Review of the Marine Mammal Unusual Mortality Event Response Program of the National Marine Fisheries Service

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EXECUTIVE SUMMARY

Rising numbers of reports of diseases in marine organisms have raised concerns over deteriorating ocean health amongst scientists, politicians, managers and the public. These marine diseases and die-offs can alter marine populations and cause major changes in marine communities, and may impact human health. Furthermore, these die-offs often command considerable public and media interest. Whether or not this increase in reports represents a true general deterioration in health of marine mammals is unclear, as investigations of marine mammal health remain very limited. To date, the National Marine Fisheries Service (NMFS) has implemented a variety of approaches to improve responses to marine mammal Unusual Mortality Events (UMEs). These have been achieved with a limited budget and few staff, and have relied upon in-kind work and funding from stranding network participants and collaborating researchers. This document reviews the NMFS program to respond to marine mammal mortality events, and identify strategies to improve responses so that health trends and causes of disease can be determined, and effective timely responses that meet animal welfare and public outreach needs are mounted.

Since 1978, 57 mortality events have been detected by the stranding network, of which 29 were declared UMEs. Despite significant efforts and financial resources directed at UME responses, the causes of many mortality events remain unknown, and the rate of diagnosis has not improved over the last 14 years since the UME program was established. Prior to establishing the UME response program in 1991, the etiologies of 10/11 (91 percent) mortality events were determined and reported. Since 1991, the etiologies of 26/46 (56 percent) mortality events and 14/29 (48 percent) of UMEs have been identified. Thus it appears that establishing the UME process has not enhanced the identification of causes of mortality events. However, mortality events with identified causes are more likely to be documented in the peer reviewed literature, and thus identified retrospectively, than events with no identified causes. Thus, there may have been a number of marine mammal mortality events of unknown etiology between 1978 and 1991 that are not recorded here. Determinations of causes of mortalities have also been influenced by the development of assays; some assays used today were not available 5-10 years ago.

Causes of mortality events have included biotoxins, viruses, bacteria, parasites, human interactions and oil spills, as well as changes in oceanographic conditions and detection rate of carcasses by humans. Prior to 1996, when a manatee UME was caused by brevetoxin, only 5 marine mammal mortality events of 24 reported (20 percent) were associated with exposure to biotoxins. Since then, 12/31 (39 percent) of mortality events have been associated with exposure to biotoxins, and events caused by domoic acid and brevetoxin appear to be increasing in frequency. Interestingly, influenza virus was the cause of two mortality events in 1979 and 1982, but in more recent years, morbillivirus epidemics have been the more common causes of virus-associated mortality events. Some mortality events, such as those along the California coast associated with El Niño and leptospirosis, occur at regular intervals, and the decision as to whether or not to classify these as UMEs has varied among years. The factors predisposing marine mammals to mortality events and the impacts of such events on host population dynamics are unclear.

To improve effective responses to marine mammal mortality events, the following actions are recommended:

1. Expand the National stranding database to: include data on causes of death and disease investigations; integrate single stranding, mass stranding and UME data into one real time searchable database with a method for rapid identification of these "group" events; and develop data sharing protocols to facilitate collaborations and extensions of analyses.

2. Improve the stranding network's surveillance capabilities by: dedicating funding sources (e.g. Prescott program) to stranding network members to ensure a consistent level of response; holding regular training workshops for Letter of Authorization Holders including necropsy techniques, sample collection, archiving and shipping, chain of custody and evidence handling procedures, and disposal techniques for hazardous materials and carcasses; directing training and funding to areas of the network with poor coverage of the coastline and detection rates; developing protocols for regional stranding coordinators on event notification; stocking each region with supplies for emergency sampling of marine mammals and identifying appropriate storage facilities in each response area; posting response, sampling and shipping protocols to a website for easy access; and identifying funds for carcass handling and disposal so that large whales can be towed ashore for examination then disposal.

3. Improve the administrative process involved in mounting mortality event investigations by maintaining a full time dedicated UME coordinator (Executive Secretary) to track the administrative process, develop effective intra-agency communication, facilitate communication between the Working Group and the field investigation team and act as an off-site coordinator.

4. Establish emergency response teams of trained personnel with allocated time to be employed during responses to UMEs. These would include an on site coordinator, a pathologist, a research assistant and a data manager, from which would be drawn appropriate response teams for specific events, based on the existing abilities and needs of the local stranding networks. Availability of team members would be accommodated with a retainer and NMFS would pay for all travel associated with the response.

5. Require timely submission of final reports and encourage peer reviewed publications on UME investigations by: requiring final reports to be submitted from UMEs as a condition of receiving funds; funding report writing by qualified personnel; fostering research collaborations through workshops and seminars

6. Develop a centralized national sample archiving system to include fluids and tissues from animals during UME events.

7. Improve the availability and quality of diagnostic tests performed on samples from marine mammals by: identifying and funding dedicated laboratories for pathology, infectious diseases, biotoxin and contaminant analyses; developing a quality assurance

program for laboratories analyzing marine mammal samples; and ensuring collection of suitable samples by establishing protocols for investigation of specific events that are known to occur, such as domoic acid toxicosis, brevetoxicosis, leptospirosis, beaked whale strandings, morbillivirus and influenza epidemics, and human interactions.

8. Integrate the Marine Mammal Health and Stranding Response Program with stock assessment and population monitoring programs of the NMFS, U.S. Fish and Wildlife Service, and U.S. Geological Survey, as well as with other federal programs addressing environmental and climate parameters impacting marine mammal health (e.g.: the Ecology and Oceanography of Harmful Algal Blooms), to determine the impact of disease and changes in health on host population dynamics.

9. Develop and fund a research plan addressing factors predisposing populations to mortality events.

INTRODUCTION

Why Investigate Marine Mammal Mortality

Rising numbers of reports of diseases in marine organisms have raised concerns over deteriorating ocean health amongst scientists, politicians, managers and the public (Epstein 1996, Harvell et al. 1999). These marine diseases and die-offs can alter populations and cause major changes in marine communities (Harvell et al. 2004, Kim et al. 2005). Furthermore, threats to ocean health can directly and indirectly impact human health (National Research Council 1999, Knap et al. 2002).Whether or not this increase in reports represents a true general degeneration in the health of marine life is unclear (Harvell et al. 1999, Lafferty et al. 2004, Ward and Lafferty 2004). Also unclear is the impact of human activities on health of marine life. Morbidity and mortality of marine mammals have resulted from pathogens originating on land spreading to the ocean, as well as from harmful algal blooms and epidemics of virulent viruses and bacteria (Geraci et al. 1999). The role of anthropogenic factors and climate change in these die-offs is unknown. This lack of information on the true incidence of disease in marine life and its underlying causes is due to the lack of long term data on health of marine organisms (Harvell et al. 2002, Kim et al. 2005). Amongst marine organisms, marine mammals are hard to study due to their pelagic life styles, long generation time and large size. However, when marine mammals wash ashore sick or dying, they command considerable attention and concern. There is thus an interest from the public, as well as from scientists and managers, to determine the state of marine mammal health, and identify the anthropogenic influences on the health of these animals.

The Marine Mammal Protection Act (MMPA), established in 1972, recognized the need for determining the cause of death or injury of marine mammals. The MMPA was amended in 1992 to specifically establish of a Marine Mammal Health and Stranding Response Program (MMHSRP), with three purposes:

1. Facilitate the collection and dissemination of reference data on the health of marine mammals and health trends of marine mammals in the wild;

2. Correlate the health of marine mammals and marine mammal populations, in the wild, with available data on physical, chemical, and biological environmental parameters; and

3. Coordinate effective responses to unusual mortality events by establishing a process in the Department of Commerce.

Within the Department of Commerce, the National Marine Fisheries Service (NMFS) has developed a program to investigate marine mammal health, so as to understand the causes of marine mammal morbidity and mortality and their impacts on populations, as well as to minimize deaths of marine mammals and provide care for marine mammals during unusual mortality events (UMEs). Data from this program can be used to develop a baseline on marine mammal health from which changes in ocean health might be inferred.

Marine Mammal Mortality

There are four sources of information that can be used to detect changes in the frequency of disease and die-offs of marine mammals: decreases in population estimates during regular population censuses, changes in the prevalence of disease and other health parameters detected during handling of animals, changes in individual records of stranded animals, and increases in UMEs. Regular population monitoring can reveal declines in abundance suggesting increases in mortality occurred, but often carcasses are not found. For example, aerial counts and skiff surveys revealed a 70 percent decline in sea otters (*Enhydra lutris*) around the Aleutian Islands from 1992 to 2000 (Doroff et al. 2003). Similarly, demographic data on the western population of Steller sea lions (*Eumatopias jubatus*) indicate a 70 percent decline from the late 1970s through the 1980s associated with juvenile mortality (York 1994), and a further 40 percent decrease through the 1990s associated with increased adult mortality (Holmes and York 2003). The lack of carcasses associated with these declines may be a result of their consumption by predators or scavengers, decomposition at sea, or be a result of the lack of detection due to inaccessible or sparsely populated coastlines. Furthermore, although surveys detect population changes such as declines caused by mortality, the degree of change must be considerable before such a decline can be detected, so that significant declines are often not detected for years after their initial occurrence (Gerodette 1987). Strandings may thus help identify issues affecting marine mammal populations before surveys detect declines. For example, an increase in gray whale strandings was observed along the west coast of the U.S. and Mexico in 1999, but a decline in the population was not detected by survey effort until 2001 (Gulland et al. 2005).

Directed health assessments of marine mammal populations can provide information on health parameters, incidence and prevalence of disease, and body condition, along with data on factors that may impact population health, such as environmental contaminants. For example, population health evaluation systems are being developed for bottlenose dolphins utilizing data and samples collected during capture, sample, mark, and release operations (Wells et al. 2004). These programs are allowing the evaluation of health and reproductive risks from environmental contaminants (Schwacke et al. 2002, Wells et al. 2005), and provide a mechanism for comparing risks across populations (Hansen et al. 2004). Population health assessments have the potential to identify health issues before they lead to increased morbidity and mortality, but logistics and expense often limit these kinds of efforts, and thus their coverage of the species' range.

An increase in numbers of strandings can indicate that an increase in marine mammal mortality is occurring, although stranding rates do not correlate directly with mortality rates due to a variety of factors influencing carcass deposition and detection on beaches (Eguchi 2002). A stranded animal is defined as "any dead marine mammal on a beach or floating near-shore; any live cetacean on a beach or in water so shallow that it is unable to free itself and resume normal activity; any live pinniped which is unable or unwilling to leave the shore because of injury or poor health" (Wilkinson 1991). Although some causes of strandings have been identified, the majority, especially those of cetaceans, remain enigmatic (Geraci 1978, Geraci et al. 1999). Documentation of stranding events has improved globally over the last 70 years, the earliest organized attempts originating in the United Kingdom. These records have allowed reviews of such occurrences (Fraser 1934, 1946, 1953, and 1956; Geraci 1978, Sergeant 1982, Dierauf and Gulland 2001).

Strandings have been defined as single, mass or part of unusual mortality events. A mass stranding of cetaceans is an event in which two or more individuals of the same species, excluding a single cow-calf pair, beach within a given spatial and temporal reference (Wilkinson 1991). Typically mass strandings involve a single species known to have strong social bonds although multi-species events also occur. A mass stranding event may span one or more days, and range over miles of shoreline bridging multiple counties, or sandbars and outlying islands. Despite the attention mass strandings receive from both the public and scientific community, they remain hard to manage as they are often logistically overwhelming, and the reasons for their occurrence remain hard to identify. UMEs are strandings of multiple animals under unusual circumstances, involving a significant die-off of marine mammals and demanding an immediate response.

