding and personnel.

Marine mammals are long-lived, apex predators that bio-accumulate toxins, attract high levels of public attention, and function as sentinel species of ecosystem health with wide-ranging and localized home ranges. There are numerous regional marine mammal health sampling programs; however, these efforts are not unified on a national, or often even an ecosystem-wide, scale. Thus, development of a national and eventually global marine mammal health surveillance program, through improved coordination of existing efforts and further integration with other ocean observing systems, is essential to understanding the multiple factors that impact marine mammal and ocean health.

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