18

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Marine Mammal Stranding Networks

The popular perception of a response to a marine mammal stranding is of people taking heroic measures to rescue a group of live pilot whales stranded on a beach (Fig. 18-1). In several respects, this is a mistaken picture of the typical marine mammal stranding. The definition adopted by the U.S. National Marine Fisheries Service gives a sense of the difference between reality and popular perception: "A stranded marine mammal is: Any dead marine mammal on a beach or floating nearshore; Any live cetacean on a beach or in water so shallow that it is unable to free itself and resume normal activity; or Any live pinniped which is unable or unwilling to leave the shore because of injury or poor health" (Wilkinson 1991).

Although the U.S. Fish and Wildlife Service has not adopted a formal definition of a stranding for species under its jurisdiction (i.e., sea otters, manatees, walruses, and polar bears), the functional definitions are virtually identical to those for pinnipeds and cetaceans.

The most commonly stranded marine mammal is a dead, beach-cast, often decomposed animal (Fig. 18-2). In the United States, far more pinnipeds strand each year than cetaceans, and mass strandings are rare. Even in the case of live stranded cetaceans, single stranded animals that are ill or injured are more common than mass strandings.

From 1989 through 1994 a total of 21,228 marine mammal strandings was reported in the United States—an annual mean of 3,538 animals. Of these, 12,681 (mean, 2,113) were pinnipeds (National Marine Fisheries Service, unpublished data), 6,768 (mean, 1,128) were cetaceans (National Marine Fisheries Service, unpublished data), 649 were southern sea otters (*Enhydra lutris*) (mean, 108) (California Department of Fish and Game, Monterey Bay Aquarium, unpublished data), and 1,130 were West Indian manatees (*Trichechus manatus*) (mean, 188) (Florida Department of Environmental Protection, unpublished data). The data shown in Figure 18-3 are the result of the efforts of a large body of volunteers involved in stranding response networks administered by the National Marine Fisheries Service and the Fish and Wildlife Service.

Although the means are significantly higher than those reported for the six years from 1983 to 1988 (Wilkinson 1991), this trend is, at least in part, attributable to increased effort and not solely the result of increased numbers of stranded animals. Because of the difficulty in covering the Alaska coast, little concerted effort has been made to record pinniped strandings there.

The 1992–1993 pinniped totals are inflated by occurrence of an El Niño event. Such meteorological events originate in the South Pacific with weakened easterly winds. They cause changes in both climate and sea temperatures. The increase

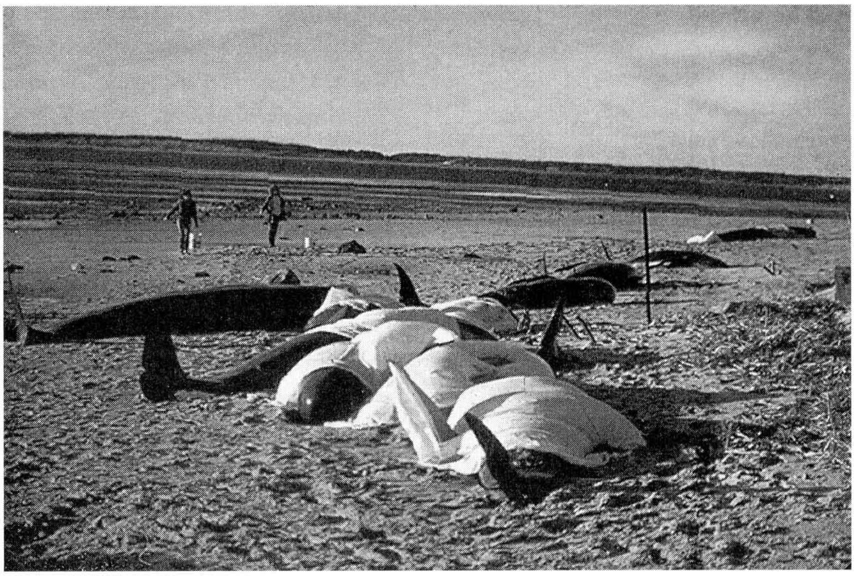

Figure 18-1. Part of a pod of long-finned pilot whales that stranded alive on Cape Cod near Eastham, Massachusetts. The animals, some draped with sheets, are being kept cool by volunteers bringing buckets of water. (Photograph courtesy of Center for Coastal Studies, Provincetown, Massachusetts)

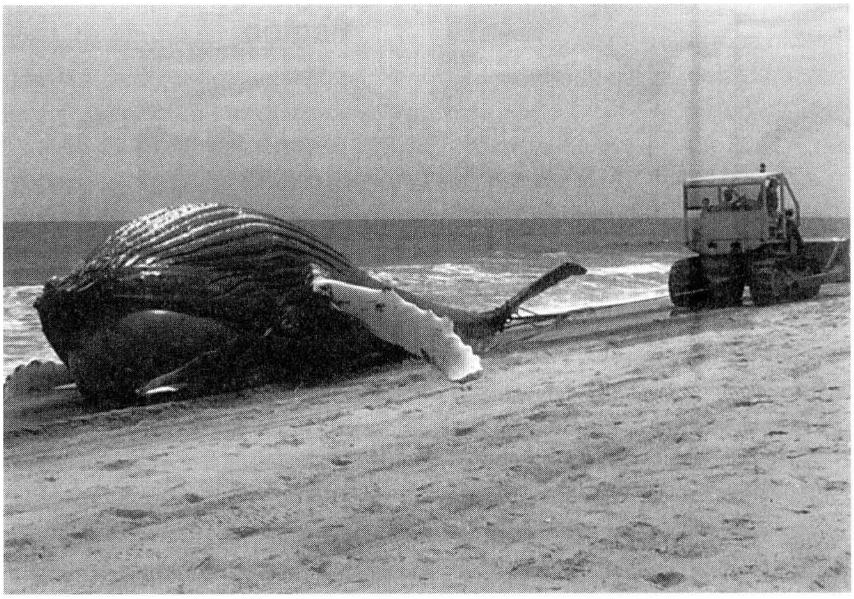

Figure 18-2. A humpback whale being towed from the surf, Virginia Beach, Virginia, 4 June 1995. (Photograph by C. Driscoll)

in water temperature changes the abundance and distribution of fish populations and has a significant impact on pinniped mortality rates due to reductions in prey populations (Trillmich and Ono 1991).

It is statistically possible to predict with some certainty which species are most likely to strand. During the 1989–1994 period, the most commonly stranded pinniped was the California sea lion (*Zalophus californianus*), with 5,812 animals recorded. The most commonly stranded cetacean was the bottlenose dolphin (*Tursiops truncatus*), with 3,676 recorded. Other pinniped species that often stranded were harbor seals (*Phoca vitulina*) (3,426) and northern elephant seals (*Mirounga angustirostris*) (1,598). Other frequently stranded cetaceans were harbor porpoises (*Phocoena phocoena*) (485), long-finned pilot whales (*Globicephala melas*) (222), gray whales (*Eschrichtius robustus*) (234), and pygmy sperm whales (*Kogia breviceps*) (195). Because the species is often involved in mass strandings, there is considerable year-to-year variation in the numbers of pilot whales recorded.