Agency Process for Responding to Marine Mammal UMEs

In 1988, the dramatic phocine distemper epizootic that killed over 18,000 harbor seals (*Phoca vitulina*) in Europe raised awareness of the need for contingency plans to investigate marine mammal die-offs, and for long-term monitoring of strandings (Heide-Jorgensen et al. 1992, Thompson and Hall 1993). In 1989, the Department of the Environment in the United Kingdom established a national program to investigate marine mammal mortalities, and to coordinate responses. In the U.S., three specific events triggered the development of a legal framework that addressed marine mammal unusual mortality events. The first was a stranding of 14 humpback whales (*Megaptera novaeangliae*) off Cape Cod, Massachusetts in 1987 (Geraci et al. 1989). The second was a bottlenose dolphin (*Tursiops truncatus*) die-off along the Atlantic seaboard during 1987 and 1988 (Geraci, 1989), and the third was the Exxon Valdez oil spill in Prince William Sound, Alaska, in 1989 (Loughlin 1994). As a response to the increased concerns over these die-offs and potential for environmental degradation, the Marine Mammal Health and Stranding Response Act was established as Title IV of the MMPA.

To determine when an unusual mortality event is occurring, and then to direct responses to such an event, a body of scientific experts called the Working Group on Marine Mammal Unusual Mortality Events (the Working Group), was developed in 1991 as an advisory board to the Secretary of Commerce and Secretary of the Interior. In 1992, the legislation (Title IV Section 404) was codified to establish the group. The Working Group is now composed of 12 members from academia, conservation organizations, state and/or federal natural resource agencies who have expertise in marine mammal biology, toxicology, pathology, ecology and epidemiology, and marine conservation. Agencies represented at meetings of the Working Group include the NMFS, the U.S. Fish and Wildlife Service (USFWS), the Marine Mammal Commission, the U.S. Environmental Protection Agency, and the U.S. Department of Agriculture. Since 1999, in response to die-offs of species crossing the U.S. border (gray whales, harp seals and right whales) an international liason from Canada and another from Mexico have joined the WG. A staff person from NMFS serves as Executive Secretary of the Working Group, working for the Chair of the Working Group, the latter being elected by the Working Group members every two years from among its 12 members. Working Group member terms are three years, with no person being allowed to serve more than two consecutive terms. Every three years, a third of the Working Group members may rotate off, and new members are invited to join the Working Group. The charges of the Working Group, as mandated in Title IV, are to determine whether or not a UME is occurring, to determine, after a UME has begun, when response to that UME is no longer necessary, and to help develop a Contingency Plan for responding to and investigating marine mammal UMEs. The Working Group is not currently mandated to review reports on UMEs or to issue follow up advice, however NMFS has established that as policy for NMFS marine mammal species.

Despite the establishment of a protocol and Working Group to advise on UME responses and investigations, funding for such activities was minimal until 2000. An emergency fund for UMEs was authorized under Title IV in 1992, but funds were not appropriated until 2005. In 2000, a small amount of MMHSRP research funds were used establish a cooperative agreement with the National Fish and Wildlife Foundation to reimburse stranding network members. In 2005, specific appropriations language enabled establishment of the formal fund within the U.S. Department of Treasury into which private donations can be accepted.

There are four aims of a UME investigation: to minimize deaths, determine the cause of the event, determine the effect of the event on the population, and to identify the role of environmental parameters in the event. These investigations are logistically difficult, labor intensive and expensive. Preparation, training and detection of events have been difficult to maintain due to minimal funding. Efforts thus need to be focused to maximize the success of the program with the resources available. This report reviews the response of the MMHSRP to UMEs, and identifies areas for future investment to improve our understanding of marine mammal health and its impact on populations.

ANALYSIS OF 27 YEARS OF MARINE MAMMAL UNUSUAL MORTALITY EVENTS, 1978-2005

Marine Mammal UMEs are detected by the stranding network members through their regular stranding response. This response effort varies temporally and spatially around the coast of the U.S. depending upon the topography of and access to the coastline, the density of human population, the weather, and the level of expertise of the personnel involved. The stranding network personnel are authorized by either NMFS or the USFWS to collect stranded marine mammals through Letters of Agreement (LOA), or are local, state or federal government employees operating under Section 109h of the MMPA. The locations of LOA holders authorized to respond to stranded marine mammals are shown in Figure 1. The training and financial resources available to LOA holders varies enormously, from individuals with an interest in marine mammals, to organizations with all the resources of a veterinary school. Stranding data collected by these LOA holders are used to detect UMEs, and the stranding network members are the key responders to the UME. When an increase in strandings or an unusual type of stranding occurs, the LOA holders contact NMFS or USFWS who consult with the Working Group to determine whether or not a UME is occurring using seven criteria.

Although the criteria were established in 1991, the formal declaration of a mortality event as a UME by the NMFS was not routine until 1994. From 1991 to 2003, the criteria were:

1. A marked increase in the magnitude of strandings when compared with prior records.
2. Animals are stranding at a time of the year when strandings are unusual.
3. An increase in strandings is occurring in a very localized area.
4. The species, age, or sex composition of the affected animals is different than that of animals that normally strand in the area at that time of the year.
5. Stranded animals exhibit similar and/or unusual pathologic findings, or the general physical condition of stranded animals is different from what is normally seen.
6. Mortality is accompanied by behavior patterns observed among living individuals in the wild that are unusual, such occurrence in habitats normally avoided or abnormal patterns of swimming and diving.
7. Critically endangered species are stranding.

In 2004, these were modified by the Working Group to the following, but have not been formally adopted:

1. A marked increase in the magnitude or a marked change in the nature of morbidity, mortality or strandings when compared with prior records.
2. A temporal change in morbidity, mortality or strandings is occurring.
3. A spatial change in morbidity, mortality or strandings is occurring.
4. The species, age, or sex composition of the affected animals is different than that of animals that are normally affected.
5. Affected animals exhibit similar or unusual pathologic findings, behavior patterns, clinical signs, or general physical condition (e.g. blubber thickness).
6. Potentially significant morbidity, mortality or stranding is observed in species, stocks or populations that are particularly vulnerable (e.g. listed as depleted, threatened or endangered or declining). For example, stranding of three or four right whales may be cause for great concern whereas stranding of a similar number of fin whales may not.
7. Morbidity is observed concurrent with or as part of an unexplained continual decline of a marine mammal population, stock, or species.

If a mortality event is officially declared a UME, then the Contingency Fund can be used to finance response to the event. This response consists of care of live animals, response to dead animals, determining the cause of the event, its impact on the population, and the role of environmental variables in triggering the event.

Temporal and Spatial Trends in Mortality Events

From 1978 to the establishment of the Working Group in 1991, 11 die-offs were reported in U.S. waters. Since 1991, there have been 46 die-offs, of which 29 were formally declared UMEs (Table 1). These occurred in all regions of the stranding network (Figure 1), although most events and declared UMEs occurred in California and Florida. These are also areas with more LOA holders in the stranding network per state than other areas (Figure 1). California and Florida are also states with very accessible coastline and high human population density to detect strandings. There were one to six mortality events a year, with no significant trend in the number of UMEs or mortality events per year (Figure 1). Bottlenose dolphins were the species most commonly impacted by UMEs, followed by California sea lions and Florida manatees (Figure 2), this species distribution corresponding to the spatial distribution of mortality events (Figure 1). Despite significant efforts and financial resources directed at UME responses, the causes of many mortality events remain unknown, and the rate of diagnosis has not improved over the last 14 years. Prior to 1992, the etiologies of 10/11 (91 percent) mortality events were determined and reported in peer reviewed literature. Since 1992, the etiologies of 26/46 (56 percent) mortality events and 14/29 (48 percent) of UMEs have been identified (Table 1, Figures 3, 4, and 5). It therefore appears that establishing the UME process has not enhanced the identification of causes of mortality events. However, mortality events with identified causes are more likely to be documented in the peer reviewed literature, and thus identified retrospectively than events with no identified causes. Thus there may have been a number of marine mammal mortality events of unknown etiology between 1978 and 1992 that are not recorded here.

Causes of mortality events have included biotoxins, viruses, bacteria, parasites, human interactions and oil spills, and changes in oceanographic conditions and detection rate of carcasses by humans (Figure 3 and 5). Prior to 1996, when a manatee UME was caused by brevetoxin, only five mortality events (20 percent) were associated with exposure to biotoxins. Since then, 12/31 (39 percent) of mortality events have been associated with exposure to biotoxins. Events caused by domoic acid on the west coast of the U.S. and brevetoxin on the east coast appear to be increasing in frequency. Comparing the etiologies of mortality events before the UME process was established in 1992 to afterwards (Figure 5) the percentage of mortality events due to harmful algal blooms (HABs) has increased, although the determination of etiology of die-offs has not changed significantly. This may reflect an increase in the frequency of HABs around the U.S., although some of the diagnostic tests for detecting biotoxins have only recently become available. Interestingly, influenza virus was the cause of two mortality events in 1979 and 1982, but in more recent years, morbillivirus epidemics have been the more common causes of virus-associated mortality events. Some mortality events, such as those along the California coast associated with El Niño and leptospirosis, occur at regular intervals, and the decision as to whether or not to for classify these as UMEs has varied among years. The factors predisposing marine mammals to mortality events and the impacts of such events on host population dynamics are unclear.

Table 1. Summary of Mortality Events in the United States Reported by the Stranding Network between 1978 and 2005.

Year	Species and number affected	Location	Working Group consulted, Declared a UME, Onsite coordinator appointed	Cause and comments	References
1978	Hawaiian monk seal *Monachus schauinslandi* (50)	North West Hawaiian Islands	Not applicable	Ciguatoxin and maitotoxin suspected	Gilmartin et al. 1980
1979-1980	Harbor seals *Phoca vitulina* (400)	Cape Cod, Massachusetts	Not applicable	Influenza A A mycoplasma was concurrently isolated from these seals	Geraci et al. 1982
1982	Harbor seals *Phoca vitulina*	Cape Cod, Massachusetts	Not applicable	Influenza A	Hinshaw et al. 1984
1982	Florida manatees *Trichechus manatus latirostris* (39)	Southwest Florida	Not applicable	Brevetoxin	O'Shea et al. 1991
1983	Several pinniped species (Hundreds)	West coast of U.S.	Not applicable	El Nino	Trillmich and Ono 1991
1984	California sea lions *Zalophus californianus* (226)	California	Not applicable	Leptospirosis	Dierauf et al. 1985
1987	Sea otters *Enhydra lutris* (34)	Kodiak Island, Alaska	Not applicable	Saxitoxin	DeGange and Vacca 1989
1987	Humpback whales *Megaptera novaeangliae* (14)	Massachusetts	Not applicable	Saxitoxin	Geraci et al. 1989
1987-1988	Bottlenose dolphins *Tursiops truncatus* (645)	New Jersey Delaware Virginia North Carolina South Carolina Georgia Florida	Not applicable	Morbillivirus. Brevetoxin was detected in dolphins, its role in the event is unclear.	Scott et al. 1988 Geraci et al. 1989 Lipscomb et al. 1994 Duignan et al. 1996 Schulman et al. 1997 Friedlaender 2000 McLellan et al. 2002
1989	Sea otters *Enhydra lutris* (3,500-5,000)	Alaska	Not applicable	*Exon Valdez* oil spill	Loughlin 1994
1990	Bottlenose dolphins *Tursiops truncatus* (146)	Texas Louisiana Mississippi Alabama	Not applicable	Unknown. Unusual skin lesions observed	Memo B. Brown to N. Foster March 2 1990 Kuehl and Haebler 1995 Hansen 1992 Medway report to Fox June 29 1990