Development of Stranding Networks

Wherever marine mammals strand, people take notice. In many areas, this has prompted groups of people to organize themselves into informal networks to help the animals. Researchers also have recognized that stranded animals are a source of information that otherwise could be difficult to obtain. The nature and composition of stranding networks vary from country to country, as well as within countries. In

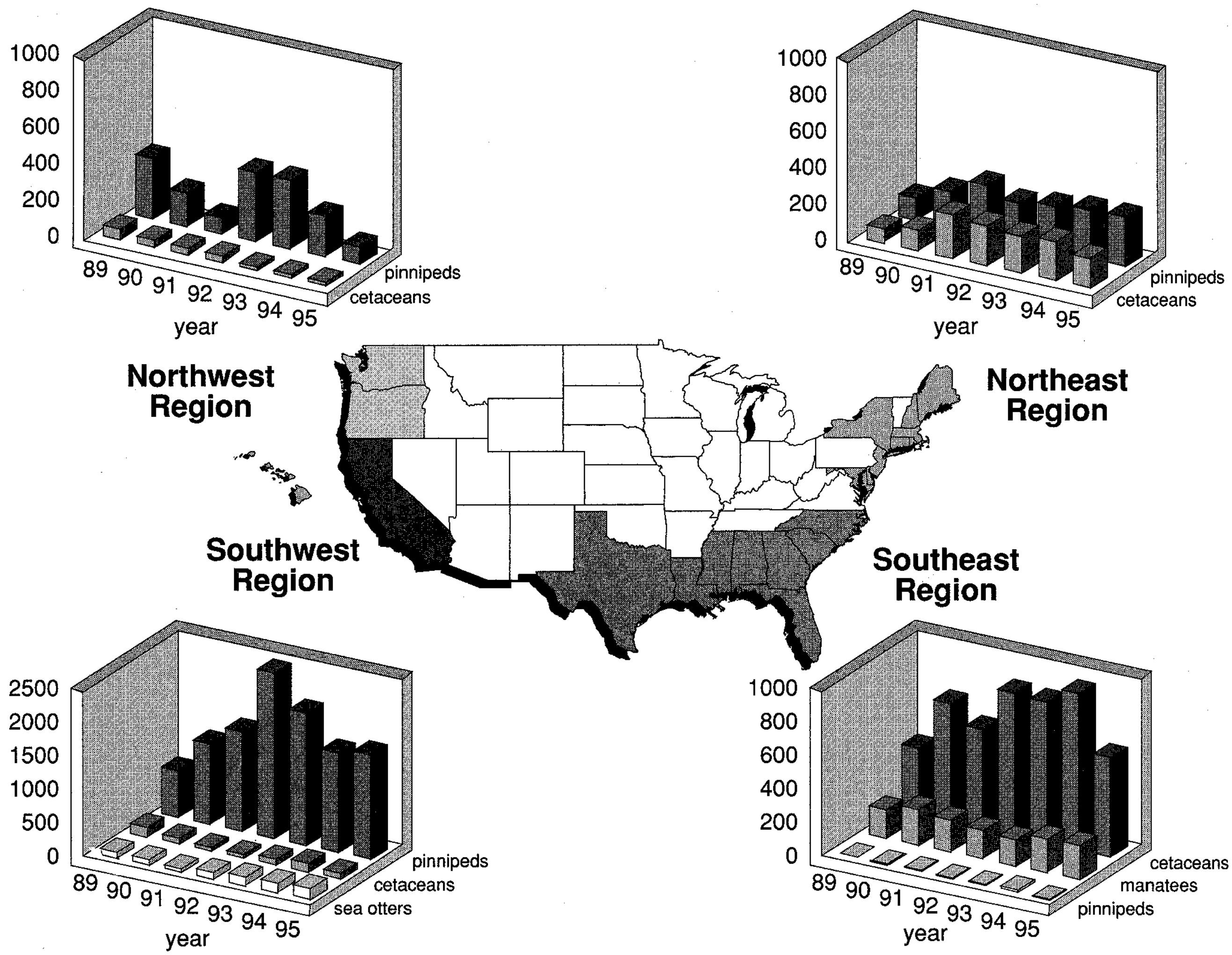

Figure 18-3. Map of the United States showing the four geographic regions that compose the stranding network. Insets illustrate stranding frequency by taxonomic group and by year, based on data collected through the stranding network.

some cases, they are sponsored by governments; in others, they primarily involve people motivated by academic interest. In southern Argentina, a single individual, Nathalie Rae Goodall, has functioned as a one-person stranding network (Goodall 1978, 1989).

Levels of effort also vary. In some countries, only cetaceans are recorded; in others, such as the Netherlands, extensive efforts have been made to document both pinnipeds and cetaceans. In New Zealand and Australia, detailed protocols for handling mass strandings have been prepared (Anonymous 1984, Baker 1986). Cetacean strandings have been recorded systematically in the United Kingdom since 1913 (Sheldrick 1979). In many ways the U.S. stranding network is unique, in terms of both government involvement with an extensive volunteer network and the range of activities involved.

Although individuals and institutions in various parts of the United States had made efforts to monitor strandings in their own areas, no systematic effort was made to collect such information nationwide until 1972. The U.S. network had its genesis when James G. Mead of the Smithsonian Institution in Washington, D.C., began to compile stranding records from researchers throughout the country. This effort eventually led to the standardization of the way stranding data were collected.

Legal authority for the U.S. stranding response network is contained in the Marine Mammal Protection Act (Public Law 92-522, as amended), which is discussed below. The National Marine Fisheries Service's original interpretation of the Marine Mammal Protection Act caused some scientists to become concerned that access to tissues and other research opportunities involving stranded animals could be unduly restricted. To address this issue and others related to strandings, the Marine Mammal Commission sponsored a workshop in 1977. Among the recommendations of the workshop was that a regional stranding response system, coordinated by the National Marine Fisheries Service, be established (Geraci and St. Aubin 1979).

It was not until 1981 that the regional apparatus was in place and the procedures for network participation and reporting were established. Between 1981 and 1991 regional networks administered by the National Marine Fisheries Service's regional offices operated virtually independently. A massive mortality of bottlenose dolphins in 1987–1988, and the attendant public concern, led to the realization that what had been, in many ways, a laissez-faire approach toward strandings was inadequate.