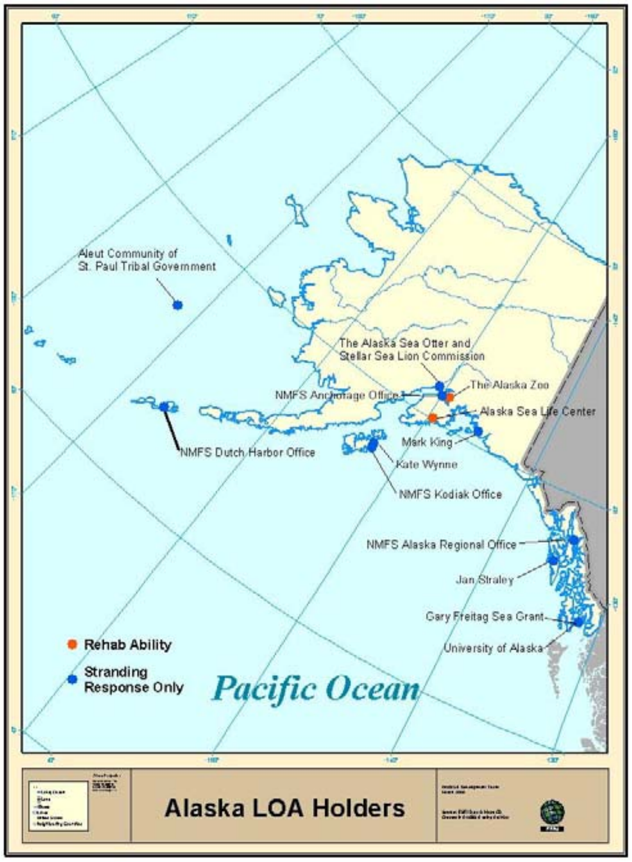
Year	Species and number affected	Location	Working Group consulted, Declared a UME, Onsite coordinator appointed	Cause and comments	References
Formation of the Working Group on Marine Mammal Unusual Mortality Events					
1991	Harbor seals *Phoca vitulina* (34)	New Jersey	Yes, no, no (WG consulted. Formal criteria not in place).	Unknown. *Erysipelothrix rhusiopathiae* cultured from 4 seals, poxvirus present in one, saxitoxin negative	Informational Memo J.A. Knauss May 10 1991
1991	California sea lions *Zalophus californianus* (160)	California	Yes, no, no	Leptospirosis	Gulland et al. 1996
1991	Bottlenose dolphins *Tursiops truncatus* (30)	(Sarasota) Florida	Yes, yes, medical director requested	Unknown	
1992	Harbor seal *Phoca vitulina* (29) Harbor porpoise *Phocoena phocoena* (5) Rough toothed dolphin *Steno bredanensis* (1)	Oregon Washington	Yes, yes, no.	Unknown	H. Braham. Memo to W. Aron Oct 9 1992, Oct 16 1992 and December 1992
1992	Phocids (24)	Maine Massachusetts Connecticut	Yes, yes, yes	Unknown. Morbillivirus and/or influenza suspected	Geraci et al. 1993. Callan et al1995. Early 1992.
1992	Bottlenose dolphins *Tursiops truncatus* (220)	Calhoun and Aransas counties, Texas	Yes, yes, no	Carbamates suspected	Colbert et al. 1999 Duignan et al. 1996 Sweeney 1992
1992-1993	California sea lions *Zalophus californianus* (Approximately 1000)	California	Yes, no, no	El Nino, 50 gunshot	Greig et al. 2005
1993	Harbor porpoises *Phocoena phocoena* (64)	Maine Massachusetts Connecticut New Jersey Delaware Virginia North Carolina	No, no, no	Fisheries interaction	Haley and Read 1993 Read and Murray 2000.
1993	Pinnipeds (53) 9 Steller, 15 California sea lions, 28 harbor seals, 1 unknown species sea lion	Washington	Yes, no, no. Considered unusual by the Region due to strategic stock (Steller sea lions) involved.	Gun shot. Bullets found on gross necropsy and X-ray.	Norberg, pers. comm..

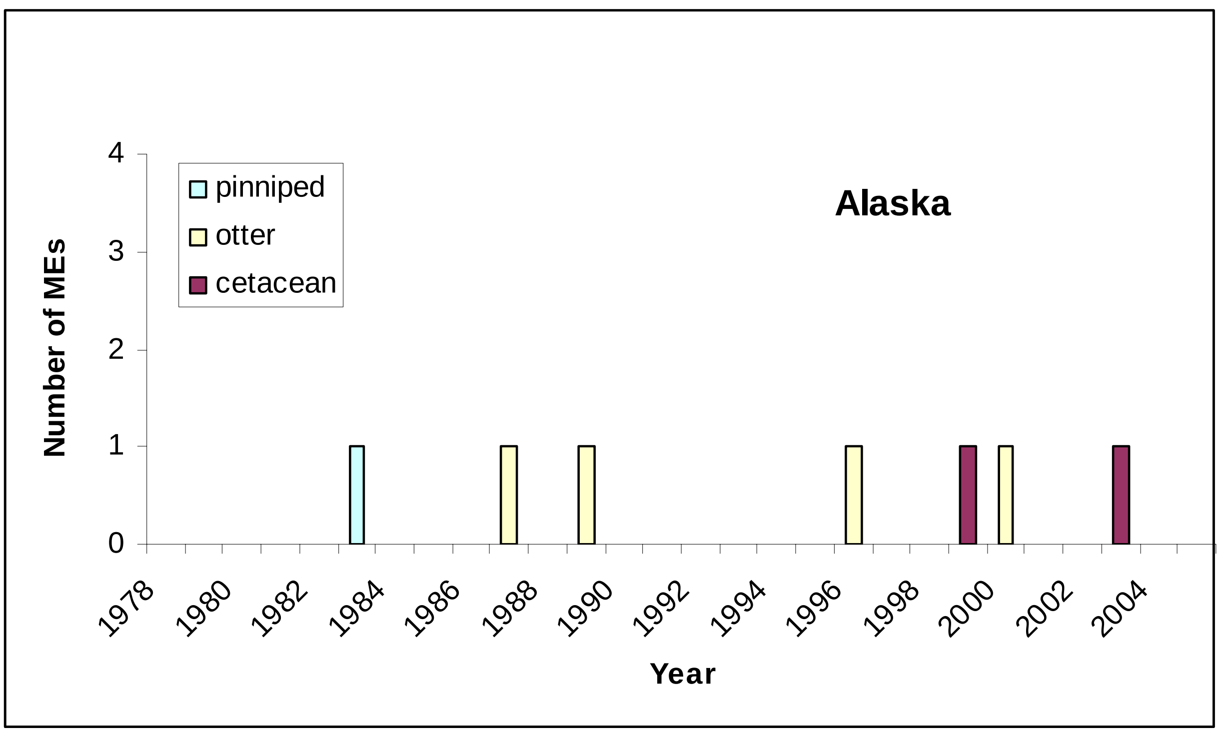
Year	Species and number affected	Location	Working Group consulted, Declared a UME, Onsite coordinator appointed	Cause and comments	References
1994	Common dolphins *Delphinus delphis* (53)	California	Yes, no, no	Listed in Wilkinson 1996 as a mortality event but not formally voted a UME by the Working Group. Etiology unknown	Reidarson et al. 1998
1994	Bottlenose dolphins *Tursiops truncatus* (72)	Texas	Yes, yes, yes	Morbillivirus	Lipscomb et al. 1996
1995	California sea lions *Zalophus californianus* (222)	California	No, no, no	Leptospirosis	Greig et al. 2005
1996	Sea otters *Enhydra lutris* (68)	(Cordova), Alaska	No, no, no	Malnutrition, parasites, cold	Ballachey et al. 2002
1996	Right whales *Eubalaena glacialis* (6)	Florida, Georgia	Yes, yes, no	Blast injury suspected	Ridgway 1996
1996	Florida manatees *Trichechus manatus latirostris* (149)	Florida (west coast)	Yes, yes, yes	Brevetoxin	Bossart et al. 1998 Landsberg and Steidinger 1998
1996	Bottlenose dolphins *Tursiops truncatus* (30)	Mississippi	Yes, yes, no, response by NMFS lab	Unknown. Coincident with algal bloom.	WG annual meeting report 1997 notes
1997	Harbor seals *Phoca vitulina* (90)	California	Yes, yes, yes	*Pseudomonas aeruginosa* associated with pneumonia. Virus suspected.	None
1998	California sea lions *Zalophus californianus* (70)	California	Yes, yes , yes	Domoic acid	Scholin et al. 2000 Gulland 2000, Silvagni et al. 2005
1997-1998	California sea lions *Zalophus californianus* (hundreds)	California	No, no, no	El Nino	Greig et al 2005
1999	Harbor porpoises *Phocoena phocoena* (216)	Maine, Massachusetts, Maryland, Virginia, North Carolina	Yes, no, no	Oceanographic factors suggested (Hohn pers. comm..)	Marine Mammal Commission, Annual report to Congress
2000	Sea otters *Enhydra lutris* (100)	Cordova, Alaska	No, no, no	Parasites ingested at a fish processing plant with discarded waste	Minutes of Working Group meeting 2001

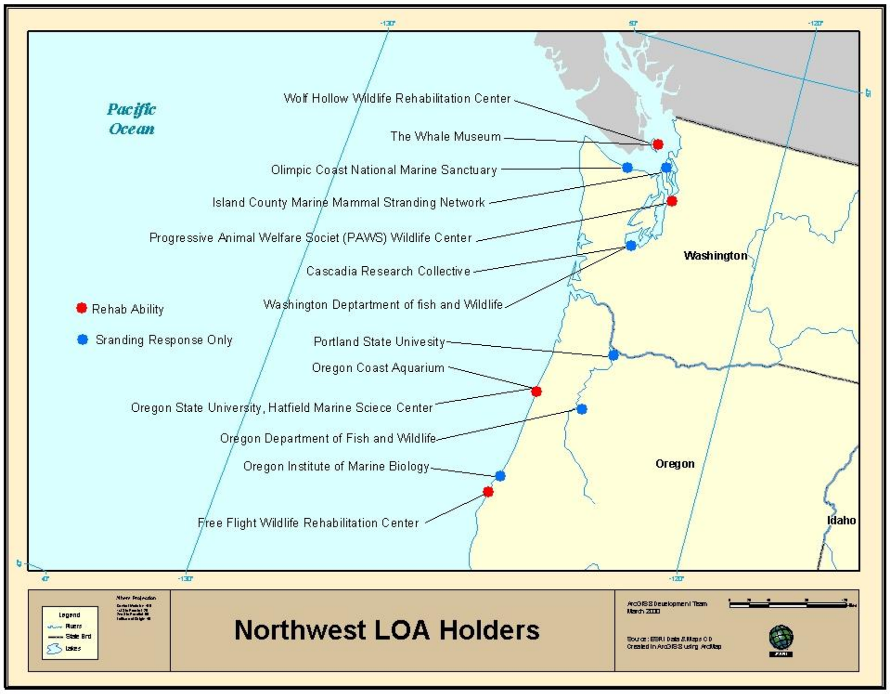
Year	Species and number affected	Location	Working Group consulted, Declared a UME, Onsite coordinator appointed	Cause and comments	References
1999-2000	Bottlenose dolphins *Tursiops truncatus* (115)	Florida (Panhandle)	Yes, yes, yes	Brevetoxin	Mase et al. 2000
1999-2001	Gray whales *Eschrichtius robustus* (651)	California, Oregon, Washington, Alaska (Canada, Mexico)	Yes, yes, multiple OSC one for each region,	Unknown	Gulland et al. 2005 Moore et al. 2001
2000	California sea lions *Zalophus californianus* (178)	California	No, no, no	Leptospirosis	Greig et al. 2005
2000	California sea lions *Zalophus californianus* (184)	California	Yes, yes, yes	Domoic acid	Gulland et al., 2002
2000	Harbor seals *Phoca vitulina* (26)	California	Yes, yes, no	Unknown. Viral pneumonia suspected.	
2001	Bottlenose dolphins *Tursiops truncatus* (35)	Florida (Indian River Lagoon)	Yes, yes, yes	Unknown. Saxitoxin present in puffer fish.	Barros 2001 unpublished Leighfield 2002 unpublished
2001	Harp seals *Phoca groenlandica* (453)	Maine Massachusetts	No, no, no	Unknown	Harris et al. 2002
2001	Hawaiian monk seals *Monachus schauinslandi* (11)	Hawaii (Northwest Hawaiian Islands)	Yes, yes, yes	Malnutrition	Antonelis et al. 2001
2002	Multispecies (Common dolphin, California sea lion, sea otter) approx. 500	California	Yes, yes, yes	Domoic acid	Mazet et al. 2005
2002	Florida manatees *Trichechus manatus latirostris* (34)	Florida (west coast)	Yes, yes, yes	Brevetoxin	Flewelling et al. 2005
2003	Multispecies (Common dolphin, California sea lion, sea otter) approx. 500	California	No, no, no	Domoic acid	
2003	Sea otters *Enhydra lutris* (69)	California	Yes, yes, yes	Ecological factors	Draft report to WG
2003	Beluga whales *Delphinapteus leucas* (20)	Cook Inlet, Alaska	No, no, no	Increased detection, ecological factors	Vos and Shelden 2005

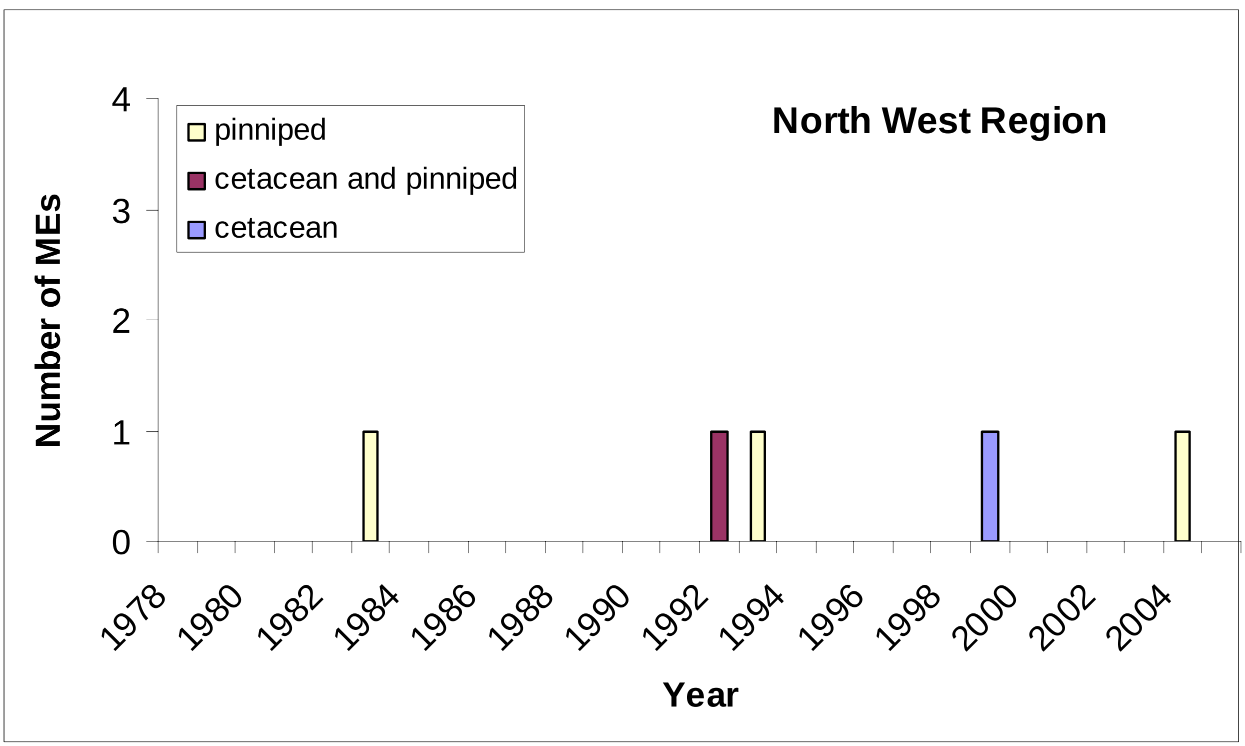
Year	Species and number affected	Location	Working Group consulted, Declared a UME, Onsite coordinator appointed	Cause and comments	References
2003	Large whales (16 humpback, 1 fin, 1 minke, 1 pilot, 2 unknown)	Maine	Yes, yes, yes	Unknown. Saxitoxin and domoic acid detected in 2 and 3 humpbacks respectively.	
2003-2004	Harbor seals *Phoca vitulina* Minke whales *Balaenoptera acutorostrata*	Gulf of Maine-EEZ	Yes, yes, yes	Unknown	Touhey, pers. comm.
2003	Florida manatees *Trichechus manatus latirostris* (96)	Florida (west coast)	Yes, yes, yes	Brevetoxin	
2004	Bottlenose dolphins *Tursiops truncatus* (107)	Florida (Panhandle)	Yes, yes, yes	Brevetoxin	Draft report to WG, Gaydos, in prep. Flewelling et al. 2005
2004	Small cetaceans (67)	Virginia	Yes, yes, yes	Unknown	Barco, report to WG
2004	Small cetaceans	North Carolina	Yes, yes, yes	Unknown	Hohn, pers. comm..
2004	California sea lions (405)	California. Oregon, Washington, Canada	Yes, no, no	Leptospirosis	Raverty et al. 2005
2005	Manatees *Trichechus manatus* Bottlenose dolphins *Tursiops truncatus (ongoing Dec 2005)*	Florida (west coast)	Yes, yes, yes	Brevetoxin. Bird, turtle and fish kills associated with the event	
2005	Harbor porpoises *Phocoena phocoena (ongoing at Dec 2005)*	North Carolina	Yes, yes, yes	Unknown	Hohn, pers. comm..
2005	California sea lions *Zalophus californianus* Northern fur seals *Callorhinus ursinus (several hundred)*	California	Yes, no, no	Domoic acid	Goldstein et al. 2005
2005	Large whales	North Atlantic	Yes, yes, yes	Domoic acid suspected	Touhey pers. comm..
2005-2006	Bottlenose dolphins *Tursiops truncatus (ongoing at Dec 2005)*	Florida	Yes, yes, yes	Brevetoxin suspected	

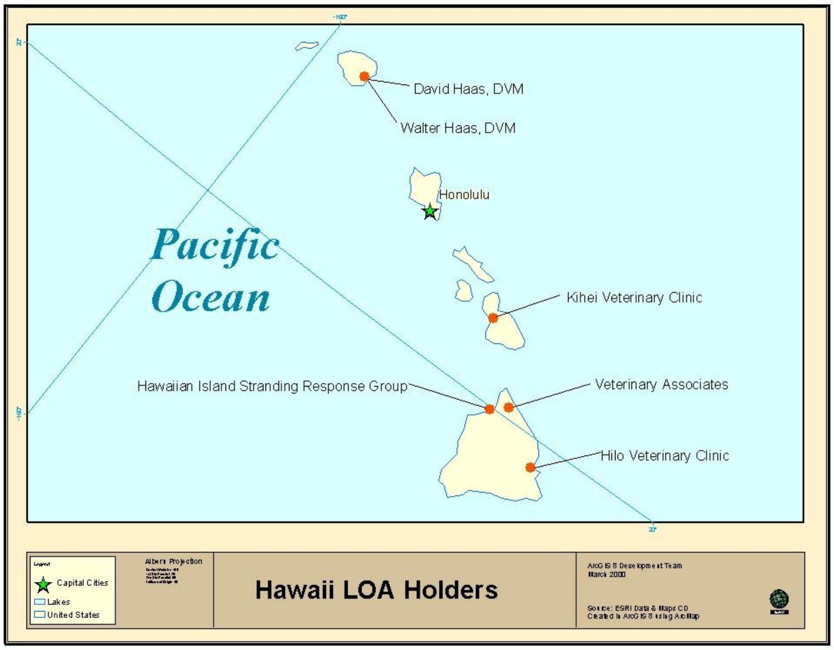
Figure 1. Stranding Network LOA Holders and Number of Mortality Events in Each Region.