In 1991 a National Marine Fisheries Service–sponsored program review identified inconsistencies in policies among the regions and made recommendations to address this and other problems (Wilkinson 1991). Soon thereafter, the Service created the position of national stranding coordinator. The coordinator's chief responsibilities are to define national stranding policy, standardize network operations, and enhance the capabilities of network members.

Network members are issued letters of authorization by the Service's regional offices. Although there are some gaps in coverage, network members can be found in all the coastal states, and thousands of individuals from various backgrounds participate. Members include government entities, aquariums, rehabilitation centers, academic institutions, research organizations, individual scientists, veterinarians, and nonspecialists with appropriate interests and skills. Virtually everyone involved has expertise in some area of marine mammal science or has received training to supplement a background in biology. Some institutions make extensive use of volunteers. As an example, several hundred volunteers work with the Marine Mammal Center in Sausalito, California (Fig. 18-4). In Massachusetts, more than 500 potential volunteers help respond to mass strandings on Cape Cod.

Members of the stranding networks are not reimbursed for their time or expenses. Lack of stable financial support has often created problems for the stranding networks, and many inevitably operate on inadequate budgets. Members respond to stranded animals at inconvenient times. As any experienced network member can attest, the stench from a dead stranded cetacean can be almost overwhelming. Even worse, the smell clings to a person's skin and clothing for many days regardless of how thoroughly they are washed. In light of such negative aspects, one is tempted to ask why anybody would undertake such a task. Considering the costs, inconveniences, and discomfort involved, there seems little doubt that the volunteers are motivated by genuine concern for the animals and a desire to learn as much as possible about them.

Legal Background for Stranding Operations

Two provisions of the Marine Mammal Protection Act deal with the rescue of stranded marine mammals in the United States. Section 109(h) states:

> (1) Nothing in this title or title IV shall prevent a Federal, State or local government official or employee or a person designated under section 112(c) from taking, in the course of his or her duties as an official, employee or designee, a marine mammal in a humane manner (including euthanasia) if such taking is for—
> (A) the protection or welfare of the mammal,
> (B) the protection of the public health and welfare, or
> (C) the nonlethal removal of nuisance animals.
> . . . (3) In any case in which it is feasible to return to its natural habitat a marine mammal taken . . . under circumstances described in this subsection, steps to achieve that result shall be taken.

Letters of authorization are issued under provisions of section 112(c) that allow the Secretary of Commerce to enter into cooperative agreements to carry out the purposes of the Act.

In 1992 the stranding networks received explicit recognition within the Marine Mammal Protection Act with the addition of Title IV, the Marine Mammal Health and Stranding Response Act (Public Law 102-587). Among other things, Title IV requires the National Marine Fisheries Service to collect and disseminate information regarding the health of marine mammals and health trends of wild populations. The Service is also specifically required to collect information on strandings; to "monitor species, numbers, conditions, and causes of illnesses and deaths of stranded animals"; and to collect "other life history and reference level data, including marine mammal tissue analyses, that would allow comparison of the causes of illness and deaths in stranded marine mammals with physical, chemical, and biological environmental parameters."

The two sections of the Marine Mammal Protection Act reflect different objectives regarding the stranding networks. Section 109 has as its primary purpose the rehabilitation of stranded animals and their return to wild populations. Title IV is intended to ensure that as much scientific information as possible is obtained from stranded animals. Although the aims are not mutually exclusive, they relate to different issues.

The letters of authorization issued to stranding network members have two levels of authority. All members are authorized to collect information from dead stranded marine mammals. Because physical facilities and veterinary expertise are necessary to successfully rehabilitate live animals, the issuance of authority for this level of activity is more limited. Most of the letters of authorization dealing with rehabilitation have been issued to institutions such as aquariums and facilities specifically set up to handle live stranded animals.

Network Activities: The Texas Marine Mammal Stranding Network as an Illustration

The extent of coverage and the organizational structure of the networks vary widely, depending on numbers and types of animals that strand in each area, the availability of physical and financial resources, and scientific expertise present. In the southeast region, for example, coverage and involvement range from virtually no coverage in Louisiana to a statewide organization in Texas with hundreds of volunteers. The Alabama network is essentially a single person, whereas Florida's consists of many interactive, but independent, groups of academics, aquariums, and trained members of the general public. The network in South Carolina is administered by the state government. This range of organizational size and structure has resulted in a variety of solutions to funding needs.

The Texas Marine Mammal Stranding Network is one of the most active participants in the national network system, and a review of its evolution and activities, and the difficulties it has faced, may be useful. In addition to responding to strandings, the Texas network has developed major fund-raising and education programs.

Before 1980 sporadic responses to strandings in Texas were coordinated by David J. Schmidly of Texas A&M University. Activities were at a relatively low level with little public awareness. In 1980 Raymond J. Tarpley and Gregg Schwabb formally founded the Texas network as part of the southeast regional stranding program. It was designed to cover the entire Texas coast.

During the 1980s the Texas network grew tremendously, and large numbers of volunteers came forward to help. The growth in public awareness of the program and its purposes is reflected in the dramatic increase in the number of animals recovered, from 14 in 1981 to an average of 160 animals annually from 1986 through 1993. Most of the increase in the early years was a result of increased surveillance and not increased mortality rates.

A board of directors for the network was established in 1989, and it was formally incorporated as a nonprofit organization. This allowed it to solicit tax-deductible donations from individuals and to apply to foundations for financial support.

Organizationally, the salvage component and the fund-raising component of the organization have independent roles. The aims with respect to salvage are to respond to all marine mammal strandings within the state of Texas, to care for live stranded animals, to perform necropsies and collect selected tissues for scientific research, and to maintain a database and tissue archives that are available to all researchers. The major goals of the fund-raising component are to raise funds to support the salvage network, to promote public education, and to support student projects through scholarships and grants-in-aid for research.

Network coverage extends from the Texas-Louisiana state line to the Mexican border, a coastline of more than 1,600 km (1,000 miles), including the barrier islands. Six network regions have been designated along the coast: Sabine Pass, Galveston, Port O'Connor, Port Aransas, Corpus Christi, and South Padre Island. Each has a regional coordinator who organizes local volunteers to assist with recoveries and necropsies, contacts local businesses for donations, and communicates with the local media. The regional coordinators work with the state operations coordinator based at Texas A&M University-Galveston—the Texas network's only full-time paid position.

The state operations coordinator is responsible for coordinating and storing all data and samples collected, coordinating responses to live strandings, communicating with the Service, organizing public education services, and overseeing large-scale fund-raising. Because good communications are vital for timely responses, the operations coordinator's office is equipped with a statewide paging system, a toll-free telephone line to receive reports, and two cellular telephones. A four-wheel-drive truck is available for recovering animals.