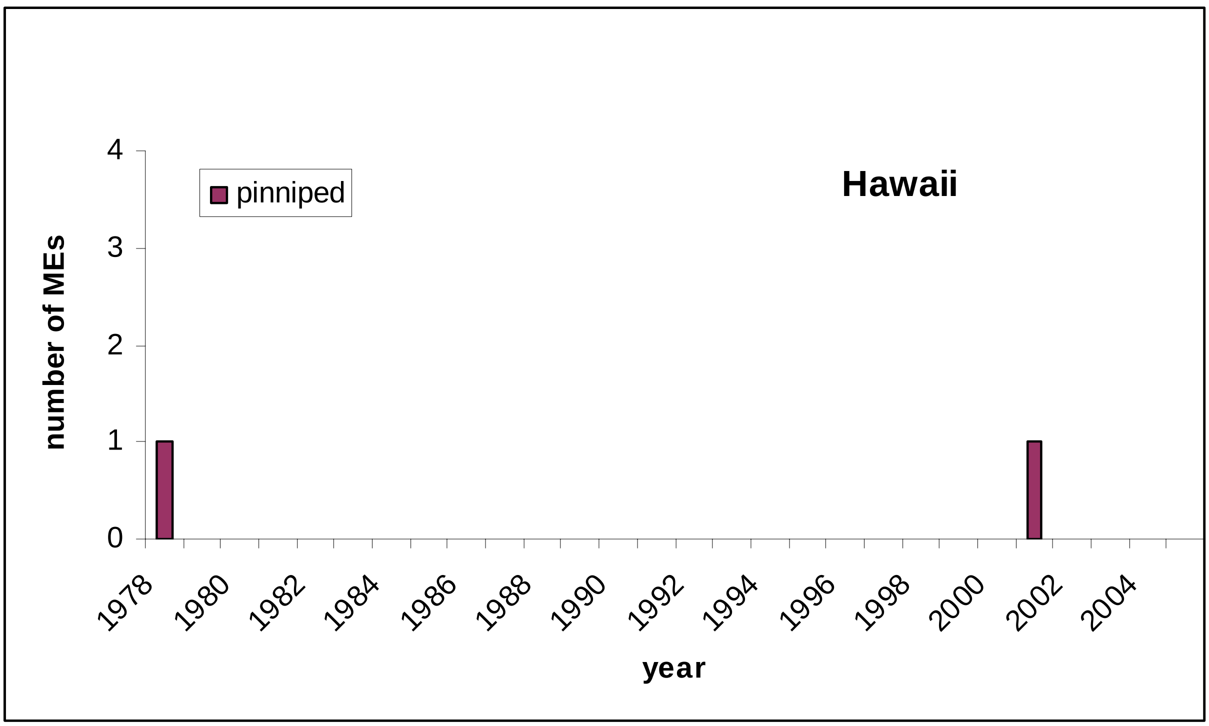


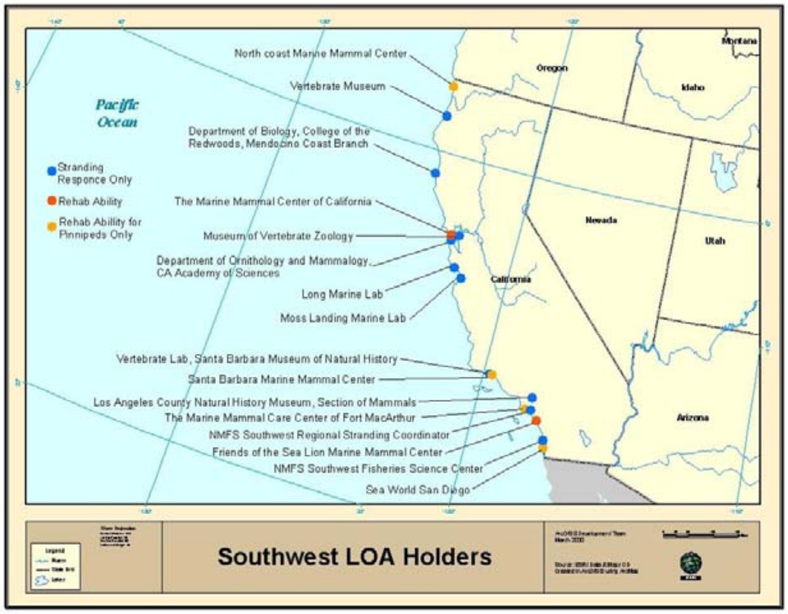


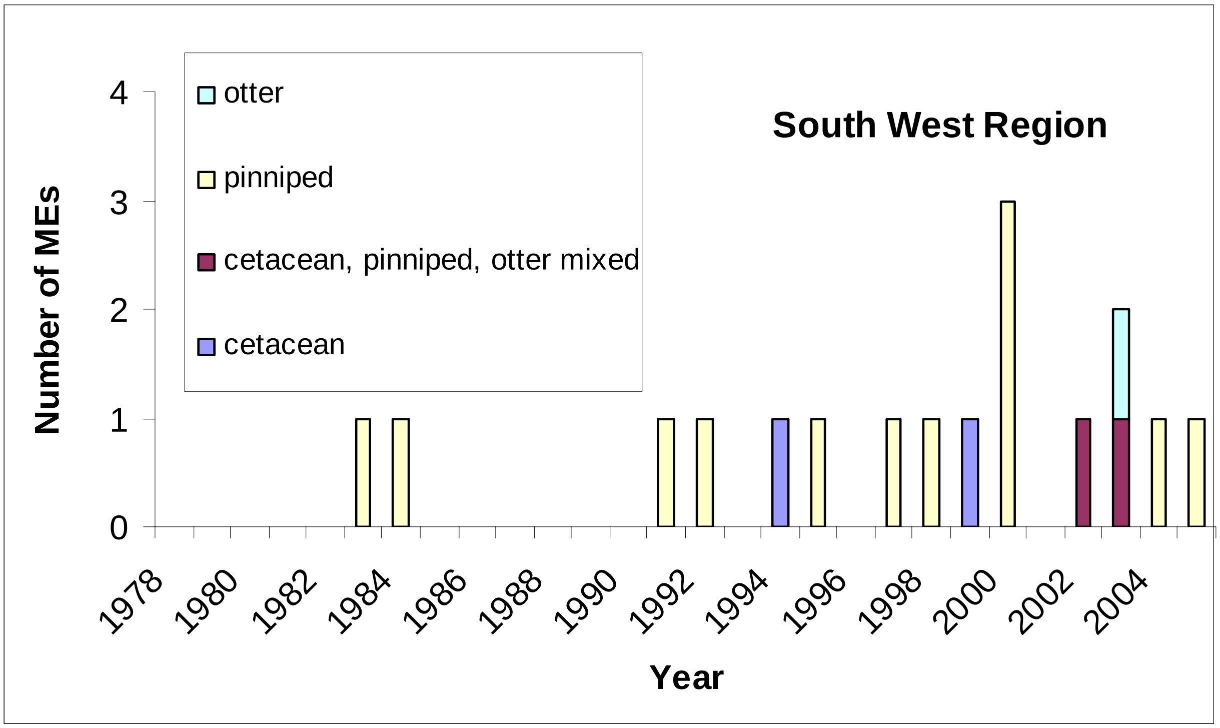

Pacific Ocean
Wolf Hollow Wildlife Rehabilitation Center
The Whale Museum
Olimpic Coast National Marine Sanctuary
Island County Marine Mammal Stranding Network
Progressive Animal Welfare Societ (PAWS) Wildlife Center
Cascadia Research Collective
Washington Deptartment of fish and Wildlife
Rehab Ability
Sranding Response Only
Portland State Univesity
Oregon Coast Aquarium
Oregon State University, Hatfield Marine Sciece Center
Oregon Department of Fish and Wildlife
Oregon Institute of Marine Biology
Free Flight Wildlife Rehabilitation Center
Washington
Oregon
Idaho
Northwest LOA Holders

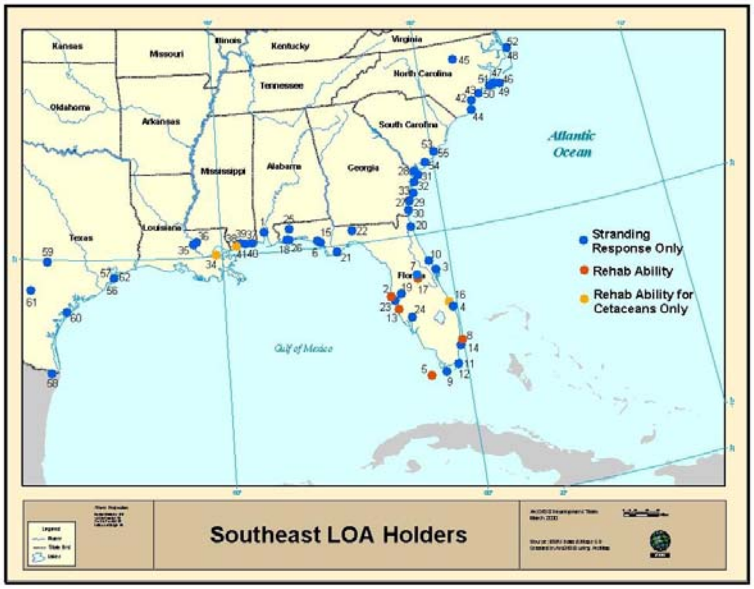

North West Region
pinniped
cetacean and pinniped
cetacean
Number of MEs
0
1
2
3
4
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year

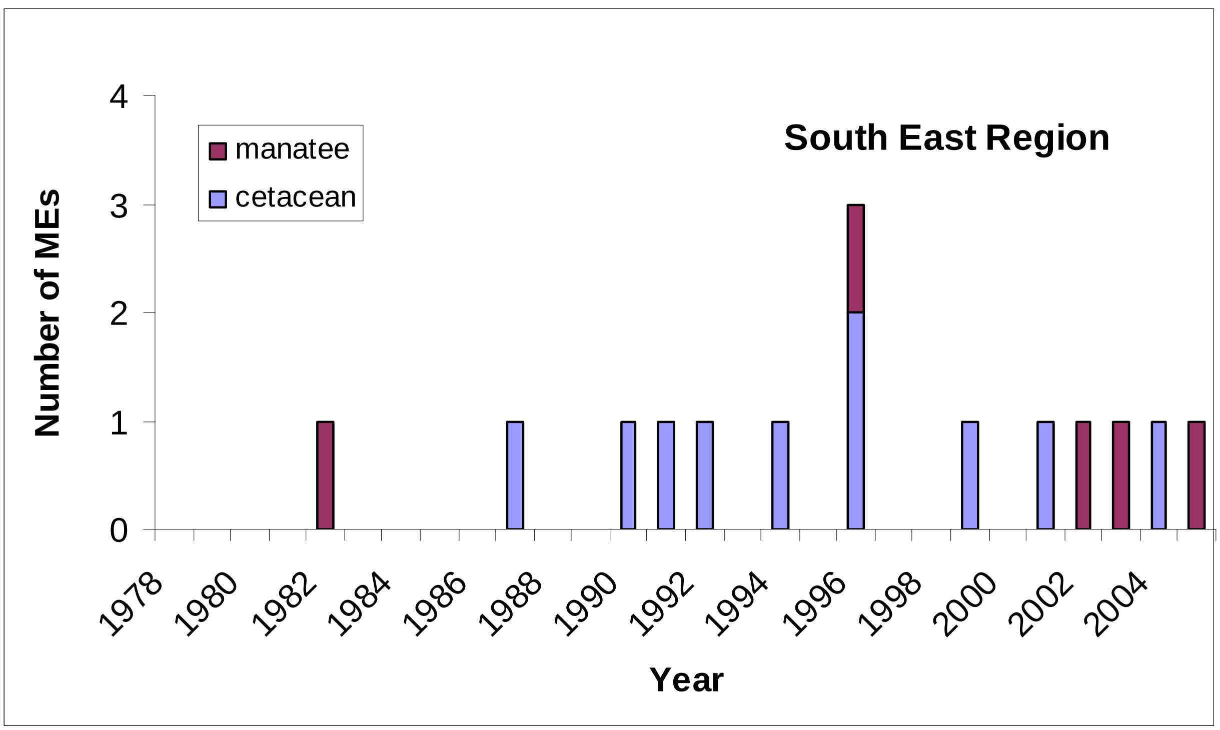

David Haas, DVM
Walter Haas, DVM
Honolulu
Pacific Ocean
Kihei Veterinary Clinic
Hawaiian Island Stranding Response Group
Veterinary Associates
Hilo Veterinary Clinic
Capital Cities
Lakes
United States
Albers Projection
Hawaii LOA Holders
March 2000


Hawaii
pinniped
number of MEs
year
0
1
2
3
4
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004


Pacific Ocean
Stranding Responce Only
Rehab Ability
Rehab Ability for Pinnipeds Only
North coast Marine Mammal Center
Vertebrate Museum
Department of Biology, College of the Redwoods, Mendocino Coast Branch
The Marine Mammal Center of California
Museum of Vertebrate Zoology
Department of Ornithology and Mammalogy, CA Academy of Sciences
Long Marine Lab
Moss Landing Marine Lab
Vertebrate Lab, Santa Barbara Museum of Natural History
Santa Barbara Marine Mammal Center
Los Angeles County Natural History Museum, Section of Mammals
The Marine Mammal Care Center of Fort MacArthur
NMFS Southwest Regional Stranding Coordinator
Friends of the Sea Lion Marine Mammal Center
NMFS Southwest Fisheries Science Center
Sea World San Diego
Oregon
Idaho
Montana
Nevada
Utah
California
Arizona
Southwest LOA Holders


South West Region
otter
pinniped
cetacean, pinniped, otter mixed
cetacean
Number of MEs
0
1
2
3
4
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year


Southeast LOA Holders
Atlantic Ocean
Gulf of Mexico
Stranding Response Only
Rehab Ability
Rehab Ability for Cetaceans Only


South East Region
manatee
cetacean
Number of MEs
Year
0
1
2
3
4
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004


Canada
Atlantic Ocean
Maine
Vermont
New Hampshire
New York
Massachusetts
Rhode Island
Connecticut
Pennsylvania
New Jersey
Ohio
Michigan
Maryland
Delaware
District of Columbia
West Virginia
Virginia
Kentucky
North Carolina
Lake Huron
Lake Ontario
Lake Erie
Allied Whale, College of the Atlantic
Marine Animal Lifeline
University of New England
Whale Center of New England
Protected Resources Division NMFS Northeast Region
New England Aquarium
NAtional Park Service Cape Cod National Seashore
Cape Cod Stranding Network
Protected Species Branch NMFS Northeast Fisheries Science Center
Mystic Aquarium
Riverhead Foundation for Marine Research
Marine Mammal Stranding Center
Marine Animal Rescue Program, National Aquarium in Baltimore
MERR Institute, Inc
MD DNR, Oxford Cooperative Laboratory
Smithsonian Institute National Museum of Natural History
Virgina Institute of Marine Science
Virginia Marine Science Museum
Stranding Responce Only
Rehab Ability
Rehab Ability for Pinnipeds Only
Northeast LOA Holders

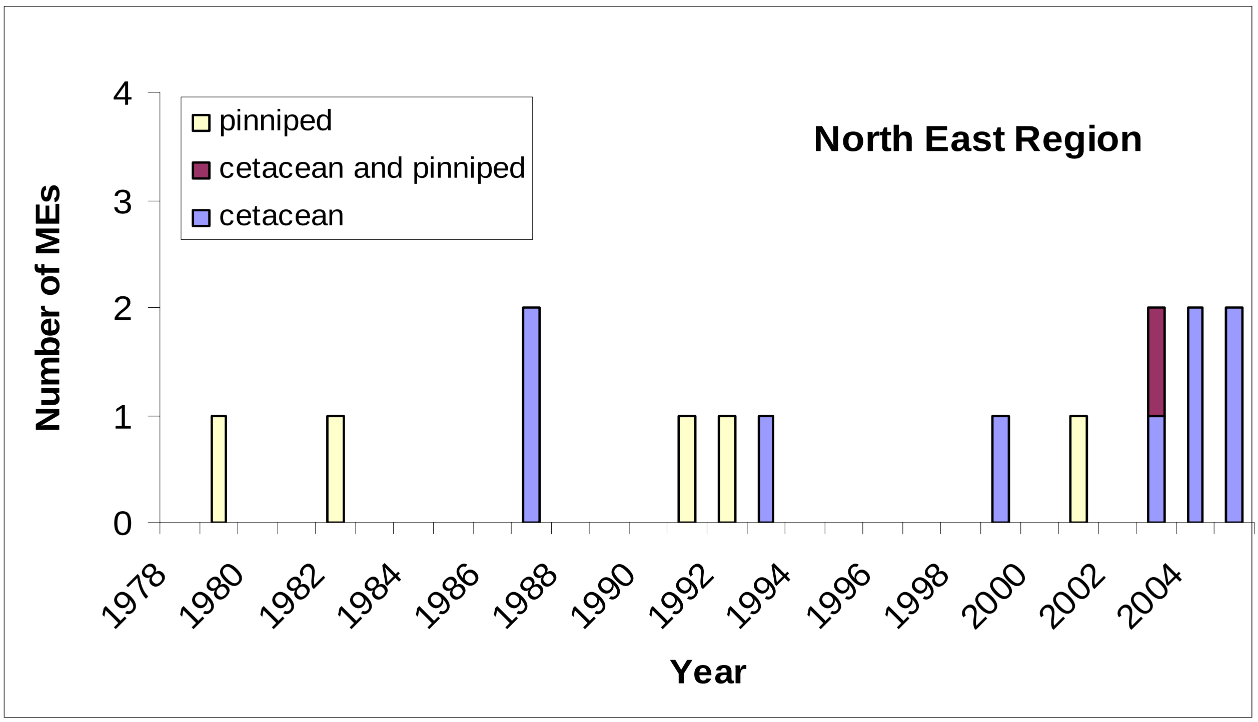
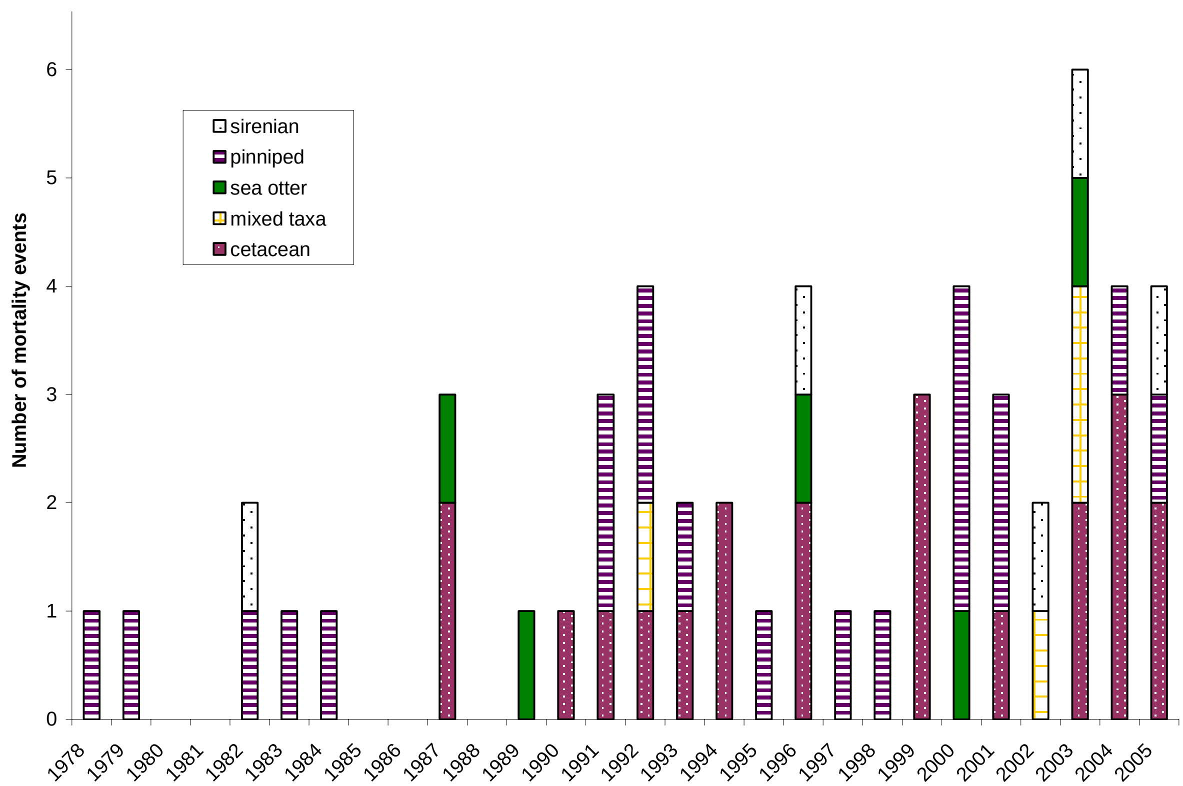

North East Region
pinniped
cetacean and pinniped
cetacean
Number of MEs
0
1
2
3
4
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year

Figure 2. Marine Mammal Mortality Events in Different Taxa, 1978-2005.



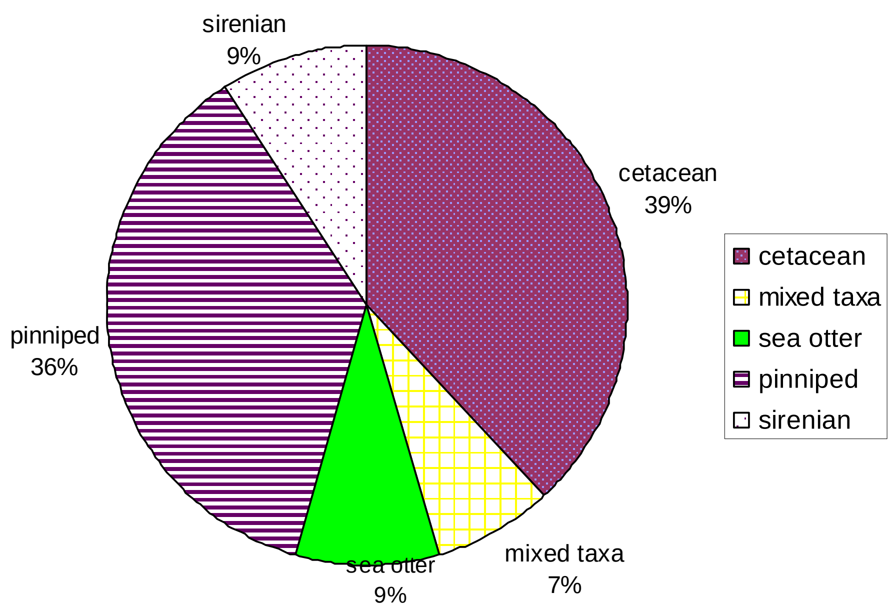
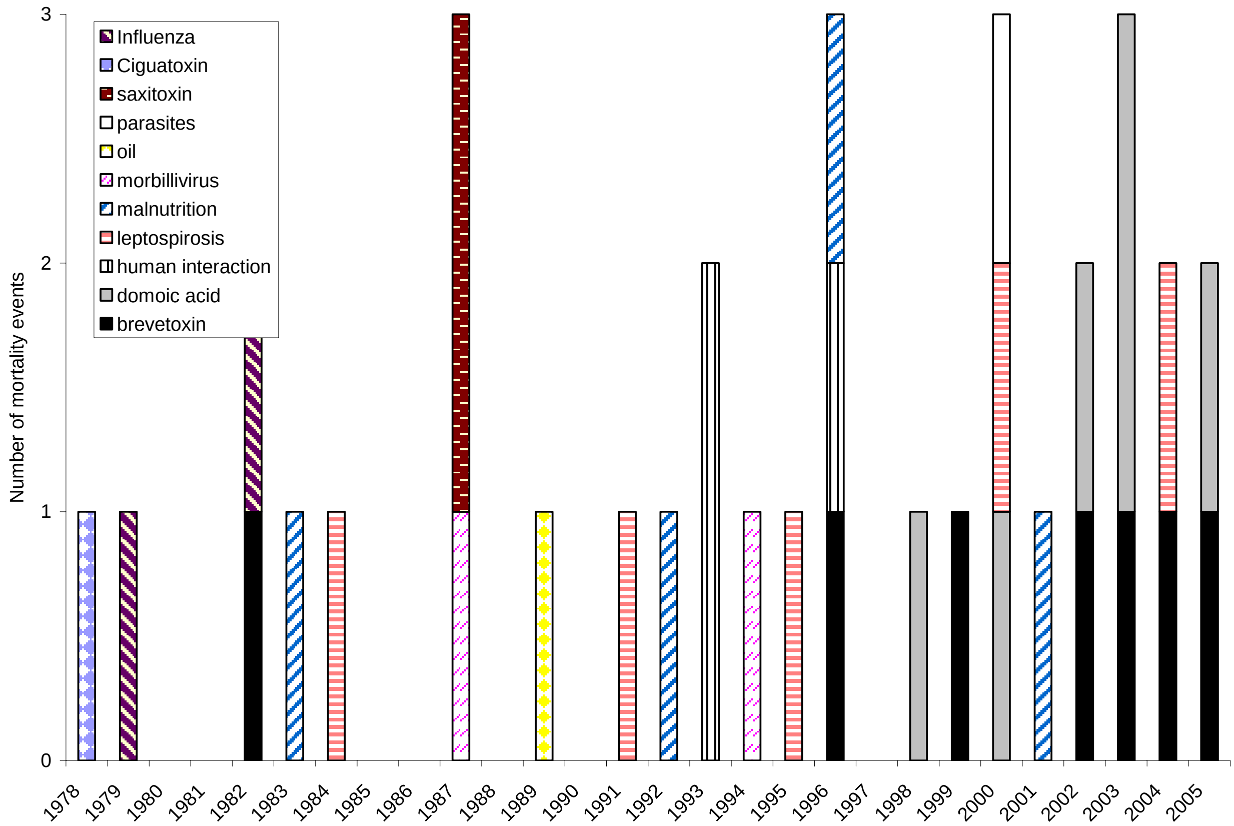