A special response team of trained volunteers works out of the state office. The team is dispatched immediately to respond to fresh strandings or live strandings anywhere in the state and to transport all freshly dead animals to Galveston, where a detailed necropsy is performed. The necropsy includes sampling for histopathology, toxicology, infectious diseases, life history data, and anatomical studies. The response team also assists local volunteers with primary care for live stranded animals. The Texas network has three portable holding tanks that can be set up to hold dolphins temporarily. Longer-term care is provided at several cooperating facilities along the coast.

During the period 1989 through 1994 the Texas network recovered 1,163 marine mammals, 94% of which were bottlenose dolphins. This figure accounts for 17% of all cetacean strandings and 28% of all bottlenose dolphin strandings recorded in the United States during that time. In 1994 the Texas network responded to nine live strandings. One pygmy sperm whale required euthanasia on the beach and three other animals—a striped dolphin (*Stenella coeruleoalba*), a Fraser's dolphin (*Lagenodelphis hosei*), and a bottlenose dolphin—died immediately after stranding. Four

Figure 18-4. Tube-feeding a harbor seal during rehabilitation. (Photograph courtesy of the Marine Mammal Center, Sausalito, California)

adult bottlenose dolphins were rehabilitated and released, and one very young bottlenose dolphin was transferred to Sea World of Texas for extended care.

Unusual mortality events occurred in the Texas area in 1990, 1992, and again in 1994. The Texas network responded to more than 200 dolphin strandings each in 1990 and 1992 and 296 in 1994. In March 1994 as many as 50 dolphins a week washed ashore along a 62-km (100-mile) stretch of coastline near Galveston.

In addition to responding to strandings, the Texas network has become increasingly involved in public education. Ultimately, the program depends on public support. At the operating level, the general public is likely to be the source of most stranding reports. An informed public also is much more likely to make individual donations and encourage government support. Without such funding, the networks would not be able to survive.

The Texas network is involved with educating people through lectures, training sessions, and a traveling museum display. During 1994 more than 70 public seminars, presentations, and training necropsy sessions were conducted for audiences ranging from elementary schools to Elderhostel groups. These presentations covered general marine mammal biology as well as specific topics related to strandings. Actual necropsies were undertaken by some groups, and role-playing activities were provided for the younger ones. The network is completing production of a training video on proper necropsy techniques to help train members who respond to strandings.

Rehabilitation Issues

The definition of "rehabilitation" commonly used by the stranding networks differs from the general definition of the term. It refers to the period of time during which a marine mammal requires treatment. After an animal has recovered, it is deemed to be rehabilitated, whether it is returned to the wild or retained in captivity.

The rehabilitation of abandoned, injured, or sick marine mammals is consistent with humane concern for wild animals. With very limited exceptions, however, one should not be misled into believing that such rehabilitation contributes to the maintenance of healthy wild populations. Just as people may place a value on the treatment of injured songbirds, even though it is known that this makes no significant contribution to the overall health of songbird populations, the rehabilitation of stranded marine mammals is regarded by many as a humane and responsible gesture toward individual animals.

Rehabilitation has the potential to contribute to the conservation of only two marine mammal species in U.S. waters—Hawaiian monk seals (*Monachus schauinslandi*) and West Indian manatees. For both of these species, directed rehabilitation programs are part of official recovery programs. In Hawaii, a "head-start" program has been set up to increase the survival rate of monk seal pups. Although the pups in question are not ones that have stranded, the program has potential implications for stranded animals (see Ragen and Lavigne, this volume). A U.S. Fish and Wildlife Service program in Florida has successfully rehabilitated and released a number of manatees back into the wild (see Reynolds, this volume).

There are two main reasons why rehabilitation efforts for other species are not likely to contribute significantly to their conservation. First, the number of animals successfully rehabilitated is relatively small. Second, the size of most wild populations is large when compared with the number of live strandings.

Between 1972 and 1995 only 65 cetaceans were successfully rehabilitated. There are several reasons for this low number. Cetaceans are exclusively aquatic and typically strand alive only when extremely ill or seriously injured. Second, the facilities required for treating such animals are much more elaborate than those needed for treating most terrestrial animals or pinnipeds, and the number of such facilities is limited. Finally, knowledge has come slowly for those involved in the care and treatment of cetaceans. For example, only within the past few years have formulas been developed that allow for successful feeding of unweaned calves. For species such as the pygmy sperm whale, only recently has enough been learned to permit successful rehabilitation. Before 1990 stranded pygmy sperm whales almost inevitably died before treatment could be initiated. As knowledge increased, efforts were more successful, and several pygmy sperm whales have now been successfully rehabilitated and released.

In contrast, each year several hundred pinnipeds are successfully rehabilitated and returned to the wild. The largest number for any one species was 525 California sea lions rehabilitated in 1992, but this number is relatively insignificant when compared with an estimated U.S. population of up to 160,000 animals (Barlow et al. 1995). Even those pinniped populations that are designated as depleted exist in large enough numbers that rehabilitation is unlikely to contribute to their recovery. For example, the Pribilof Islands stock of northern fur seals (*Callorhinus ursinus*) is estimated at about 982,000 animals (National Marine Fisheries Service 1993). Even if a large-scale rehabilitation project were possible, its effect on the population would be minuscule.

Although rehabilitation and release of stranded marine mammals have limited value in terms of population conservation, the care of live stranded animals can provide useful information applicable both to maintenance of captive animals and management of wild populations. Stranded animals are often ill and thus can provide information on the pathogens and parasites that affect wild populations. By treating stranded animals, veterinarians can obtain information and experience that can be applied to captive populations. Treatment of live animals can also provide information on the physiology, life history, and behavior of marine mammals—information that can be gained only with difficulty in the wild.

Apart from the issue of whether rehabilitation programs contribute to the conservation of wild populations, it is appropriate to ask whether rehabilitated animals can resume a normal life after release. Confirmation of an animal's survival after release back to the wild is critical, and limited data are available on this point. The National Marine Fisheries Service has required that released animals be marked or tagged so that they can be identified if they strand again. However, because of the difficulty and cost of monitoring cetaceans and pinnipeds in the marine environment, only a few serious efforts have been made to confirm survival. Seagars (1988) reported tag resighting data on California pinnipeds. Studies done on released rehabilitated or captive pinnipeds and cetaceans using radio or satellite tags include Payne and Rimmer (1982), Mate (1989), Harvey (1991), Gales and Waples (1993), Mate et al. (1994), and Davis et al. (1996). Because the species is endangered, a more extensive effort has been made to track released manatees using tether tags (Rathbun et al. 1990, Reid et al. 1995).

The use of such technology has been increasing, but it is expensive. Such efforts should be encouraged for reasons beyond the question of whether an individual animal survives. Transmitter tags can also provide behavioral information such as dive times, depth of dives, and movement. Although continued receipt of signals in such circumstances is confirmation of survival, the opposite is not necessarily an indication that an animal has perished. Without routine verification of survival, the effectiveness of rehabilitation programs will continue to be uncertain. To many people, however, success will continue to be gauged by numbers of animals successfully treated and released.

The issue of survival introduces an ethical element—should animals be released if their chance of survival is low or unknown? Because of limited capacity, a rehabilitation facility may have to choose between the release of a less-than-completely-healthy animal or euthanasia. Premature release can be justified by the argument that the animal will have at least a chance to survive. Because of the Marine Mammal Protection Act's requirement that animals be treated humanely, the question is whether releasing an animal with a low chance of survival may contribute to its suffering. Very young animals, even healthy ones, may not have acquired the skills needed to forage or avoid predators. In light of these uncertainties, no single policy can apply in every case. Those engaged in rehabilitation and management simply have to exercise their best judgment.

Issues also arise with respect to the possible impacts of released animals on wild populations. In 1991 the Marine Mammal Commission and the National Marine Fisheries Service cosponsored a workshop to examine these issues (St. Aubin et al. 1996). Participants agreed that the health of a wild population outweighs the welfare of an individual animal. During the workshop, two issues received particular attention: the introduction of diseases into wild populations and the possible genetic consequences of releasing stranded animals.

Marine mammals are often ill when they strand, and such animals may function as reservoirs for disease if they are returned to the wild. Also, an animal may contract diseases during its rehabilitation period and then carry them into the wild.

Some scientists have argued that the least fit members of a population are those that strand. If these animals are released back into a wild population, they argue, the overall health of that population could be affected and the natural selection process could be altered. For example, one of the most common afflictions of stranded pinnipeds is lungworm. Although a lungworm condition is treatable, a genetic factor could make some animals more vulnerable than others. If rehabilitated animals are released, the genetic fitness of entire populations could be affected.

A fallacy of such an argument is that virtually any physical condition may be linked to genetics. Our knowledge of genetically caused health problems in marine mammals is extremely limited, however. Without at least some evidence that a particular condition has a genetic basis, the decision usually should be in favor of the individual animal.

A point to consider is the level of scientific certainty that must be reached before an action is taken. If the requirement is to prove an absolute cause-and-effect relationship, a problem may be exacerbated and corrective action may be either precluded or not taken in a timely manner.

Translation of science into policy may present a dilemma. Management decisions often have to be made based on scientific evidence that is less than definitive. As an example, the Endangered Species Act (Public Law 93-205, as amended) provides that individuals may petition an agency to designate a species as threatened or endangered. The agency responsible for the decision must act on the basis of the "best scientific and commercial data available." In some cases, the "best" information may be less than definitive, but the agency is required to make a decision.

Two release decisions illustrate this dilemma and how different determinations may be made in similar circumstances. In 1991 stranding network members found antibodies to phocine distemper virus in pinnipeds that stranded along the U.S. Atlantic coast. The decision was made that no animal showing positive antibody titers to the virus could be released into the wild population, even if the individual appeared to be healthy. This decision was based, at least in part, on the fact that the same disease had previously been responsible for the deaths of more than 17,000 pinnipeds in Europe (Osterhaus and Vedder 1988), and there was uncertainty as to the etiology of the disease and its prevalence in populations in the western Atlantic. In a similar case, a number of sea otters being rehabilitated after the 1989 *Exxon Valdez* oil spill were found to have a herpesvirus, and a decision was made that they could be released (R. Keith Harris, pers. comm.).

Despite their controversial aspects, it is clear that rehabilitation and release programs have helped foster much of the support, in terms of both public sentiment and finances, for stranding network operations. The Marine Mammal Protection Act also provides an unambiguous mandate for rehabilitating stranded animals.

Strandings and Science

In the Marine Mammal Health and Stranding Response Act, Congress observed that stranding networks have the potential of gaining valuable information but that realization of this potential depends on the training and education of network members. When setting up network operations, it is important to recognize that there is a trade-off between the extent of coverage and the amount of scientific information that can be obtained. It is not possible to deploy highly trained professional personnel throughout all the coastal areas where animals may strand. However, nonspecialists with scientific backgrounds can be given the training and field resources needed to collect basic information.

To enhance the abilities of network members, the National Marine Fisheries Service and the Fish and Wildlife Service have developed a series of documents to distribute to volunteers. The primary reference is a field guide that includes a species identification key, treatment protocols for live stranded animals, and basic information on tissue collection (Geraci and Lounsbury 1993). A more detailed manual covering pinnipeds has also been developed. It provides information on methods for gross necropsy and instructions on collecting life history data and collecting and preparing tissues for pathogen detection, histopathology, and contaminant and toxicological analyses (Dierauf 1994). The Fish and Wildlife Service prepared a similar manual on manatees (Bonde et al. 1983). With support from the Marine Mammal Commission, an instructional video was prepared by Sea World, Orlando, Florida, and distributed to network members.

From a management perspective, it is important to have baseline data with which to make comparisons. To develop this baseline, the National Marine Fisheries Service requires the collection of a minimum set of data from each stranding. The standardized data collection form is reproduced in Figure 18-5. The Service may make requests for additional information, but such information is not required as a condition of network participation. Network members are also encouraged to provide tissues to scientific investigators.

Observations of dead stranded animals can reveal much about their lives and, with a sufficient sample size, about the species as a whole. Much of the professional literature on marine mammals has been the result of information gained from stranded animals. Species such as the pygmy sperm whale strand commonly but are seldom observed in the wild, and most of our knowledge of this species has come from stranded animals. More may have been learned about the life history of the Atlantic white-sided dolphin (*Lagenorhynchus acutus*) from a single mass stranding than from all of the previous work on this species (Geraci et al. 1978).

Even the basic information requested on the stranding data sheet can be useful for management decisions. Knowing the species and location of a stranding may provide information on a species' range and distribution. For instance, stranding data from the early 1990s indicate that some pinniped species on the Atlantic coast may be expanding their range south. Previous strandings of seals in the southeast region of the United States have been considered anomalous, but that assessment may change based on evidence that several harbor seals strand each year in North Carolina. Farther north, strandings of arctic seals such as harp seals (*Phoca groenlandica*) and hooded seals (*Cystophora cristata*) have become more common in New England and the mid-Atlantic states. This is most dramatically illustrated by the number of harp seal strandings, which has increased steadily from three animals in 1989 to 78 in 1995. Expansion of range may be coincident with increases in population abundance.

Changes in the length and sex distribution of stranded animals may indicate that something unusual is occurring. In some marine mammals, length measurements correlate roughly with age. A change in the length distribution of stranded animals may indicate a change in mortality patterns or the age structure of the population.