Figure 3. Identified Causes of Marine Mammal Mortality Events, 1978-2005



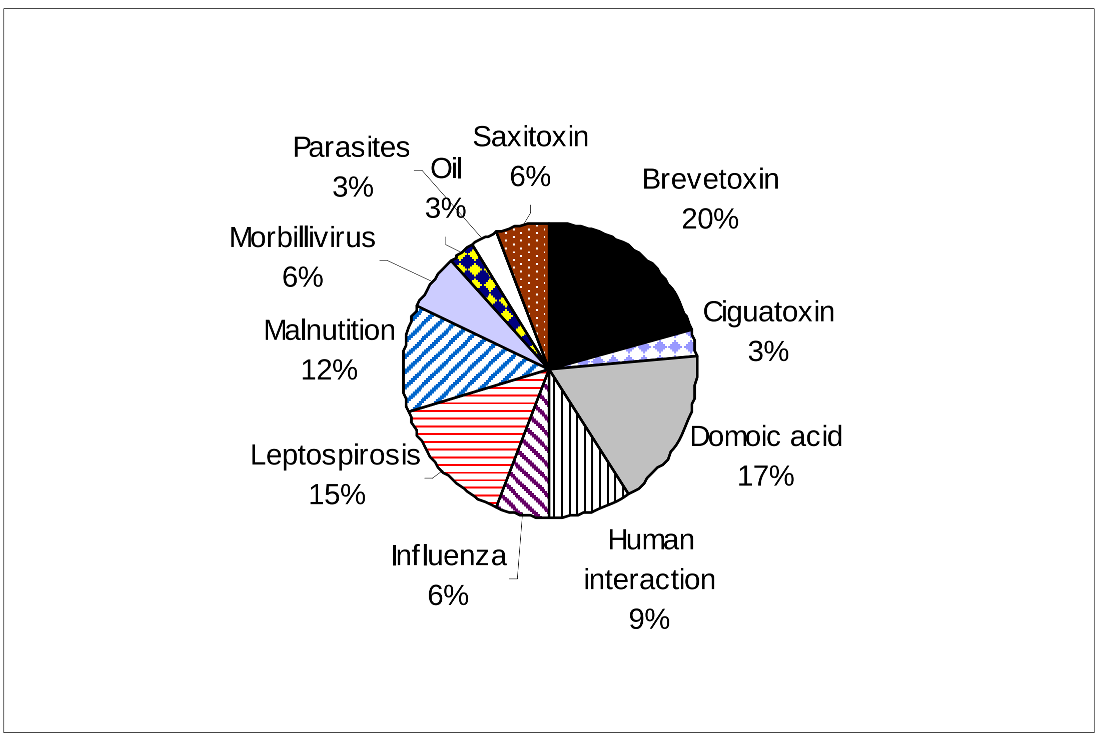


Figure 4. Unknown Causes of Marine Mammal Mortality Events

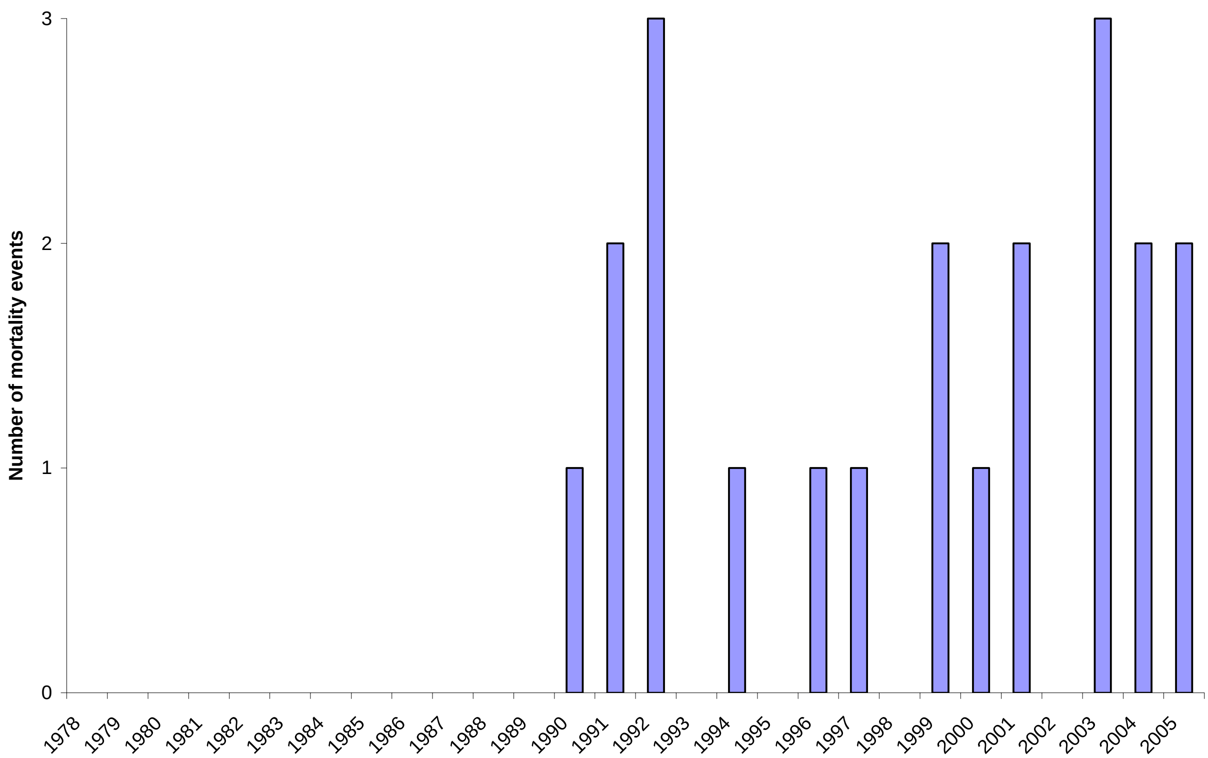
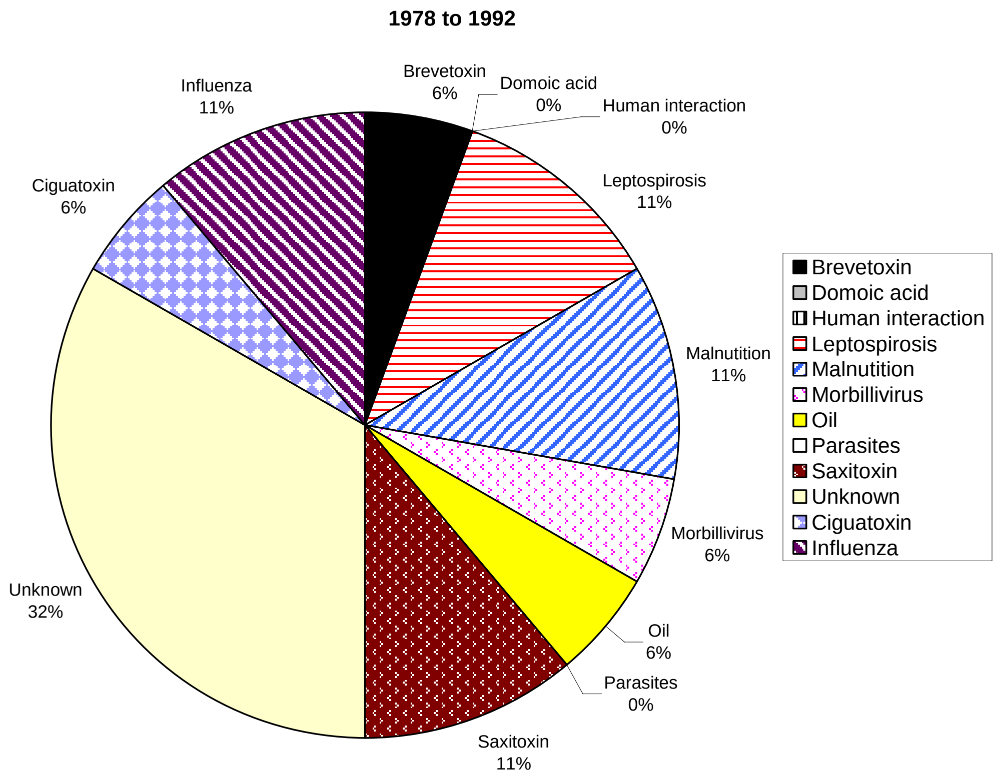
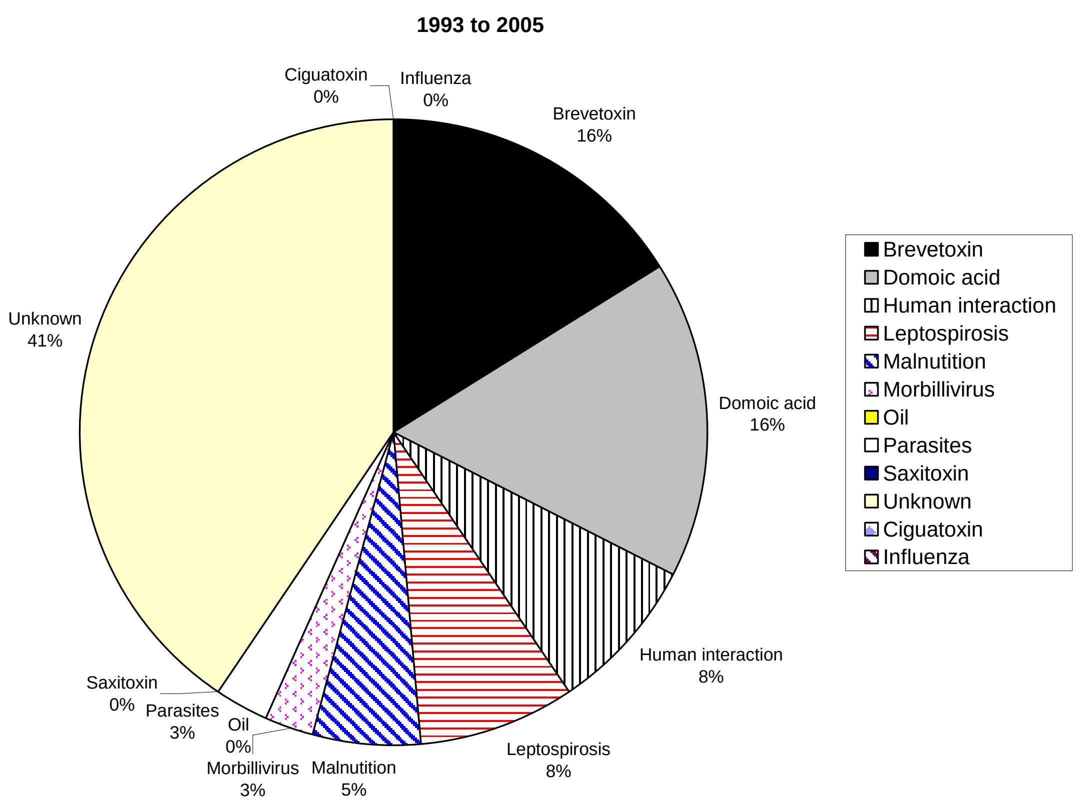


Figure 5. Causes of Mortality Events in 1978-1992 Compared to 1993-2005.





Efforts to Improve Response

To date, NMFS has implemented a variety of approaches to improve responses to marine mammal UMEs. These have been achieved with a limited budget and few staff, and have relied upon in-kind work and funding from stranding network participants and collaborating researchers.

A National Contingency Plan for response to UMEs was published in 1996 (Wilkinson 1996). This has details of the UME legislative process; outlines public health and welfare concerns and advance planning needs; gives considerations required for live animal management; lists methods for tissue collection, preservation and shipping; post-event activities; and gives lists of stranding network members and agencies. Since then, several species specific contingency plans have been developed with greater details about response logistics. A contingency plan for responding to mortality of Florida manatees was developed in 1997 and has been regularly updated by the U.S. Department of the Interior (Geraci and Lounsbury 1997) and a plan for unusual mortality of Hawaiian monk seals was developed in 2004 (Yochem 2004). There are also response plans for events involving oil discharges or releases of hazardous substances developed by NOAA and by the USFWS distributed through its Contaminants Program (USFWS 1995).

In 1999, the addition of the international members as liaisons on the Working Group greatly enhanced communication amongst agencies in Mexico, the U.S. and Canada concerned with health and conservation of marine mammals. Wildlife disease surveillance is an international concern, as not only is the impact of the disease on transboundary marine mammal stocks important, but disease outbreaks can have important impacts on trade and movement of domestic animals and animal products. With the increased use of the internet for disease reporting, the public and scientific community is rapidly informed of emerging diseases, and wildlife disease surveillance needs to cross national boundaries to be effective.

Additional preparation of the stranding network for response to a UME has been achieved by training members likely to be On-site Coordinators (OSC). A training workshop was held in October 2003 at the National Conservation Training Center that covered contingency planning, necropsy techniques, data management, report writing and media management. The OSCs for two events in 2004 had attended this training prior to becoming OSCs. Supplementing these detailed training sessions, and involving larger numbers of stranding response personnel were two National Stranding Conferences, held in December 1987 and April 2005.

A common concern for network members when responding to dead marine mammals is the availability of diagnostic resources that can examine samples collected from stranded animals. To address this concern NMFS has ongoing contracts with several laboratories to provide histology, serology and bacterial culture diagnostics on samples submitted from stranding network members. These contracts improve the quality and reliability of data resulting from investigations by eliminating potential problems associated with inter-laboratory variability, and provide opportunities to establish acceptable levels of quality assurance and quality control. The contacts and methods for sample collection and submission for these services were provided during the OSC training in 2003. However, it should be noted that the long-term availability of contracted independent laboratories is not guaranteed, and in the near future several crucial labs will cease operations, leaving significant gaps in diagnostic capabilities.

A limited amount of sample archiving from animals dying during UMEs has been achieved through the National Marine Mammal Tissue Bank program, jointly managed by the NMFS and the National Institute of Standards (NIST). Tissues banked include blubber, liver, kidney and muscle, which have been used for retrospective toxicological analyses.

CHALLENGES AND FUTURE DIRECTIONS

Although there are four aims of responses to UMEs: to minimize deaths, determine the cause of the event, determine the effect of the event on the population, and to identify the role of environmental variables in the event, only the first two of these have been significantly addressed since the UME program was established in 1992. Efforts to minimize deaths have improved as an increasing number of stranding network facilities employ veterinarians to advise on medical care of stranded marine mammals, and the field of marine mammal medicine has developed considerably over the last 10 years (Dierauf and Gulland 2001). Identification of the cause of mortality events has been achieved in just over half (56 percent) of the investigations, some of these resulting in the detection of novel disease syndromes in marine mammals (Geraci et al. 1989, Lipscomb et al. 1994, Bossart et al. 1998, Scholin et al. 2000). Identification of novel diseases requires significant resources and collaboration, thus achieving this through investigations of mortality of wild mammals is a considerable accomplishment. However, trends in the frequency of these diseases, the impact of environmental change on these diseases, and the effects of these mortality events on host populations cannot be determined from the data currently available to the UME program, given the limited resources available. Without this information, the status of marine mammal health and the impacts of anthropogenic activities and environmental factors (e.g. climate change) on it cannot be assessed. Thus the first two purposes of Title 1V of the MMPA are not being adequately met by the current program to investigate marine mammal mortality events. Specific issues that need to be addressed to improve the ability of the stranding network to respond successfully to UMEs are discussed below.