Similarly, a change in the sex distribution of stranded animals may warrant investigation. As an example, when a leptospirosis epizootic occurred in 1984, a disproportionate number of male California sea lions stranded. There was

MARINE MAMMAL STRANDING REPORT SID#______ (NMFS USE)

FIELD NO.:______ NMFS REGISTRATION NO.______

COMMON NAME:______ GENUS:______ SPECIES:______

EXAMINER
Name:______ Agency:______ Phone:______
Address:______

LOCATION
State:____ County:____
City: ____
Locality Details: ____
*Latitude:____N
*Longitude:____W

TYPE OF OCCURRENCE
Mass Stranding: (Yes) / (No) # Animals____
Human Interaction: (Yes) / (No) / (?)
Check one: __1. Boat collision
__2. Shot
__3. Fishery interaction
__4. Other____
How determined: ____
Other Causes (if known):____

DATE OF INITIAL OBSERVATION:
Yr ____ Mo ____ Day ____
CONDITION: Check one:__1.Alive
__2.Fresh dead
__3.Moderate decomp.
__4.Advanced decomp.
__5.Mummified
__? Unknown

DATE OF EXAMINATION:
Yr ____ Mo ____ Day ____
CONDITION: Check one:__1.Alive
__2.Fresh dead
__3.Moderate decomp.
__4.Advanced decomp.
__5.Mummified
__? Unknown

LIVE ANIMAL - Condition and Disposition:
Check one or more: __1.Released at site
__2.Sick
__3.Injured
__4.Died
__5.Euthanized
__6.Rehabilitated and released
__? Unknown
Transported to: ____
(Died) / (Released) Date:____

TAGS APPLIED?: (Yes) / (No)
TAGS PRESENT?: (Yes) / (No)

	Dorsal	Left	Right
Tag No.(s):	____	____	____
Color(s):	____	____	____
Type:	____	____	____
Placement		Front/Rear	Front/Rear

CARCASS - Disposition, check one:
Check one: __1.Left at site
__2.Buried
__3.Towed
__4.Sci. collection (see below)
__5.Edu. collection (see below)
__6.Other ____
__? Unknown
NECROPSIED? (Yes) / (No)

MORPHOLOGICAL DATA:
Sex - Check one: __1.Male
__2.Female
__? Unknown
Straight Length:____(cm)/(in)/(est)
*Weight:____(kg)/(lb)/(est?)
PHOTOS TAKEN? (Yes) / (No)

REMARKS: ____

DISPOSITION OF TISSUE/SKELETAL MATERIAL: ____

*Record data if available

It is estimated that completion of this form requires 20 minutes.

OMB#0648-0178, expires 01/31/97

Figure 18-5. Standard data reporting form used by the stranding network to obtain information on every stranded marine mammal.

also a change in the age distribution of stranded animals. The majority of the animals were either juveniles or subadults (Dierauf et al. 1985).

It might seem that the most obvious information that could be obtained from dead marine mammals would relate to the causes of death and rates of mortality. Without baseline information, however, the significance of such information is limited. In other words, without an adequate sample to define normal conditions, it is difficult to detect the abnormal. Detection of the abnormal is important in evaluating epizootic events. By providing baseline information, stranding networks contribute to the ability to detect such events.

Although stranding data cannot provide absolute mortality levels, they can help detect changes in mortality rates (Hersh et al. 1990). Because stranding coverage had been consistent over time along several areas of the east coast, the Service was able to use historic stranding rates as an index to determine that the epizootic affecting the coastal migratory stock of bottlenose dolphins during 1987–1988 had caused the death of more than 50% of the population over a 10-month period (Scott et al. 1988).

Many members of the stranding networks do more than collect the basic data required, conduct gross necropsies, and collect tissues for analysis. Their efforts have provided information on the parasites and diseases affecting marine mammal populations. Treatment of live stranded animals has provided similar information. A large body of literature has been produced on the pathogens and parasites affecting marine mammals, much of which has been the result of work with stranded animals.

If there has been a weakness in this area, it is the tendency by researchers to report only new and unusual findings in the scientific literature. A wealth of information on marine mammal diseases exists in the gray literature and on forms stashed away in filing cabinets. There have been relatively few efforts to systematically survey the causes of morbidity and mortality in stranded animals (Schroeder et al. 1973, Stroud and Roffe 1979, Cowan et al. 1986, Steiger et al. 1989, Dieter 1991, Gerber et al. 1993). For example, most stranding network members involved in the rehabilitation of pinnipeds state that among the most common pinniped pathologies are lungworms and heartworms, but there have been few efforts to quantify such findings (van der Kamp 1987, Gerber et al. 1993).

Strandings and Management

Systematic efforts to gather information from stranded animals have potential for improving management capabilities. In addition to providing an indication of mortality rates, stranding data can provide insights about stock identity, life history and population dynamics, and human–marine mammal interactions.

If the total number of bottlenose dolphins in U.S. waters remained constant, yet the species became extinct in the Gulf of Mexico, management would be judged to have failed. A central goal of management is to prevent populations from becoming severely depleted or extinct within specific parts of their range. To achieve this goal, a good understanding of stock identity and boundaries is necessary. The importance of stock differentiation was demonstrated during the 1987–1988 die-off of bottlenose dolphins on the U.S. Atlantic coast. There are two stocks of bottlenose dolphins in the area: a coastal stock that migrates seasonally along the coast and a more abundant offshore stock (Scott et al. 1988, Kenney 1990). When carcasses found on beaches from New Jersey to Florida were examined for morphological features, it was discovered that virtually all the animals were from the coastal stock. This raised concern that the stock may have been seriously depleted by the die-off.

Traditionally, morphology has been the primary standard for evaluating systematic differences between species. It can also be used to define stocks, and information from strandings can provide key information. By comparing cranial measurements, tooth and vertebral counts, and color patterns, scientists were able to differentiate the Baja California neritic (coastal) stock of common dolphins (*Delphinus delphis*) from other common dolphins in the eastern Pacific. As a result of these studies, a separate species, *D. capensis*, has been established (Heyning and Perrin 1994).

Differences in parasite infestation can reflect differences in species distribution and prey species and help define populations. For example, there are marked differences between the parasites of inshore and offshore western North Atlantic bottlenose dolphins (Mead and Potter 1990, 1995). Coastal animals commonly have *Braunina* in the stomach and do not have *Phyllobothrium* and *Monorhygma* in other tissues. The situation is reversed with the offshore stock.

It may be a tragic commentary, but the presence of specific contaminants or the ratio of contaminant burdens also can help define stocks (Aguilar 1987). As in the case of parasites, differences may indicate either spatial segregation or differences of contaminant levels in prey. One study of stranded animals on the west coast of North America indicated that the ratio of DDT metabolites to PCBs was higher in harbor porpoises from California than in those from Washington and Oregon, suggesting that porpoises in the two regions were from different stocks (Calambokidis 1986).

Another tool for distinguishing populations is genetic analysis. DNA can be obtained from a small piece of skin or other tissue. By sequencing mitochondrial or nuclear DNA, it may be possible to define specific populations (Amos et al.