Data Quality and Management

The results of the majority of these marine mammal mortality event investigations have not been published in peer reviewed journals, nor in many cases have technical reports been filed for the administrative record with the NMFS or USFWS (Table 1). Thus efforts to compile data on mortality events have been severely compromised, and have relied heavily on personal communications and anecdotal reports. Furthermore, not all marine mammal mortalities have been assessed consistently to determine whether or not they fulfill the criteria for UME classification. In some cases, significant die-offs of marine mammals occurred, but neither the National Stranding Coordinator nor the Working Group Executive Secretary were notified, and the event was not recorded in the UME database. The stranding data have, however, been recorded by local networks, and sometimes published in the peer reviewed literature. Notification of the National Stranding Coordinator, and consultation of the Working Group on whether or not an event is a UME, have both been somewhat arbitrary, and have depended upon the levels of concern, the degree to which local stranding network responder resources have been strained by stranding increases, and involvement of the stranding network responder and the regional stranding coordinator. This means that the UME record is not a reliable dataset from which to assess trends in marine mammal health and frequency of die-offs.

For example, Table 1 lists one mortality event of California sea lions (*Zalophus californianus*) in 1991 due to leptospirosis about which the Working Group was consulted. However, leptospirosis epidemics also occurred in 1994, 1995, 1999 and 2000 (Greig et al. 2005). Each of these had higher sea lion mortality than in 1991, yet the neither the National Stranding Coordinator nor the Executive Secretary were notified. In another example, there were increased strandings of malnourished sea lions in California in 1992, some of which were gunshot, and this event was declared a UME. In 1998, twice as many sea lions stranded associated with El Niño conditions (Greig et al. 2005), but this event was not reported to the National Stranding Coordinator.

A second limitation of the current UME process for assessing the frequency of disease outbreaks in marine mammals and using the frequency of UMEs as a metric of health is that it does not include data on gradual increases in single strandings that might reflect increases in mortality, or mass strandings. Stranding network members submit Level A data (species, age class, size, strand location, date, sign of human interaction) to the National Stranding database, but this does not include disease data or cause of mortality. Trends in individual strandings or mass strandings may provide important insights into the role of environmental variables in UMEs (the third aim of UME response).

The third limitation to the data in the UME database as it is currently structured is that detection of UMEs relies upon an efficient stranding network that detects stranded animals, has the training and expertise to examine animals and collect the required samples and data, and submits the data to a centralized database. Changes in the baseline stranding data are used to detect UMEs, using the criteria listed above. In many areas of the U.S., there is poor detection rate of stranded marine mammals, due to low human population density, social attitude, few trained LOA Holders (Figure1), and lack of funding to support response to stranded animals. Detection of stranded marine mammals will also be influenced by weather conditions affecting human activity on beaches, as well as by tides and currents affecting carcass deposition.

To address these limitations and improve the utility of the data collected through the UME response, the following actions are recommended:

1. Expand the National Stranding database to:
    a. Include data on cause of death and disease investigations.
    b. Integrate single stranding, mass stranding and UME stranding data into one real time searchable database with a method for rapid identification of these “group” events.
    c. Develop data sharing protocols and agreements to facilitate collaborations and extensions of analyses.

2. Improve the stranding network's surveillance capabilities by:
    a. Dedicating funding sources (e.g. Prescott program) to stranding network members to ensure consistent levels of response capabilities for surveillance to detect UMEs. This should include responders who are employed by federal agencies whose primary employment duties do not include stranding response or UME investigation.
    b. Holding regular training workshops for LOA Holders.
    c. Increase data collection requirements from LOA Holders during UMEs.
    d. Directing training and funding above to areas of the network with poor coverage of the coastline and detection rates (Figure1).
    e. Developing protocols for regional stranding coordinators on event notification.

3. Require development and submission of final reports and encourage peer reviewed publications on UME investigations by:
    a. Requiring final reports to be submitted from UMEs as a condition of receiving funds.
    b. Funding report writing by qualified personnel.
    c. Fostering research collaborations through workshops and seminars.

4. Review of the reports on UMEs by the Working Group, and incorporate recommendations on improved response and investigation based on the reports into future UME responses.

Administrative Process

Responses to UMEs have been hindered by the administrative process involved in the declaration of a mortality event as unusual, as well as by logistics on site. Most stranding network responders do not have the extra financial resources immediately at hand to mount effective responses to UME events, and rely upon the federal funding available through the UME program of the MMHSRP to do so. Thus there is a need for a rapid response from the agency to a notification by a LOA Holder that a UME may be occurring. Section 404 of the Marine Mammal Health and Stranding Response Act provides the framework for responding to UMEs. Essentially, the UME coordinator is required to contact as many members of the Working Group as possible within 24 hours of a Regional Stranding Coordinator or standing network member contacting the NMFS, each person in the Working Group then responds within 24 hours with a vote on whether or not a UME is occurring, and, unless time is needed to gather additional information as requested by any member of the Working Group, determination of whether or not an UME is occurring takes place within 48 hours of a Regional Stranding Coordinator contacting the NMFS about a possible event. Over the last 10 years, however, many events have not been addressed within this time frame, and it has taken weeks to months for events to be declared UMEs. This has limited network member's abilities to respond to the event, and has required stranding network responders to utilize their own funds for UME response. Furthermore, there has been limited communication between the field investigation team and the Working Group.

Once a UME is declared, an appropriately qualified OSC should be designated to mobilize and manage the response to the event. The OSC is responsible for directing the response, and needs to have strong management and leadership capabilities, highly effective communication skills, the capacity to make decisions with minimal use of intermediaries, the ability to access information and expertise including interagency expertise, and, a familiarity with the Contingency Plan and the Stranding Network and sufficient time released from regular job obligations to serve as coordinator. The OSC is also responsible for preparing a report containing results of investigations and recommendations for subsequent monitoring or management activities. Despite training in 2003, few stranding network members currently have the skills or the flexibility in their work schedules to become OSCs during events, and fewer have had time to complete reports on UMEs after the events are over. Furthermore, the work load of all these responsibilities is too much for one person, especially one who often has another job.

A third concern with the process involved in declaring mortality events UMEs and mounting effective responses is that some events involve multiple species managed by separate agencies, and communication amongst these can be poor. For example, in California in 2002, sea otters (*Enhydra lutris nereis*), California sea lions and common dolphins (*Delphinus delphis*) died during the UME. Sea otters are managed by the USFWS, examined post mortem by the state California Department of Fish and Game and data on their population numbers collected by the U.S. Geological Survey, whereas NMFS is responsible for management of sea lions and dolphins. Lack of an efficient method of communication between these agencies delayed allocation of financial resources to the investigation, and limited interpretation of stranding data and detection of associations between mortality and environmental variables.

To address these concerns over the administrative process, the following are needed:

1. A full time dedicated Executive Secretary to:
    a. Track the administrative process.
    b. Develop effective inter and intra-agency communication.
    c. Facilitate communication between the working group and the field investigation team.
    d. Act as an off-site coordinator.

2. Weekly communication between the Working Group and the OSC. This could be achieved by dedicating one member of the Working Group as the liaison for each UME, and would provide the Working Group with real time information on the UME response, and the OSC with moral and logistic support.

3. Trained personnel with allocated time to be the OSC on emergency response and members of teams employed during responses to UMEs. These teams would consist of at least three people, from which would be drawn appropriate response teams for specific events, based on the existing abilities and needs of the local stranding networks. Availability of team members would be accommodated with a retainer and NMFS would pay for all travel associated with the response. Teams are described in more detail below.

Response Logistics

Logistical constraints in the field have limited investigations into the causes of UMEs, with the result that many UMEs have unknown etiologies. These constraints include lack of resources in the field, such as lack of trained personnel to examine stranded animals and collect appropriate samples, lack of equipment to collect samples with, and lack of heavy equipment or transport to access, store or dispose of carcasses. Delayed access to animals for sampling limits the quality of the samples that can be collected as decomposition affects most analyses and diagnostic tests (Geraci and Lounsbury 1993, Rowles et al. 2001). There is considerable variation in the level of training among network members, resulting in variation in the quality of post mortem examination of carcasses. For example, in northern California, marine mammals that live strand and die are examined fully at post mortem by veterinarians and board-certified pathologists, whilst dead stranded animals are examined by museum curators and typically only archival skull material is collected from these cases. Once samples are collected from marine mammals, they are shipped to diagnostic laboratories or banked for future analyses. There are a limited number of laboratories with tests adapted for these species, and many of these have no quality control program. Thus test results are often delayed and unreliable. Also, the future of some of these crucial laboratories is in jeopardy as key staff members retire or move to other positions. Problems will arise from the lack of availability of diagnostic tests, or from an inability to calibrate test results across past and future diagnostic labs, as has occurred multiple times during long-term health studies of free-ranging bottlenose dolphins (Wells et al. 2004).

There is no formal archiving system for samples collected during UME responses. Samples banked from UME events are often stored in freezers with no emergency generator for use in the event of power outages, and have limited tracking data by network responders and are often untraceable years after an event is over. This makes retrospective analyses impossible. As novel diseases and toxins are identified it is not possible to re-examine earlier UMEs to determine whether they played a role. For example, in 2002 domoic acid was identified as the cause of a UME of common dolphins in California, after being first identified as a cause of marine mammal mortality in 1998 (Scholin et al. 2000). There was a die-off of common dolphins in California in 1994 with very similar features to the 2002 event. However, as domoic acid had not been considered at the time, it was not tested for. After the 2002 event, efforts to re-examine the 1994 event to determine whether domoic acid could have been the cause were limited by the lack of archived tissues or fluids for examination.

To address these logistical difficulties, the following actions are recommended:

1. Enhance resources of stranding network members by:
    a. Regular training in necropsy techniques, sample collection, archiving and shipping to all network responders.
    b. Stocking each region with supplies for emergency sampling of marine mammals.
    c. Identifying appropriate storage facilities in each response area.
    d. Developing a permanent response team available to rapidly mobilize during a UME with a trained pathologist, research assistant and a data manager.
    e. Posting response, sampling and shipping protocols to a website for easy access.

   f. Identifying funds for carcass handling and disposal so that large whales can be towed ashore for examination then disposed of.

2. Develop a centralized national sample archiving system to include fluids and tissues from animals during UME events.

3. Improve availability and quality of diagnostic tests performed on samples from marine mammals by:
   a. Identifying and funding dedicated laboratories for pathology, infectious diseases, biotoxin and contaminant analyses.
   b. Developing a quality assurance program for laboratories analyzing marine mammal samples.
   c. Ensuring collection of suitable samples by establishing protocols for the investigation of specific events that are known to occur, such as domoic acid toxicosis, brevetoxicosis, leptospirosis, beaked whale strandings, morbillivirus and influenza epidemics, and human interactions.

4. Develop the means to fund crucial aspects of a response that are currently not allowed, such as salary support for personnel dedicated to a UME, and for carcass disposal.

Impact on Population and Role of Environmental Parameters

Two of the aims of UME responses, determining the impact of the event on the host population, and determining the role of environmental parameters in the mortality event, have rarely been addressed during UME investigations. To achieve these aims,

1. The MMHSRP needs to be integrated with the stock assessment programs of the NMFS and population monitoring programs of the FWS and USGS, as well as other federal programs addressing environmental and climate variables impacting marine mammal health (e.g. the Ecology and Oceanography of Harmful Algal Blooms). Of equal importance to performing diagnostic analyses of tissues from stranded animals is the need to identify their stock of origin, through genetic or other techniques. Stock identification facilitates evaluation of population impacts and recovery, and the identification of geographical ranges of affected animals, facilitating investigation of exposure to environmental factors. Integration with the regular, ongoing stock assessment process will not only enhance knowledge about UME impacts, but will also inform managers regarding factors influencing scheduling of stock assessment updates.

2. A research plan addressing factors predisposing marine mammal populations to mortality events must be developed and funded.

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