1992). The importance of such information is illustrated by the status of harbor porpoises in the western North Atlantic. The impact of incidental mortality from fisheries would, in this instance, be much more serious if there are three or four reproductively isolated populations of harbor porpoise than if there is one large population. A workshop on the status of the species strongly recommended that additional genetic analyses be undertaken to address the issue of stock definition (National Marine Fisheries Service 1992).

Life History and Population Dynamics

Stranded animals can also serve as a source of information on life history and population dynamics. Before it can be determined if special management action is needed for specific populations, such parameters as longevity, age at sexual maturity, reproductive rates, and mortality rates can provide the information necessary to develop population models.

Although the length of an animal can be used to infer its maturity status, there are much more exact methods of determining age. In pinnipeds and most odontocetes, teeth can be processed and growth layer groups counted to provide an estimation of age (Laws 1953, Hohn 1980). Growth layer groups in the periotic bone have been used to estimate age in manatees (Marmontel et al. 1996). For some baleen whales, ear plugs have been used to estimate age (Lockyer 1974). Accurate age determinations and a sufficient sample can provide information on the longevity of a species. Using the same technique, it also may be possible to determine the age at which a female dolphin became sexually mature (Hohn et al. 1991).

Similarly, reproductive status often can be determined from stranded animals. In the case of male pinnipeds and cetaceans, it is possible to determine sexual maturity. In female cetaceans, ovulations leave permanent corpora, and examination of ovaries may help reconstruct an animal's reproductive history (Collet and Harrison 1981).

Stranded animals are also a potential source of information on the prey species of marine mammals. In addition to identifying intact prey items, researchers can identify prey species using fish otoliths (ear bones) and squid mouthparts (Seltzer et al. 1986, Barros and Odell 1990, Barros 1992, Schwartz et al. 1992). Changes in prey composition may reflect changes in prey abundance or environmental problems. Although studies were not conducted on stranded animals, scat analysis of pinnipeds during the 1983 El Niño event mirrored changes in fish populations along the west coast (Trillmich and Ono 1991).

Diseases and Causes of Mortality

Gross necropsies, histopathologic examinations, and other analyses can provide information on the diseases and parasites afflicting marine mammals. Stranding networks played a key role in detecting phocine distemper virus in seals in the North Sea and the northeastern United States. After the disease was detected in the United States, analysis of blood serum that had been banked by network members indicated that the disease was present in the population as early as 1986 and is probably enzootic (Geraci et al. 1993). This indicated that the disease was present before the 1988 epizootic in Europe. Tissues collected by network members also enabled researchers to determine that a morbillivirus was present in bottlenose dolphins in the Gulf of Mexico and was the probable cause of a mortality event on the Texas coast in 1994 (Lipscomb et al. 1994, 1996).

Under the Marine Mammal Protection Act, the National Marine Fisheries Service has the task of reducing the impact of human activities on marine mammals, specifically the impact of fisheries. To accomplish this, data are needed on where and when such interactions occur. Although data on stranded animals cannot be extrapolated to provide total mortality levels from interactions, they can provide an indication that specific problems require further investigation. Examination of stranded animals by trained observers can provide information on human interactions (Hare and Mead 1987).

Stranding data have shown that ship collisions cause a significant number of deaths of the critically endangered northern right whale, *Eubalaena glacialis* (Kraus 1990). Based on this information, the Right Whale Recovery Team listed this problem as the top recovery priority (National Marine Fisheries Service 1991).

In recent years, direct observation indicated that the groundfish set gillnet fishery was having a significant impact on harbor porpoises in the western North Atlantic (Read and Gaskin 1990). However, strandings of 49 animals in the spring of 1993, some of which had evidence of entanglement, provided evidence that a second fishery, about which little was known, was also affecting the population. This information led to placement of government observers in the fishery in an effort to improve reporting of mortalities. Similarly, increases in the number of stranded harbor porpoises on the California coast in the mid-1980s alerted managers to a serious problem with a halibut gillnet fishery, and this led to area closures in the fishery (Seagars et al. 1986).

Stranded Marine Mammals and Contaminants

The massive mortality of bottlenose dolphins along the U.S. Atlantic coast in 1987–1988 rekindled interest in the health of marine mammals generally and in the information that could be collected from stranded animals. Although high levels of organochlorine contaminants were found in some animals, it was not possible to determine whether the contaminants played a role in the die-off. Because of the lack of baseline information and methodological differences in the information that was available, it could not be determined whether the contaminant loads were anomalous. To complicate the matter, the most likely impact of such contaminants was not direct toxicity but more subtle effects on the animals.

Some studies have raised interesting questions as to whether there is a causal relationship between a reduction in reproductive rates and organochlorine contaminants. Helle (1980) found a correlation between reduced reproductive rates in ringed seals, *Phoca hispida,* in the Baltic Sea and high levels of PCBs. Reijnders (1984) questioned the methodology of this study but found a similar correlation between contaminant levels and lack of reproductive success in harbor seals in the Wadden Sea. He showed experimentally that a diet higher in PCBs had an impact on reproduction in harbor seals that was not exhibited in control animals and hypothesized that the contaminants affected hormonal balance (Reijnders 1986). The author of a study on contaminants in harbor seals in Puget Sound noted that reproductive success was lower and juvenile mortality higher in the southern area of the sound and that seals in that area had higher levels of PCBs (Calambokidis et al. 1984).

Another potential impact of contaminants on marine mammals is immunological dysfunction. A cause-and-effect relationship is difficult to prove, however. Because the direct cause of death in such a situation is usually a pathogen that the animal might have successfully overcome, it is difficult to prove that contaminants were a contributing factor. In the case of marine mammals, details on locations, numbers of mortalities, actual causes of death, and a number of other variables may not be available. Recent efforts to characterize marine mammal immune systems have provided the first step in addressing this issue (De Swart et al. 1993, DiMolfetto-Landon et al. 1995, Erickson et al. 1995). In addition, studies in Europe indicate a correlation between reduced immunological function and pollutants (Brouwer et al. 1989, De Swart et al. 1994, Ross et al. 1995).

In both the reproductive and immunological studies, correlations were noted. Correlations alone do not establish a cause-and-effect relationship. For definitive scientific proof, adequate controls and sample size are necessary. Ideally, the mechanism by which a phenomenon occurs should be fully explained.

Stranded animals offer the potential of addressing some of the issues related to the impacts of pollutants on marine mammals, but there are limitations that must be taken into account. First, extreme care needs to be taken in collecting and preserving samples for contaminant analysis to avoid contamination. Differences as small as parts per billion may be significant for certain compounds. Therefore, extremely rigorous protocols for collecting and storing tissues are required (Geraci and Lounsbury 1993, Becker et al. 1994).

Second, the time of death usually cannot be determined for animals that wash onto the beach, and this creates uncertainty about the effects of tissue decomposition on the measurements of contaminants. Although one study monitored organochlorine levels over time in a decomposing striped dolphin, the time intervals (6, 13, 21, 29, 41, and 55 days) were longer than one usually would expect for a beach-cast animal (Borrell and Aguilar 1990). The time during which a dead animal may be useful for contaminant analysis ranges from a few hours to about a week after death. Time postmortem is not the only variable to be considered. Ambient air and water temperatures can also affect the rate of decomposition.

Third, it is important to consider the possibility that variability in the distribution of contaminants within individual tissues will influence results. Selective partitioning or seasonal differences within tissues mean that protocols on sample locations are critical. If contaminants are nonuniformly distributed within tissues, protocols must be set up to minimize bias and variability in analytical results. An analysis of the intraorgan distribution of contaminants in harbor porpoises indicated that for liver and blubber the sampling location contributed little to variation in measured levels of chlorinated hydrocarbons and heavy metals (Stein et al. 1992). Because blubber of harbor porpoises may be less metabolically active than that of other species, tests on additional species are needed.

Finally, the question of whether singly stranded animals are representative of populations as a whole must be considered. Many strand because of illness and may be debilitated. An emaciated animal that has metabolized most of its blubber reserve might have a different contaminant profile than a more robust individual.

Although there has been considerable speculation about the impacts of contaminants on marine mammals, our level of knowledge and the science needed to address questions are both still in the developmental stage.

Mortality Events

The stranding networks play another key role in detection and response to unusual mortality events. The Marine Mammal Health and Stranding Response Act sets up procedures to be followed when such events occur. The law establishes an advisory group—the Working Group on Marine Mammal Unusual Mortality Events. The working group is composed of specialists from a number of scientific disciplines and is to be consulted when an unusual mortality event is suspected. It also provides guidance on specific investigative directions.

The working group established criteria for determining whether an unusual mortality event is occurring and thus whether a response is appropriate. These are as follows:

1. A marked increase is observed in the magnitude of strandings when compared with prior records. Magnitude by itself may not be an indication of an unusual mortality event and should be weighed against other knowledge.
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 (possibly suggesting a localized problem), is occurring throughout the geographical range of the species/population, or is spreading geographically with time.
4. The species, age, or sex composition of the stranded animals is different than that of animals that normally strand in the area at a specific time of the year.
5. Stranded animals exhibit similar or unusual pathologic findings or the general physical condition (e.g., blubber thickness) of stranded animals is different from what is normally seen.
6. Mortality is accompanied by behavioral patterns observed among living individuals in the wild that are unusual, such as their presence in habitats normally avoided or abnormal patterns of swimming and diving.
7. Unusual or severely endangered species are stranding. Stranding of three or four right whales (*Eubalaena glacialis*), for example, may be cause for great concern, whereas stranding of a similar number of fin whales (*Balaenoptera physalus*) may not.

The application of these criteria is dependent on the contributions of the stranding networks in two ways. First, the networks are the initial source of the information. Second, that information must be compared with historic baseline information before a judgment can be made. Without accurate data and consistent effort on the part of the networks, such baseline information will not be available.

The networks also can play a key role in the response to unusual mortality events. If live animals are involved, network members are usually best qualified to provide treatment, although a major event can quickly overwhelm local facilities. At best, facilities can accommodate only a few cetaceans. Although the physical facilities required to treat live pinnipeds are less complex, even they can be stretched to capacity, as happened during the 1992–1993 El Niño and the outbreak of leptospirosis in California sea lions in 1984.

Institutional members of the networks also have the personnel and equipment to respond rapidly to stranded dead marine mammals. As Geraci et al. (this volume) point out, there are numerous possible causes for mortality events. These include parasites or other serious infectious agents, changes in environmental conditions such as an El Niño or a sudden change in water temperature, naturally occurring biotoxins, and fouling or toxicity caused by oil or chemical spills or toxic runoff of chemicals.

If the cause of a mortality event is not known, all possibilities may have to be investigated. Because the analyses required for each of them vary, tissue collection and preservation protocols also differ. For example, liver collected for contaminant analysis should be frozen, and liver collected for histopathologic analysis should be fixed in formalin. Improper collection or preservation could render a tissue useless for a particular type of analysis. Network members can collect tissues for such analyses, but only if they have adequate information and training.

When the die-off of bottlenose dolphins occurred in 1987–1988, it was viewed as an anomalous event. In fact, such events may be more common than previously believed. During the three-year period beginning in April 1991, there were 11 consultations with the advisory group. The events reflect the range of possible causes, including environmental conditions in the case of the El Niño, serious pathogens such as phocine distemper virus (Duignan et al. 1993) and dolphin morbillivirus (Lipscomb et al. 1994, 1996), and two events that turned out to be human interactions but that were initially investigated as mortality events.

Summary

Each year in the United States, substantial numbers of marine mammals strand. A network of volunteers has been set up to respond to these strandings. The network is responsible for the rescue and rehabilitation of live stranded animals and the collection of basic biological data from dead stranded animals.

Stranded marine mammals have contributed much to what is known about some species. Even the most basic data can provide important information, especially if the effort to detect and report strandings is consistent. Stranded animals can provide considerably more scientific information if those who respond to strandings have been adequately trained and follow standard protocols for collecting data and tissues. Because the network is made up of volunteers, there are practical limitations on the amount of effort that can be expected. As information demands increase, the willingness of network members to respond may be reduced.

In the Marine Mammal Health and Stranding Response Act, the Congress made it national policy to monitor the various factors affecting the health of marine mammal populations. Stranding networks have played a key role in this area in the past, and the role is likely to be enhanced in the future. Although stranding records usually do not provide an adequate basis for estimating actual mortality rates, they can provide many kinds of valuable information. They help document human–marine mammal interactions that warrant further investigation, and they provide information on the parasites and pathogens that affect marine mammal populations. The act requires an accelerated response to unusual mortality events, and stranding networks are likely to provide initial information that helps identify such events. Network members also participate in the collection and preparation of the tissues needed to determine the causes of such events.

Anthropogenic contaminants are ubiquitous, and some chemicals have been detected in relatively high levels in marine mammals. Before it can be determined with certainty whether such levels have a deleterious impact on marine mammals, a baseline needs to be established.

Stranded animals also can contribute information on life history and population dynamics. Morphological, genetic, and other data can help define discrete populations for management purposes.

Stranding networks around the world have made substantial contributions to our knowledge of marine mammals. The potential is even greater. These efforts have been made by dedicated volunteers receiving little government support and little recognition for their efforts. Marine mammals have assumed a special status with the public (see Lavigne et al., this volume), but, for the most part, the public is unaware of the cadre of people who rescue and treat animals and collect information that contributes to their protection.

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